Phyl O'Connell

Renovation Survey for the Security, Collection Storage, & Climate Control Systems for the Congress Street Wharf

June 1976

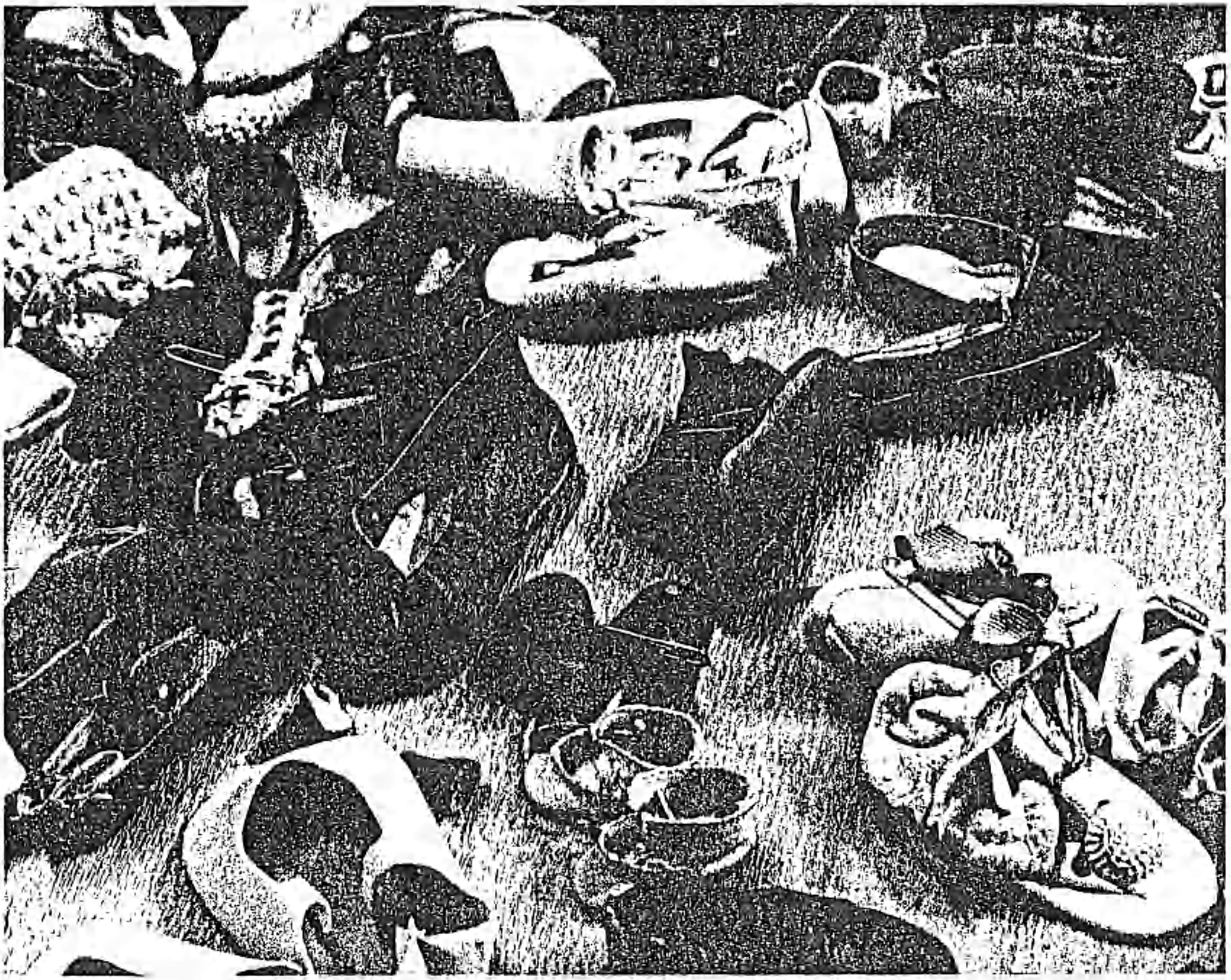
prepared by

The Children's Museum
The Museum of Transportation
Dr. William Young
Joseph C. Chapman, Inc.
Cambridge Seven Associates, Inc.
R.J. Vanderweil Engineers, Inc.

Funded in part by a grant from the National Endowment
for the Arts, a Federal Agency, Washington, D.C.
Grant #R60.20.353B

Contents

Introduction and Summary of Report Findings



The objective of this study is to provide the museums the necessary planning guidelines and technical criteria for developing a collections conservation program at their new building headquarters, the Congress Street Wharf. The renovation of the building, the housing and usage of collections, and the operational procedures for program/exhibit development will be studied, and recommendations will be generated to provide a conservation policy that maximizes the interface between these three key areas.

To undertake this study, the Children's Museum and the Museum of Transportation retained the services of their architect, Cambridge Seven Associates, Inc., and consulting engineers, R. G. Vanderweil as well as two recognized experts in the fields of artifact conservation and security, Dr. William J. Young, and Joseph C. Chapman. Also involved in this study were the following museum staff: Mr. Michael Spock, Director; Ms. Joan Lester, Curator; and Mr. Bill Mayhew, Computer Systems Developer of the Children's Museum; and Mr. Duncan Smith, Director, and Mr. Will Twombly, Curator of the Museum of Transportation.

Dr. Young, Emeritus Head of the Research Laboratory at the Museum of Fine Arts, Boston, Massachusetts, assisted in developing environmental criteria and collections handling procedures for the study. Mr. Chapman, of the firm Joseph C. Chapman, Inc., security consultant from Wilton, Connecticut, assisted in developing a security strategy for the building and specific collection housing areas which included an outline of the various levels of security and appropriate hardware. The engineering firm of R. G. Vanderweil Engineers, Inc., of Boston worked with the museums' special consultants and staff members in developing the building security, fire protection, automation, and mechanical systems.

Cambridge Seven Associates, Inc., of Cambridge, Massachusetts, provided overall coordination of the total study effort, developed planning and architectural criteria and options and, with the assistance of the museums' staff members, developed the collections storage housing criteria.

SUMMARY OF REPORT FINDINGS

The following annotated outline summarizes the recommendations and associated building costs of museum portions of the Wharf Project generated as of this writing. The outline reference numbers key the major cost items to the analysis section of this report, wherein further detail can be found.

B1.2 CONSERVATION SUPPORT SPACES $ 61,400

These spaces provide the necessary ancillary functions for the administration and maintenance of the collections. The Registrar's Office controls access to the collections and is the place where accessioning, cataloguing and inventorying tasks are performed. The Conservation Laboratory and Restoration Shop are the "in-house" maintenance and repair spaces for small and large objects, respectively.

B2.1 COLLECTION STORAGE $ 256,200

Collections Storage provides for the physical housing of the objects not on exhibit or in active programmatic use. These components have been developed into storage systems for the collections based upon the objects' physical characteristics and storage requirements. Small objects will be housed in a modular tray storage system; medium size in open shelving, cubicles and bins on casters; large objects in open steel rack shelving or in spaces subdivided by wire partitions; and special objects in storage units that are unique in configuration and do not fall into one of the above categories.

B2.2 TRANSPORT HOUSING $ 6,800

The greatest danger in terms of physical damage to collections occurs during handling and moving. To reduce this hazard, a variety of portable storage containers were studied, ranging from hand carrying tubs to carts. Container surfaces will be padded and provided with adjustable dividers to separate objects; carts will come with locking compartments and a work surface for demonstrations.

B2.4 SATELLITE HOUSING $ 53,400

To maximize contact between the public and collections, secure storage units will be developed within portions of the building outside the main collections storage area. These storage units will vary in size and level of protection. They will range from collection closets, having a micro-environment similar to collection storage areas, to display units and portable carts, which will provide only basic security to the objects.

B4. SECURITY $ 95,200

The museums will continue to rely heavily on staff as their primary security "system." To supplement this approach, an automated security system has been developed both to provide perimeter security and t monitor various spaces within the museums. This system will build upon the Children's Museum's present computer and will consist of automatic card reader controlled doors, mechanical card or high security key operated doors, and motion detectors.

B5. FIRE PROTECTION AND DETECTION $ 366,200

Fire detection will consist of ionization sensors throughout the entire building, a heat sensitive sprinkler system, smoke detectors in the air intake and returns of the air handling system, and manual pull station alarms. In addition, to maximize public safety, the museums will evacuate the entire building with audio and visual alarms.

Fire protection will consist of new standpipes and a new wet sprinkler system in all spaces of the building except the small object collection storage areas; these spaces will be protected with a gas (Halon) suppression system.

B6.1&5 AIR PURIFICATION AND HVAC SYSTEMS $1,086,420

The intake of fresh air to the building will be filtered to remove both natural and man-made gases and dirt that would adversely affect the collections. The system will also be monitored to insure adequate filtration.

Each building bay will contain its own air handling units to provide the necessary humidity and temperature controls to that bay. Through individually adjustable controls, a high level of flexibility for growth and change of bay usage is achieved without sacrificing the established environmental criteria.

B6.4 SMOKE CONTROL $ 71,800

A smoke exhaust system will be developed for the public spaces of the museums to provide a safer means of public egress and to reduce the potential hazard of smoke damage to the collections. The system consists of a series of vertical exhaust duct chases which serve every two bays. Each of the air handling units is programmed to provide positive pressure to exhaust smoke through these shafts in case of an emergency.

B6.6 BUILDING AUTOMATION $ 200,800

A semi-automated building control system is proposed to monitor the decentralized air handling system, maintain stringent air quality control, and meter energy costs. Using the Children's Museum's computer as the basis for an automated building system, the control, operation and monitoring of the mechanical, security and fire detection systems can be developed for the Wharf. Equipment in individual bays will be monitored by microprocessor units which are in turn linked to the central computer.

B7. ACCLIMATIZATION $ 67,300

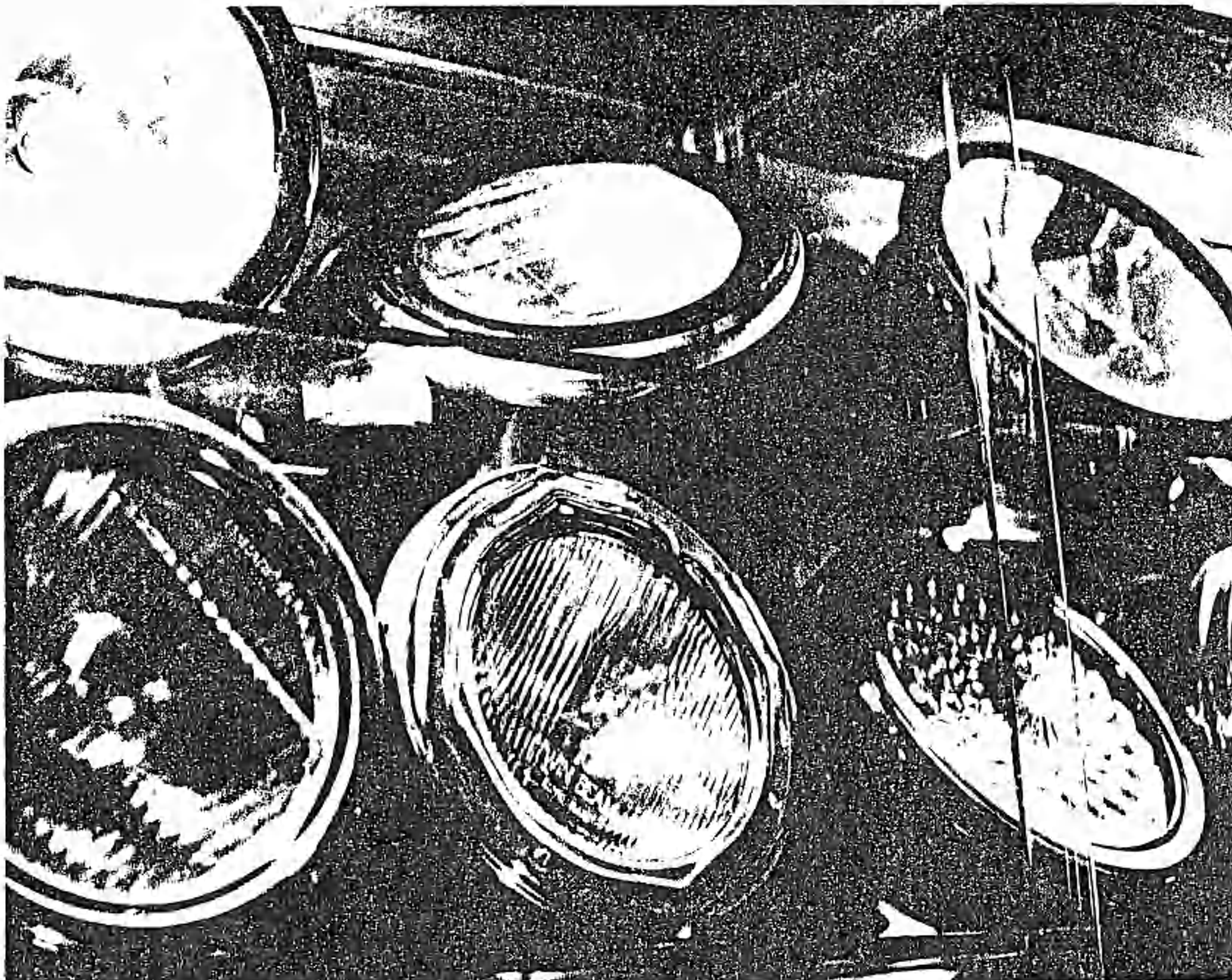
A regular maintenance program will be used by the museums for conservation of collections. Objects entering storage will be fumigated for vermin in a fumigation chamber located at the Conservation Laboratory. In addition, the entire collection storage areas will be fumigated on a periodic basis throughout the year.

At the main entry to the building, an air curtain will be installed to reduce the dust and dirt that the public carries in.

ARCHITECTURAL AND ENGINEERING FEES $ 188,800

A professional fee for designing and supervising the construction of the above elements of the building is based upon their construction cost, projected two years from the date of this report.

Study of Criteria and Existing Conditions



A. Study Criteria and Existing Conditions

A1.1 MUSEUMS' COLLECTIONS PHILOSOPHY

Although each has a well deserved reputation for hands-on and innovative approaches to interpretive programming, the Children's Museum and the Museum of Transportation are heavily commited to the documentation and conservation of significant collections of cultural and transportation artifacts and natural history specimens. (See Section A2.1.)

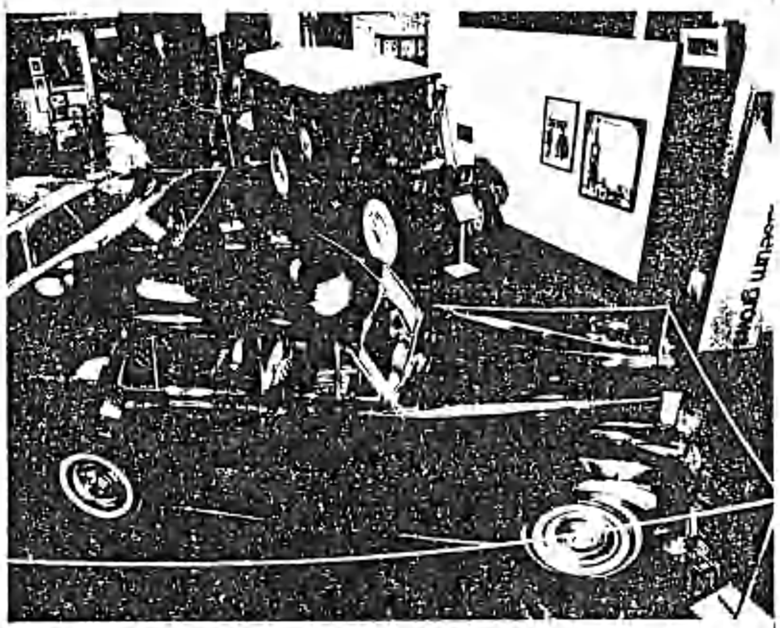
In an effort to preserve these extraordinary resources and make them available for exhibition, educational programs and scholarly research, the Children's Museum invested four years and more than $70,000 in a major analysis and recataloguing of its cultural collections. Each object was examined by a consulting expert in the culture, and described in terms of its functions, methods and materials of manufacture, design and other significant data. A thesaurus of non-technical terms (understandable to lay readers) was developed to prepare the catalogue for cross-indexing and machine retrieval. Experiments were conducted in low cost tray storage systems and all objects were rehoused by culture, and by function within the culture. The American Association of Museums accreditation visiting committee commented:

> "The collections of the institution are extremely fine; the scope of the collections in terms of potential program contributions is outstanding; the record keeping is of a very high order."

During this last year, under a National Endowment for the Arts Utilization of Collections grant, experiments have been under way to develop use and housing standards for increasing general access to the collections while maintaining suitable controls over losses from theft and damage.

The Museum of Transportation has only begun the task of accessioning, cataloguing and documenting its collections since 1970.

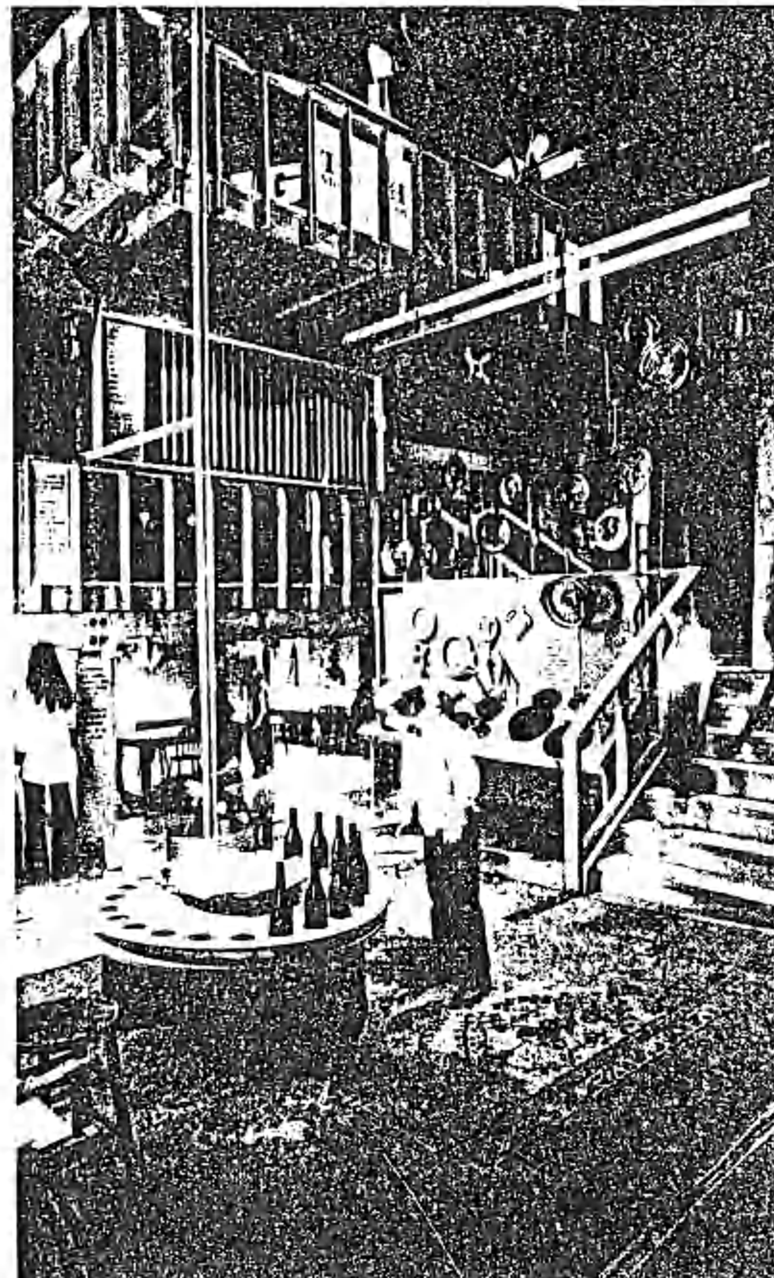
However, as presently housed in attics, garages and unheated warehouses, serious hazards continue to threaten the collections. Wide and sudden changes in temperature and humidity stress wood and other plant fibres. Moisture condensing on cold surfaces accelerates the oxidation of metals. High humidity encourages growth of mildew and other fungi. Fumigation for insect control is difficult to manage in areas that are not air tight. Highly combustible frame



structures invite fires, and suppression with hoses could cause as much damage as the flames themselves. Multiple, unsupervised access to storage areas increases the threat of theft and vandalism that can only be partially moderated with makeshift locks and detection systems.

Finally, the remote and scattered location of collections storage areas has severely limited public and staff access. Both museums believe strongly in encouraging interested visitors, scholars and staff to go beyond the limits of prepared exhibits and educational programs for more in-depth study of these materials. Yet most of the visiting public, scholary community and even many staff are completely unaware of the richness of these resources; much less how to make effective use of them.

Therefore, an overriding goal of the Wharf project will be to substantially increase safeguards to the collections, while making them more visible and usable to public and staff.

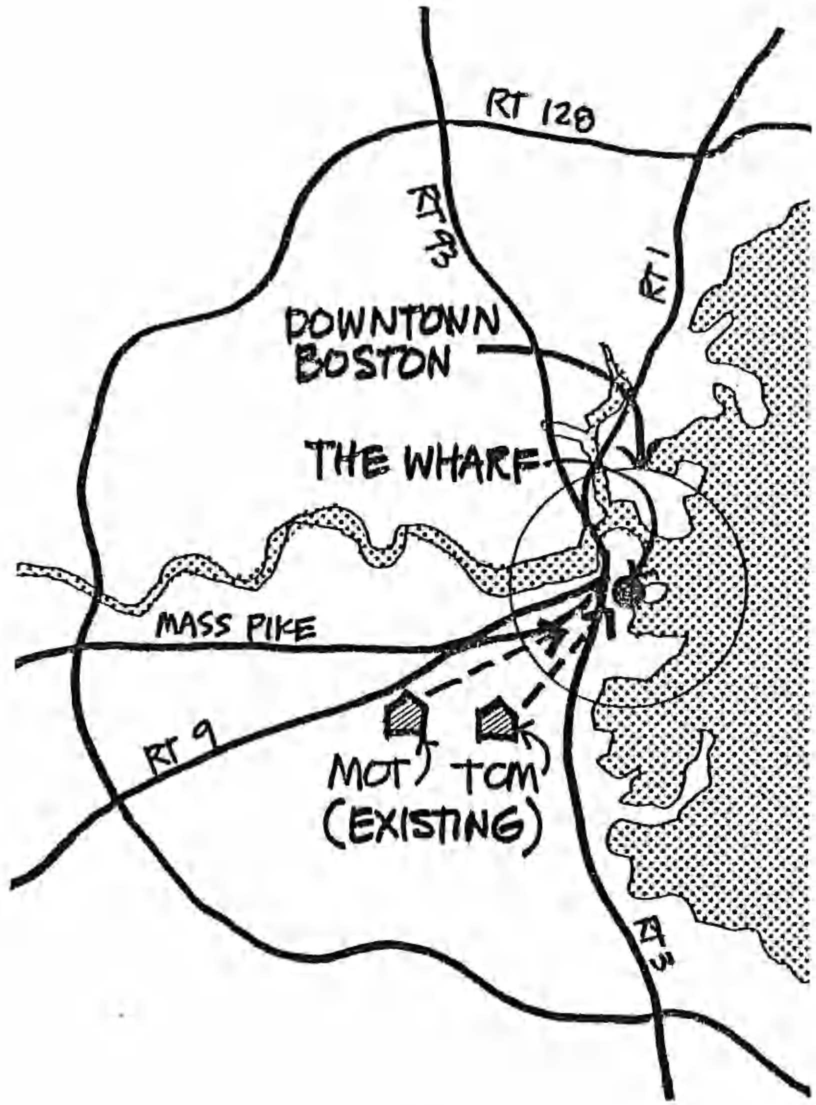


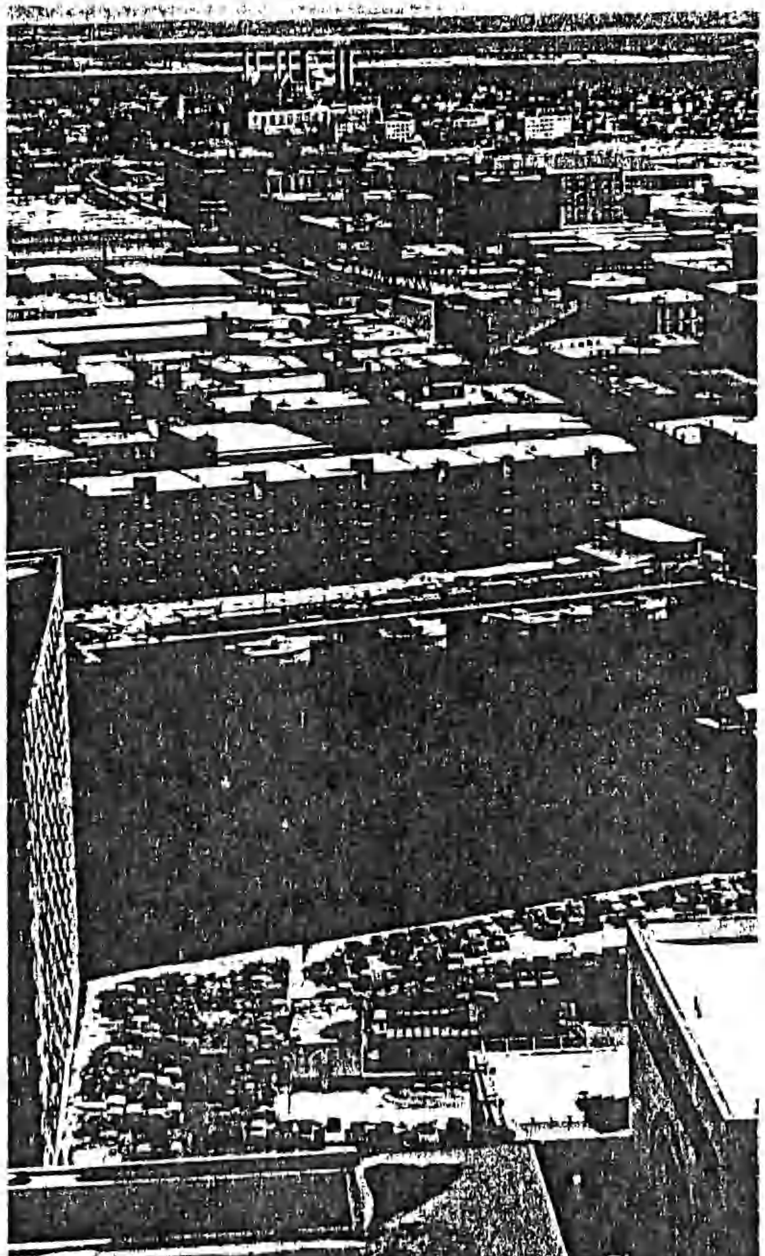
A1.2 RECYCLING OF EXISTING STRUCTURE

For the past five years, the museums have been actively investigating prospective sites and buildings in downtown Boston for their new home. This decision to centrally relocate coupled with the museums' own working philosophies of adaptive reuse and building rehabilitation dovetailed logically with the conclusion to search for an existing building that could be recycled for museum uses.

The museums' optimum spatial configuration requires a building architype having large bay sizes with minimal obstructions to the floor plan. Buildings that fall into this category and were investigated included industrial type structures, of which the Congress St. Wharf Building is one.

In meeting these objectives for the redevelopment of the Wharf for museum use, the museums must also confront certain liabilities common in most recycled buildings projects. These liabilities include: administrative regulations (i.e. building codes, zoning ordinances, etc.), physical configuration of the existing structure, minimal public amenities found in a primarily industrial area, and adverse environmental conditions arising from either the surrounding area or inherent within the existing building shell construction itself. The impact of these liabilities upon collections conservation will depend upon the careful planning of the rehabilitation program for the building, the receptiveness of local City officials, and the museums' capability to manage the program on an ongoing basis.





A1.3 JOINT USE OF FACILITIES

Finally, a third major goal of the Wharf project is to reduce capital and operating costs through the sharing of a number of support facilities and operations including lobbies, information and ticket sales, coat and parcel checking, auditoria, temporary exhibition, library reading and circulation, administrative reception and meeting, maintenance and security, design and production, shipping and receiving areas, elevators and HVAC plant.

Taking this step, it was understood that some comprimises in the straightline supervision and management of collections would be made in exchange for anticipated operating economies.

Therefore, an effort was made in this study to integrate the collections processing and storage areas as much as was practical. Objects and services were organized by size, type and function, rather than being separated and duplicated for each institution.

A2.1 DESCRIPTION OF COLLECTIONS

The Children's Museum has 20,000 catalogued objects from cultures throughout the world, with particular strengths in Japanese, American Indian and historic Americana. The Museum's natural history collections include more than 50,000 mammals, bird, insects, shells, rocks, minerals, and fossils. The Museum of Transportation has 250 vehicles including carriages, sleighs, wagons, bicycles, motorcycles, autmobiles, tricycles, buses, and ambulances, as well as 4000 related artifacts and 15,000 books, pamphlets, catalogues and other materials, all documenting changes in transportation technology and human mobility over the past hundred years.

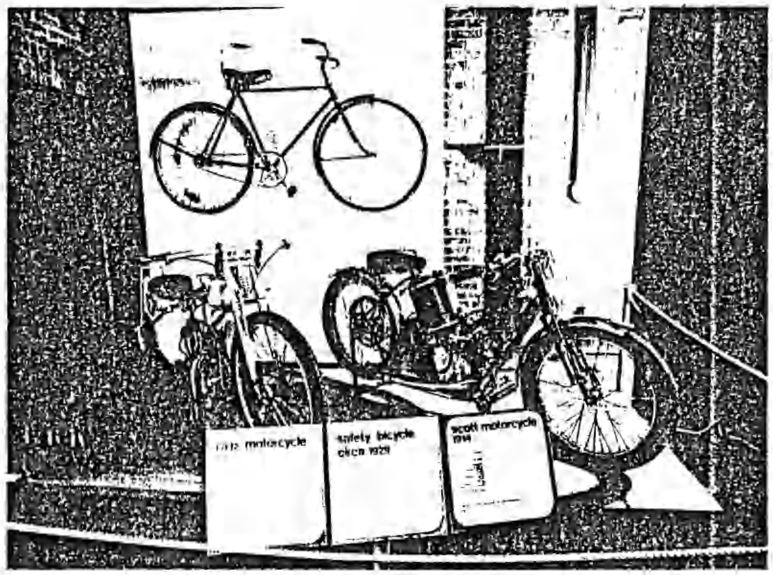
Like the products of any natural environment or human culture, both museums' collections reflect an incredible variety of interesting and valuable stuff. For example, a sampling of some of the rarer items in the Children's Museum collection might include a dozen examples of late 18th or early 19th Century Passamaquoddy silver crowns and broaches, several 18th Century wooden Queen Anne dolls, a 30 piece San Isle de Fonso pottery sequence prepared by Maria Martinez to demonstrate her manufacturing techniques, and five passenger pigeons, two Carolina parakeets, an Eskimo curlew and heath hen.

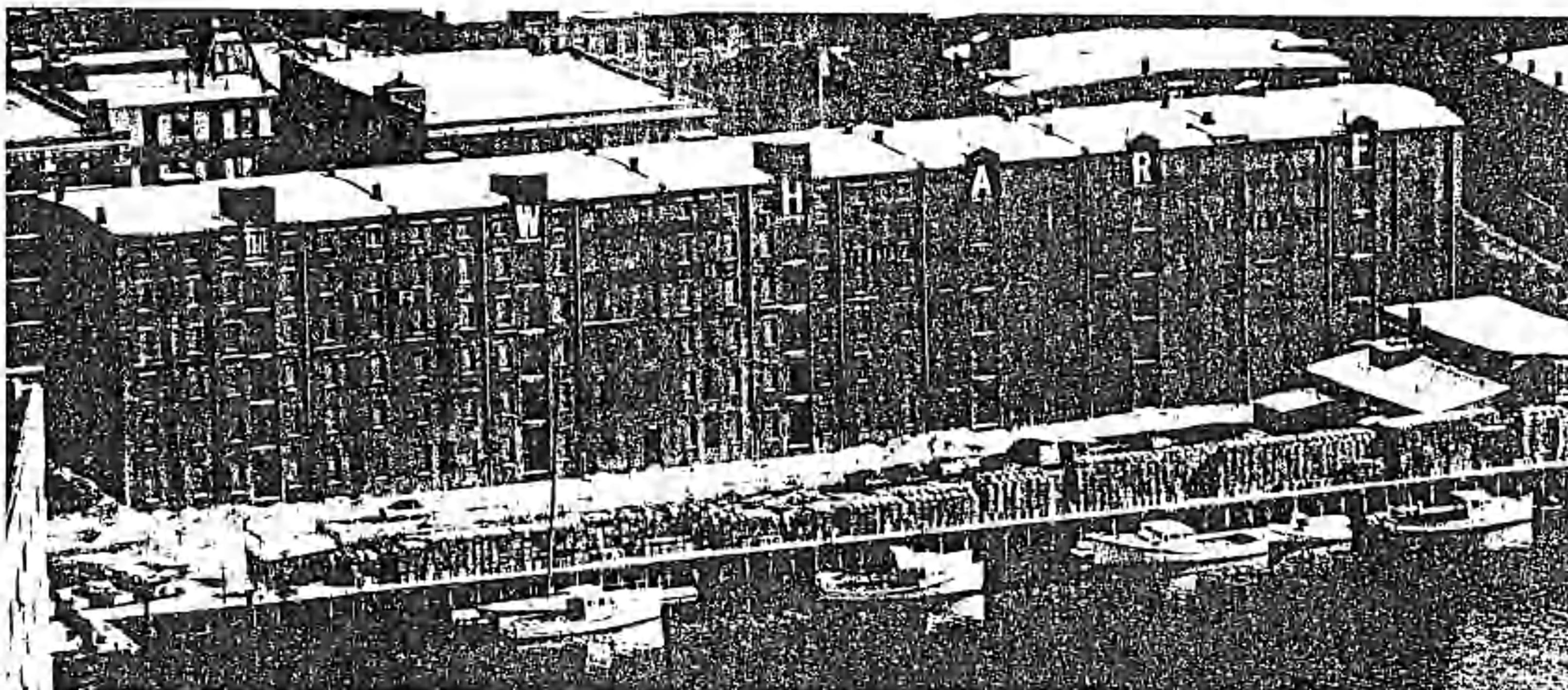
The Museum of Transportation owns a unique collection of restored early tricycles and high wheel bicycles, formal carriages and sleighs and some particularly rare automobiles including an 1898 Winton, 1912 Simplex and a model 315 four cam Ferrari roadster.

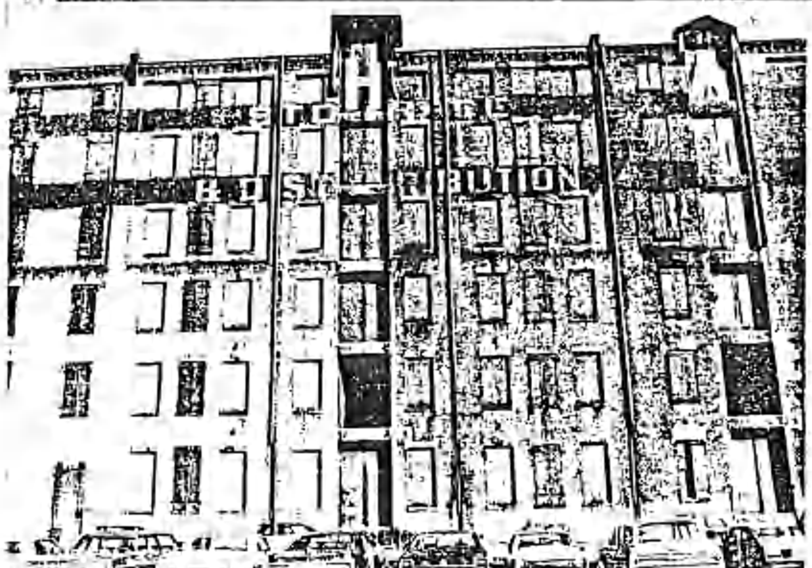
These objects range in size from doll house china to a 12-passenger mountain bus, although the bulk of TCM materials are smaller than a breadbox and MOT's are large vehicles.

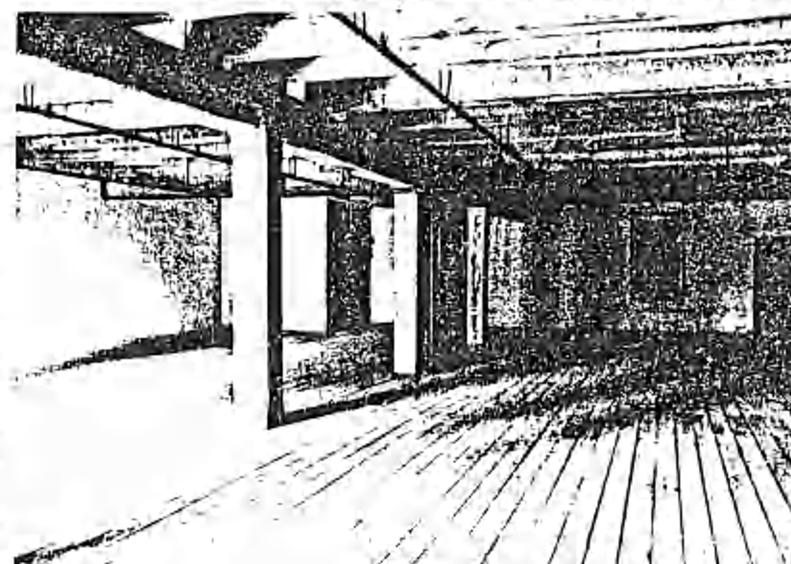
Materials include grass, reeds, wood, bark, pitch, roots, flowers, sugar, amber, leaves, seeds, gourds, feathers, down, silk, hair, quills, horn, hooves, teeth, bones, gut, sinew, wax, coral, shell, marble, plaster, clay, glass, onyx, turquoise, mercury, tin, steel, lead, gold, aluminum, copper, brass, and even plastics.

The total volume of TCM collections is approximately 60,000 cubic feet and is doubling at the rate of once every 20 years. The MOT collections occupy 40,000 cubic feet and are doubling at the rate of once every 5 years.




W H A R F





A2.2 DESCRIPTION OF THE WHARF BUILDING

The Wharf Building, a handsome brick and timber wool warehouse structure, was built in two phases during the 1880's. Six stories in height with six segregated building bays per floor, the structure provides the museums with 36 basic compartments for program development.

The site and its location, on Fort Point Channel, provides unique intown amenities for both potential water related activities and a sizable open space or apron area in front of the structure to allow for exterior program activities and future museum expansion. Unfortunately, its closeness to water also brings with it the problem of salt-laden air and its effect upon the objects, which is dealt with in other sections of this report.

The present structure is supported on piles and is composed of brick-bearing walls for the exterior and party walls with heavy timber floors and columns. Each of the six floors contains four bays at approximately 4500 GSF (Gross Square Feet) and two bays at 3500 GSF providing a total building area of 145,000 GSF.

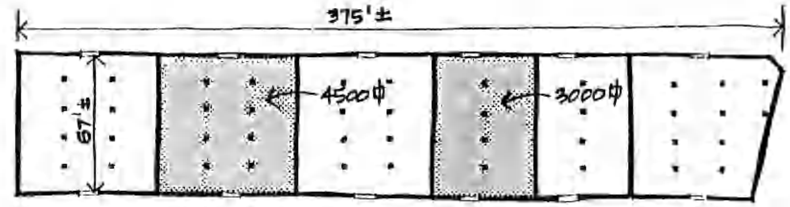
Except for a few isolated areas, the building shell is structurally sound, requiring only surface treatment to the existing masonry walls. Other basic refurbishing work will include cleaning of the brick and timbers, replacement of the existing doors and sash openings, and replacement of the roof.

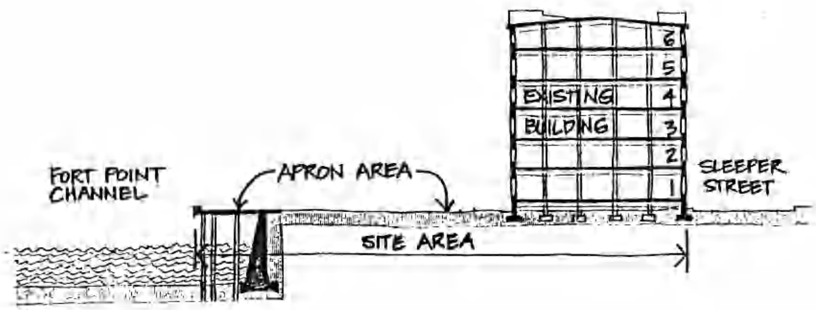
The building as it exists has very primitive utility services; therefore, development of the building will include installation of complete HVAC, electrical, fire protection and security systems. The natures of these systems are described later in this study.

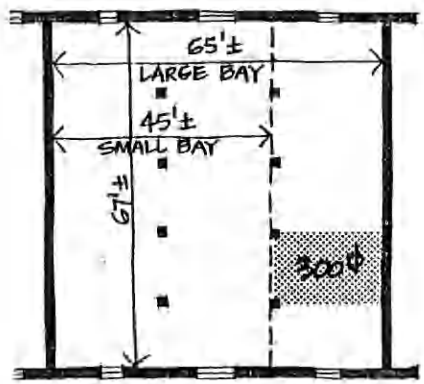
The building is presently protected with a dry pipe sprinkler system throughout and the floors are pitched to carry off water in case the sprinklers are activated. To conform to the local Building Code, the sprinkler system will be converted to a wet pipe system, and to eliminate the problems of the floor pitch, a lightweight cement fill will be poured over the existing floor deck. This cement fill will also help to reduce sound transmission between floors.

The task of this report and the ongoing program and design efforts by the museums is to develop strategies that are sympathetic with the structure and spaces existing at the Wharf while reinforcing and propagating the museums' roles in the public sector.

Thus, portions of this report will address the unique problems of artifact conservation as it pertains to the recycling of this particular existing building.







A3.1 COLLECTION USE AND STORAGE CRITERIA

To serve both museums' goals of increasing awareness and use of collections while at the same time conserving and protecting them for future generations, the following criteria have been developed for the use and storage of these materials:

- the value and durability of each object in the collection has or will be evaluated and then classified as to the circumstances under which it can or cannot be used.

- valuable and irreplaceable materials must be reasonably protected (whether on exhibit, used in a program or simply in storage) from damage and loss.

- responsibility for these standards and their application is vested in one person on each staff, although that person will be expected to consult with other experts within or outside each staff.

- reasonable public and staff access to collections storage will be encouraged, but only under the direct supervision of either the person on each staff responsible for collections, or a limited number of other staff to whom he or she has delegated that responsibilty.

- collections storage areas should be organized to limit access to one control point, but also to maximize visibility for the public.

- collections housing within storage areas should be arranged to maximize visibility (through aisle widths, shelf heights, etc.) while minimizing the potential for mechanical damage.

A3.2 SECURITY CRITERIA

The application of security equipment and procedures expressed in this study report are largely based on a concept of maximizing existing equipment and personnel. An initial requirement of the study was to incorporate the existing staffs as participants in both security planning and subsequent implementation. The goals expressed included the need to encourage procedures and equipment uses to evolve from professional site surveys, conference and reviews and to avoid adding new personnel assigned singularly to security responsibilities.

The security strategies will be developed in response to 1) the overall building access requirements; 2) the distinction between major uses; their adjacencies, schedule of operation and type of access; 3) the major museum activities, and 4) the colletion storage areas of the museums. Due to the multiplicity of functions, the final security program must be responsive to specific hazards while maintaining a flexible posture to insure its adaptibility over time.

The entire study, with development of guidelines and goals, will be subjective to the extent it incorporated the experiences of existing staff in existing spaces, and entirely objective in that no alternative will be rejected until thorough evaluation of contributing factors is completed.

The desirability of integrating the security system with the overall building automation system, will be reviewed from the standpoint of initial cost, systems integrity and ease of usage.

A3.3 FIRE PROTECTION/DETECTION CRITERIA

Fire protection will be established through the reduction of risks and hazards by selection of appropriate materials and construction techniques for the renovation of the Wharf Building and the development of suppression and detection systems throughout the building.

The suppression and detection systems shall be designed to reflect the type and level of risk for particular activities and appropriate to the preservation of collection materials, the assurance of life safety and maximum opportunity for automatic response to the threat of danger.

A3.4 ENVIRONMENTAL CRITERIA

A. Air Treatment

The type and level of contaminants in the air play a critical role in artifact conservation. The site occuring in a downtown location and on the waterfront presents a level of air quality that requires treatment prior to its introduction to the building. The offending contaminants include particulate/saline from the harbor, sulfur dioxides from man made sources and objectionable odors from the summer low tidal conditions in the Fort Point Channel area.

Prior to the usage of this air supply, a satisfactory level must be reached with the air handling equipment specified for the project while keeping capital, operational, and maintaining costs to a minimum.

B. Climate and Humidity Control

Within the building, the need for continuous monitoring and control of air quality is essential to maintaining collections objects and providing a comfortable environment for both the public and staff. The climate control system must maintain the proper temperature and humidity range to satisfy the conservation requirements for the various materials artifacts are made of.

This range must be narrow enough to prevent physical or chemical changes within these materials. Any variations must take place over long periods of time so that the objects are able to adjust gradually. The building spaces must also be developed to maintain this optimal range, and for short periods of time insulate these spaces in cases of equipment failure.

C. Smoke Control

Smoke generation, either internal to or external from the building, will damage artifacts, create hazardous exiting conditions for the public and impede the fire department's efforts at isolating and extinguishing the fire.

Incorporated with the building air control system will be equipment to monitor the air supply for smoke from sources outside the building. This equipment should be capable of insulating the building by shutting down the air intake ducts and allowing only the internal recirculating mode to operate until the hazard has been eliminated.

For fire situations within the building, a control system for all spaces not protected with a gas extinguishing system will isolate, as much as possible, the smoke within the affected bay.

D. Energy Conservation

Paramount to the success of any museum is the need to minimize both its initial and operational costs for operating and maintaining its physical facility. The demanding conservational criteria coupled with increasing energy costs dictate a thorough understanding of the system operations and all available means of minimizing energy consumption. Otherwise, the excess cost burden of running the museum will continuously limit the museum's ability to provide exhibits and programs for the community in which it serves.

Selection of the overall building systems and its components must be based upon the initial capital investment and projected operational costs in order to meet these stated conservation criteria.

E. Building Systems Automation and Integration

As the size and complexity of a building and its environmental control systems increases, the monitoring and control operation increases in sophistication. Therefore, the demands placed upon the staff and their capability of running the systems, the development of other systems throughout the building, and the overall economics of sharing common resources will be optimized through the automation and integration of as many systems as possible.

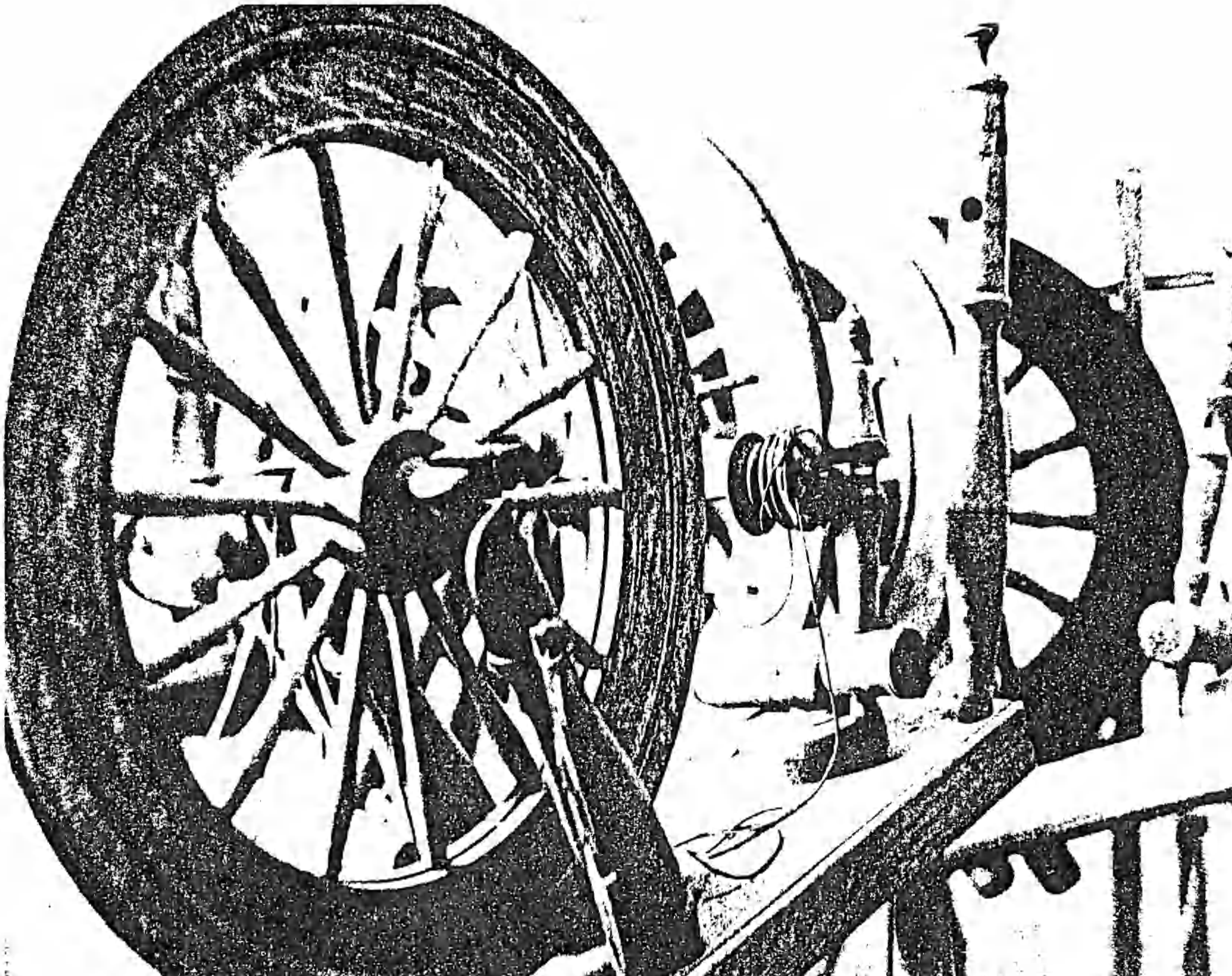
The capabilities of the Children's Museum's present computer will be developed to their fullest extent for automation of the building. The compatibility of the computer with the individual systems will be studied and the computer's flexiblity for expansion and change will be incorporated into the overall planning framework for the building automation. A strategy for adding to the automation equipment over time, criteria for maintaining the integrity of individual systems, and needed systems redundancies will also be developed.

A3.5 ACCLIMATIZATION

Substantial savings in operational costs and conservation efforts can be achieved by requiring the processing of all public visitors and objects or artifacts through various acclimatization spaces prior to their entry to the museums. People introduce to the museums environment most of the dust and lint. Therefore, a program for cleaning visitors will be developed to reduce these pollutants to a minimum.

Collections objects require an initial process of acclimatization upon entering or re-entering the museum which includes cleaning and fumigation. Objects that are within the museum will need periodic maintenance and fumigation. Therefore, a program of procedures for both conditions will be developed with these requirements, special equipment and spatial treatments will be included within the building.

General Planning and Systems Development



B. General Planning and Systems Development

Introduction

Based upon the developed artifact conservation criteria and existing building and artifact information described in the previous section, this section records the study process and the resulting design principles and options investigated for the program development of the Wharf building. The components of the study include program and architectural development, collection storage analysis, fire detection and suppression, building and space security strategies and environmental systems for the mechanical services. In describing the study process, we will only address topics which have a major influence upon the objectives of providing an optimal environment for artifact conservation. Therefore, in some cases alternative options will be developed and summarized with a recommended option; while, in other situations, where there is no apparent series of options, a design principle will be stated. Recommended options and/or principles for the various topics will then be documented in the following section.

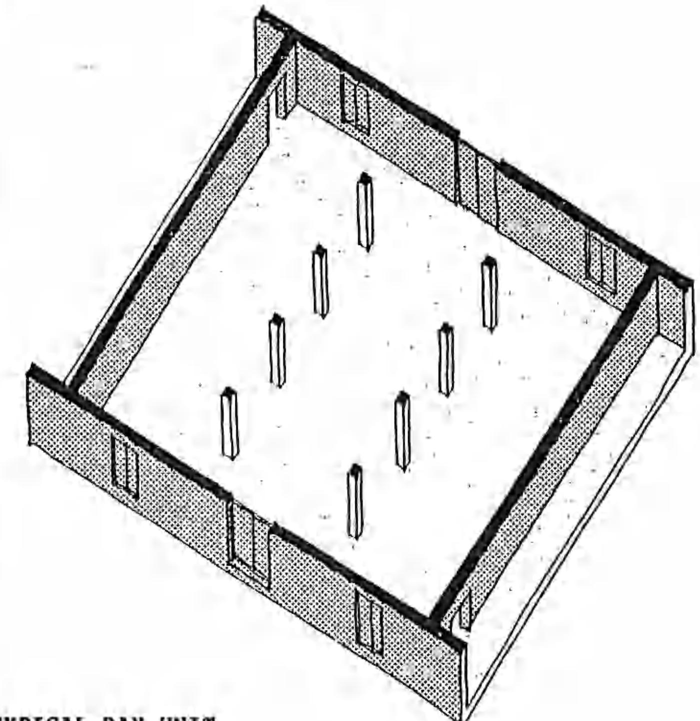
B1.1 SHELL DEVELOPMENT

A. Overall Building and Program Development

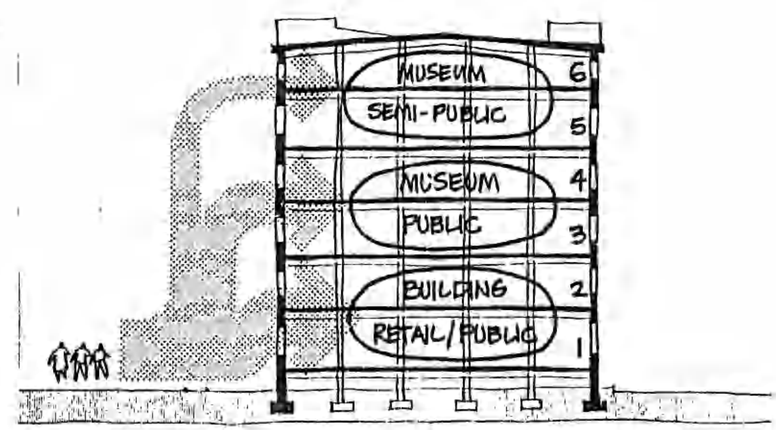
Because of the nature of the building's existing structure (load bearing walls and heavy timber floor construction), the Wharf is naturally zoned into six definable spaces or bays per floor for a total of 36 spaces over its six story height. By using these spaces as discrete planning units and thereby reinforcing their inherent zoning characteristics, program functions can be easily separated when they are incompatible in nature, require different levels of security and access, or have different requirements for air treatment and for fire detection and suppression.

This natural zoning characteristic of the existing building also carries with it liabilities in terms of developing contiguous activities between spaces. For example, visual supervision by a staff member of more than one space or bay at a time is difficult.

The adaptability of these preset building bay areas to the museums' program demands must be carefully planned. In order to achieve full utilization of this high, narrow building, careful understanding and handling of public, staff and service access will be required. Because of this, major activity groupings have been developed horizontally on a floor by floor basis. This allows easy horizontal movement through compatible activityies, while still maintaining a clear separation and effective security on different floors. Therefore, activities requiring greater public exposure with high service demands have been located in the lower floors to minimize the need for mechanical means of vertical circulation. Those activities requiring greater security and less public access are located on upper floors.



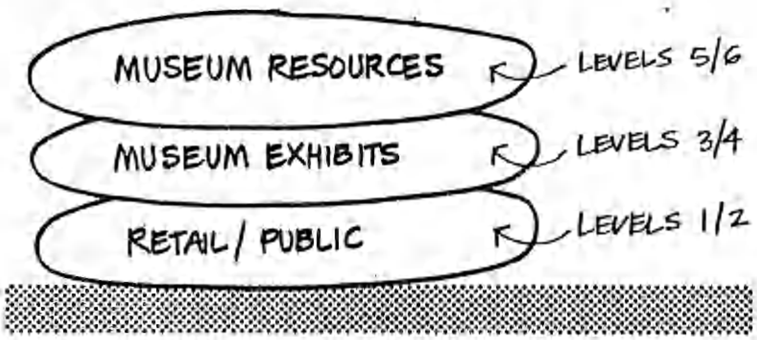
TYPICAL BAY UNIT



PUBLIC ACCESS/ACTIVITY LEVELS

B. General Building Zoning

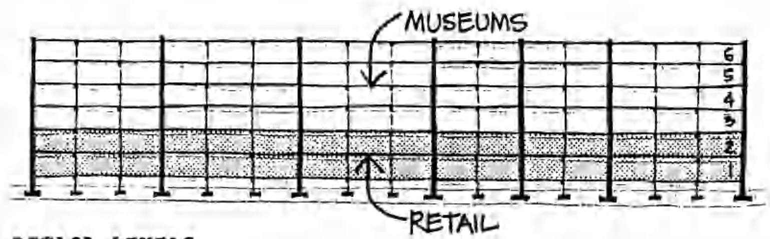
Although the museums may adopt a phased construction strategy, the report assumes the full development of the building to the program criteria established by the museums. The building would be basically separated into three major zones of two floors each. The lower two floors would be used for retail shops and public arcade with the first floor accommodating the service functions for the museums. Public access would be along the apron edge of the building facing the channel and at a central point of the second floor. The intermediate two floors will serve as the primary public exhibit and program areas and lobby spaces for the museums with access to the common orientation space directly from the building lobby at the second floor. The two upper floors will house less heavily trafficed and support functions of the museum. These functions would include the library and Resource Center, classrooms, the collections, administrative offices, staff and work spaces.



BUILDING ZONING

C. Retail Uses in the Building

In conjunction with the operation of the two independent museums within a common building shell, there is a substantial commitment by the museums to develop and lease sufficient commercial space in order to provide complementary public amenities and to partially cover building operating costs. A condition for retail development in the building is that it must be accomplished without compromise of the identities of, ease of access to, or security of the museums' spaces. This has been achieved by defining common building entry points, leading to an interior public arcade, which serves as a circulation and gathering or lobby space common to both museums' lobby and the retail area. By allowing retail activities, the public arcade and lobby to occur at the lower two floor levels within the building, and museum functions on the upper levels, they can function independently but still maintain visual and physical access from one use to the other.

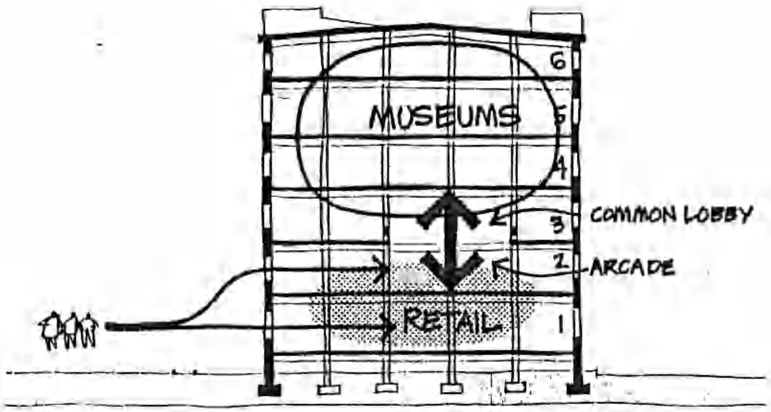


RETAIL LEVELS

D. Public Access and Circulation

The physical organization of both museums within the building also provides a single path of public entry from grade to the exhibit areas. This path passes through a common museum entry point which is basically housed three floors above grade.

This single point museum entry to exhibit spaces is maintained both for its clarity to the public and for museum security during the after hours retail operations. The entry to the exhibit areas of each museum occurs from an orientation area that is separately defined from the general building lobby and retail arcade. This orientation area is adequate for ticket sales, waiting, group preparation for the museum visit, and controlling the entry to each museum.

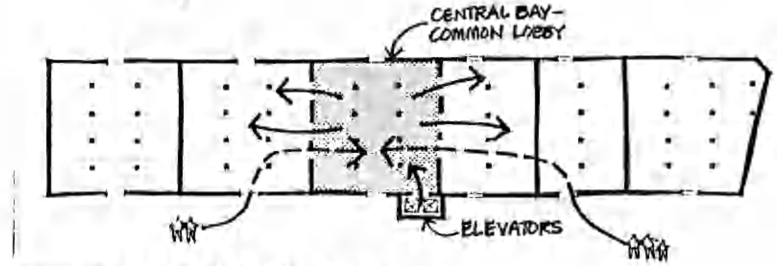


MUSEUM ACCESS/RETAIL CIRCULATION

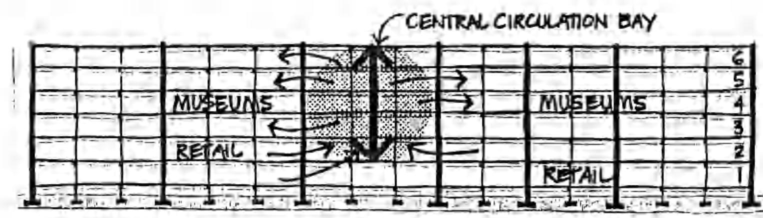
With the requirement of museum uses occurring on the upper four floors, passenger and freight elevator service will need to be provided. To minimize demands upon elevator service, high public uses are developed on the middle two floors which have a stronger direct access from the common lobby space.

The main stairway and elevator service is located within one central vertical bay in order to provide common points of entry to individual floors and thus extend the lobby functions vertically to the less frequented areas of the upper floors. The public use of the elevators for access to non-exhibit areas is controlled by key operation when these areas are closed to the public. In addition, reception and control stations are provided at the elevator and stairways on the upper floors, thus providing staff supervision of public usage of these spaces.

Local stairs will be used for local inter-floor access within public exhibit areas and within semi-public and staff spaces. Emergency stair towers will provide safe exiting from all floors to grade and will allow controlled staff usage for inter-communications between floors. For security purposes public access to these stairs will only permit exiting at grade.



PUBLIC ACCESS/CIRCULATION



CENTRAL CIRCULATION CORE

E. Building Service

Service access to the retail spaces is to be separate from that to the museums to insure adequate control over the museums' servicing operations and to provide ample storage and handling space for shipping and receiving museum materials. The loading and receiving docks will either be contiguous or located in separate areas of the building ground floor.

The passenger and service elevators are to be located to allow for direct delivery of museum materials from the receiving area to a control point within the museum at an upper floor. This will require a secure storage space at the receiving dock and a system of transporting the artifacts from this storage area to the upper floors.

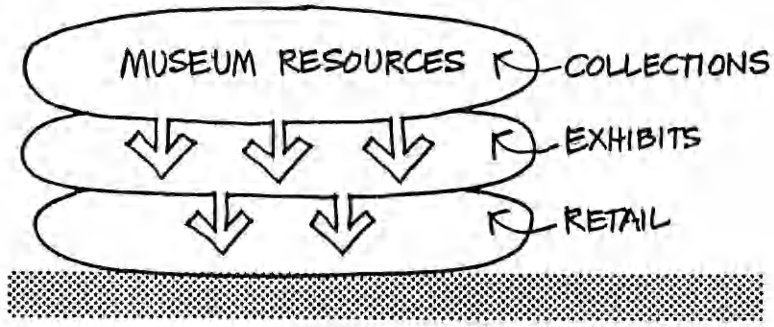
Due to the size and weight of the Museum of Transportation's artifacts and the need for moving exhibit furnishings from floor to floor, an exterior oversized freight elevator is proposed. This elevator would provide service to every floor of the building and thus a safe means of moving large objects. Where required, large openings will be provided through the masonry walls between bays to allow for the horizontal movement of large objects.

F. Expanding Museums' Public Impact Within the Wharf

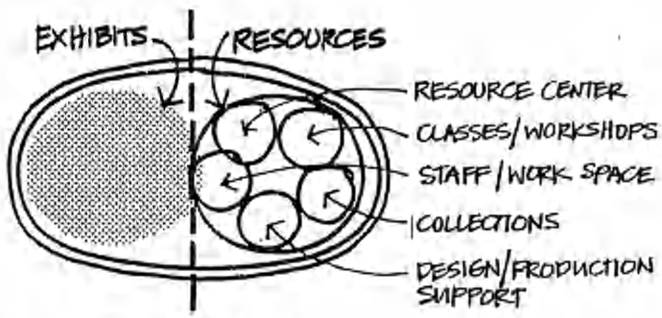
In their present facilities, the museums are unable to expose the public to large portions of their collections due to inadequate space within public areas. Their relocation to the Wharf will, in part, diminish this problem with the increase in the area set aside for exhibits and public use. It is a goal of both museums to increase public awareness and interest in museum programs through exhibits, and correspondingly encourage more in-depth exploration by the public into specific topics through the use of their resource facilities, i.e. artifacts collections.

One method of reinforcing this goal is to increase the awareness of the museums' resources by expanding them to several levels of the building. A primary concern resulting from expanding collections locations is the security of the artifacts from damage and theft. Therefore, the increase in public exposure will be primarily visual; direct access to collections areas will be accorded only to those who have a legitimate need for physical access to the artifacts and are under direct supervision by museum staff.

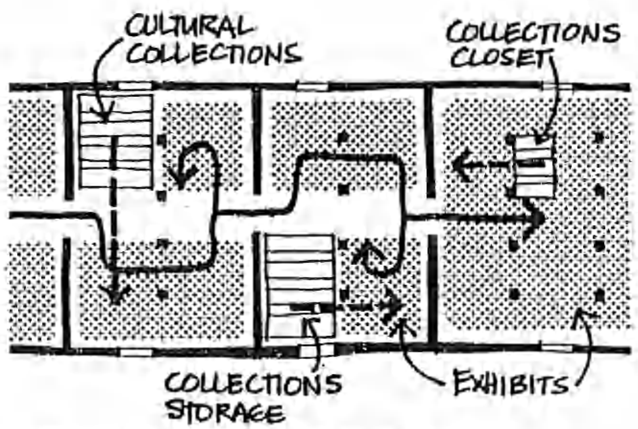
Within the retail areas of the Wharf, the public can be exposed to the museums by planning satellite exhibit components in the retail arcade. Museum exhibit space can be located adjacent to retail uses and/or incorporated into both the retail arcade and the building lobby. Within the museums proper, satellite collections and resource spaces can be developed within different exhibit areas. These areas can be fitted with either permanent collections display units or flexible storage units, depending upon different exhibit needs. However, the primary public interface with the museum's non-exhibit activities will occur at the Resource Center which will function as a general reading room of a library. Here, a broad cross section of the museums' resources, including collections storage, will be available to the public for reference use.



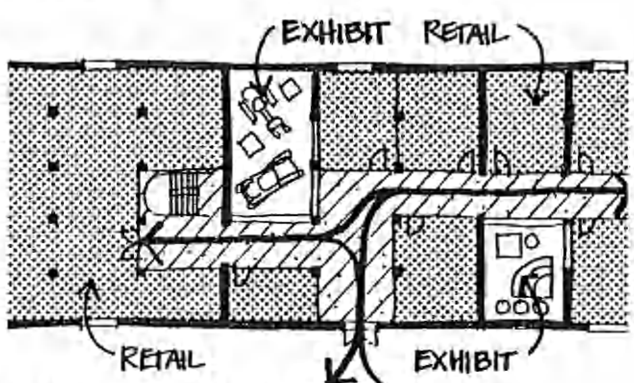
EXPAND AWARENESS OF MUSEUMS' RESOURCES



MUSEUM RESOURCE FACILITIES



SATELLITE COLLECTIONS ON EXHIBIT LEVELS



SATELLITE EXHIBITS ON RETAIL LEVELS

B1.2 DEVELOPMENT OF MUSEUM RESOURCE FACILITIES

The two uppermost floors which house the non-exhibit functions of the museum become the resource facilities for both the exhibit areas of the museums and for in-depth exploration and research of particular subjects by the public, staff and specialists. These facilities consist of the following components:

1. the Resource Center;
2. the workshops and classrooms;
3. the museum and administrative staff;
4. the exhibit design and production shop;
5. the collections and artifact conservation spaces.

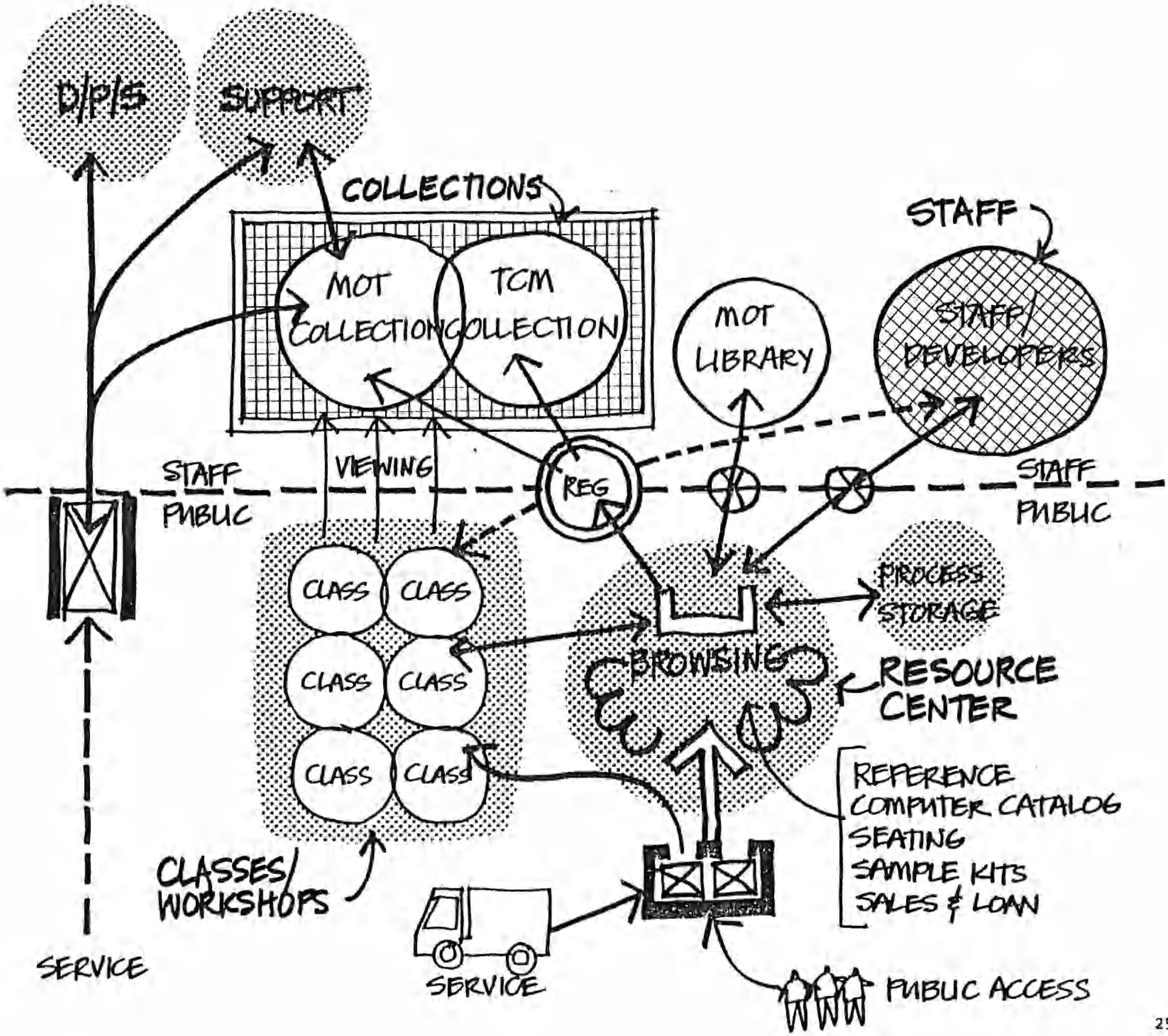
Each needs different levels of security, requires specific functional adjacencies to other resource uses and must accommodate various levels of staff and public access.

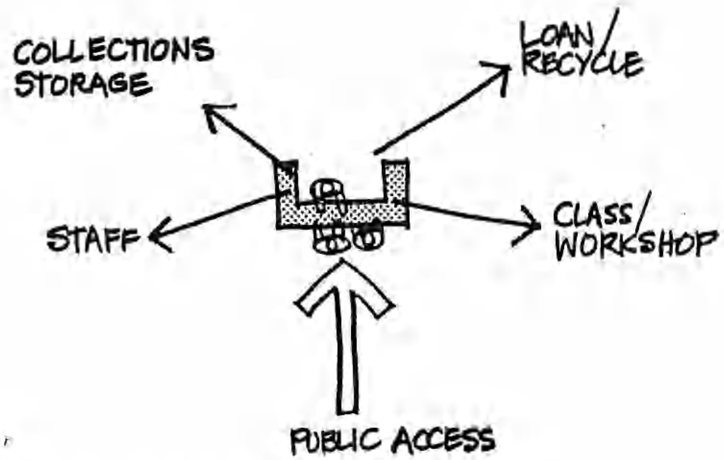
A. The Resource Center

The most public and accessible uses occur in the Resource Center and the museums' workshops and classrooms. The Resource Center provides the control point for access to other less public areas of the museum and supervision of the classroom and workshop activities. The Resource Center also houses materials for general reference and use. These include samples of educational loan kit packages, recycle materials for use as part of educational programs, reference books and slides, a teacher's saleshop and the cataloging index to the museums' artifact collection.

The Resource Center circulation desk provides supervision and assistance for the foregoing activities and the initial screening and reference to appropriate staff members for further in-depth study of the artifacts collection. Whether more than one control point is necessary will be dependent upon the museums staffing capability and the level of service demands placed upon the central circulation desk. A building program development with multiple control points would require additional staffing but also may be capable of better handling future expansion of the museums' resource facilities.

The classrooms and workshops provide for group study and educational programs. Public access and control is provided from the Resource Center. Secure storage facilities will need to be provided within the classrooms/workshops, for collections used in these programs.


D/P/S
SUPPORT
COLLECTIONS
MOT COLLECTION
TCM COLLECTION
MOT LIBRARY
STAFF
STAFF/ DEVELOPERS
VIEWING
REG
STAFF
PUBLIC
STAFF
PUBLIC
CLASS
CLASS
CLASS
CLASS
CLASS
CLASS
PROCESS STORAGE
BROWSING
RESOURCE CENTER
REFERENCE
COMPUTER CATALOG
SEATING
SAMPLE KITS
SALES & LOAN
CLASSES/ WORKSHOPS
SERVICE
SERVICE
PUBLIC ACCESS



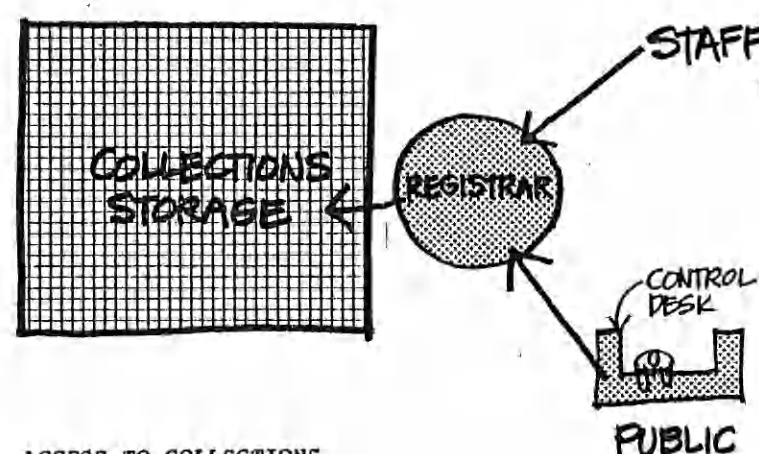
RESOURCE CENTER CONTROL DESK

Artifact Collections

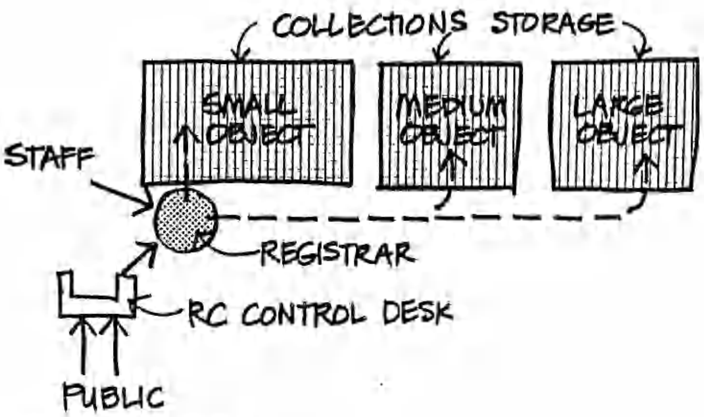
Central to the functioning of the museums are the artifact collection storage areas. Here, artifacts are stored for use as references for on-going research and program development, as a resource for educational programs and museum exhibits. Those artifacts that are not actively being used will be stored in the Collections Storage areas. Collections storage will not be physically contiguous but will function from one common access point: the Registrar's Office.

The Registrar's Office area will function as this control point for access to Collections Storage, process returned or new artifacts that are entering storage and monitor the status of each artifact. All access to Collections Storage will be recorded at the Registrar's Office. People wanting access to collections will be referred from the Resource Center to the Registrar where they will be screened to determine the appropriateness of the request, the level of staff supervision required and the type of access that should be granted. Also, staff members with authorization to use the collections will be required to check in with the Registrar for access to the collections.

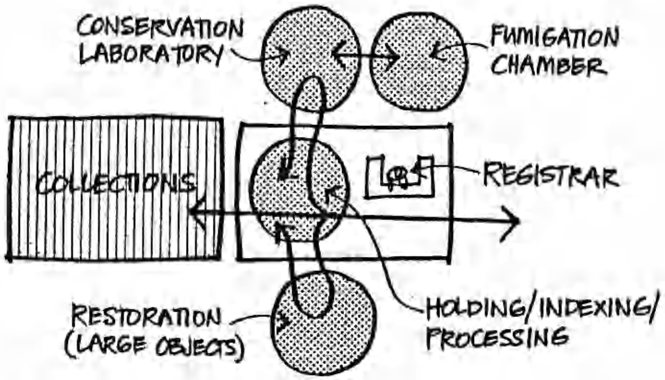
In addition to access control, the supervision of object conservation will be a responsibility of the Registrar. Storage areas will be monitored for general environmental quality. As new or returned artifacts enter Collections Storage, the Registrar will inspect for damage and either fumigate the artifact and return it to storage or refer the object for conservation work. Some conservatin work will be performed in-house in an adjacent conservation lab. Large collection items (i.e. autos, doll houses, etc.), will be processed in a separate restoration shop. If conservation or restoration of the artifact is beyond the capability of the conservation staff, the conservation space would be used as either a holding space until the artifact can be shipped to a specialist or as a work space for a visiting specialist.



ACCESS TO COLLECTIONS



COMMON CONTROL POINT

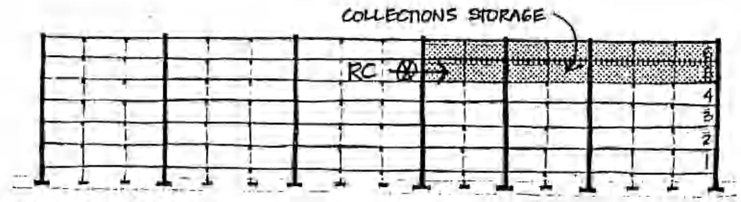


COLLECTIONS SUPPORT FUNCTIONS

B. Optional Collection Arrangements

Two general building development options studied for Collections Storage space were 1) a horizontal plan arrangement; and 2) a vertical stacked plan arrangement.

The horizontal option would locate the Collections Storage in a horizontal block utilizing one or two floors of the building, probably within portions or all of the three bays south of the central core on floors five and six.

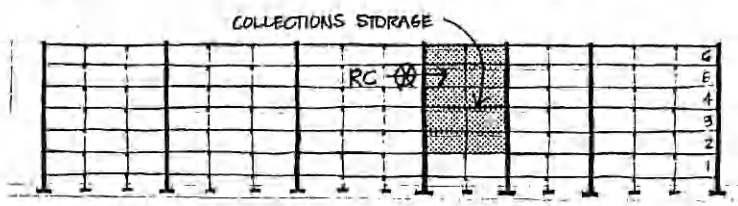


HORIZONTAL SCHEME

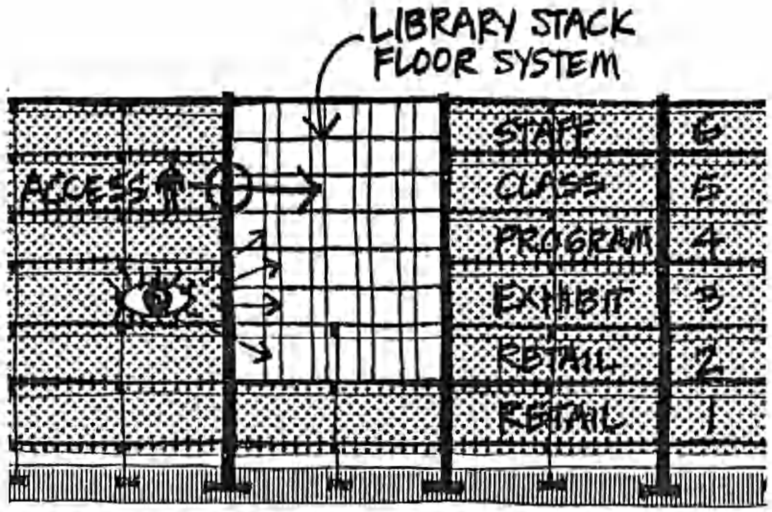
By using the existing building floors, the collections space development cost will be less than that required by providing new floors under the vertical solution. However, the density of artifacts may be less efficient since storage would be prohibited in the space between about eight feet (five-foot high stacks plus over-stack storage) and the existing sturcture of the floor above.

In contrast, the vertical option would occupy space vertically in one or two of the existing building bays by removal of the existing floors in order to provide three collections levels for every two existing building floors, thus possibly increasing the storage capacity within a particular volume.

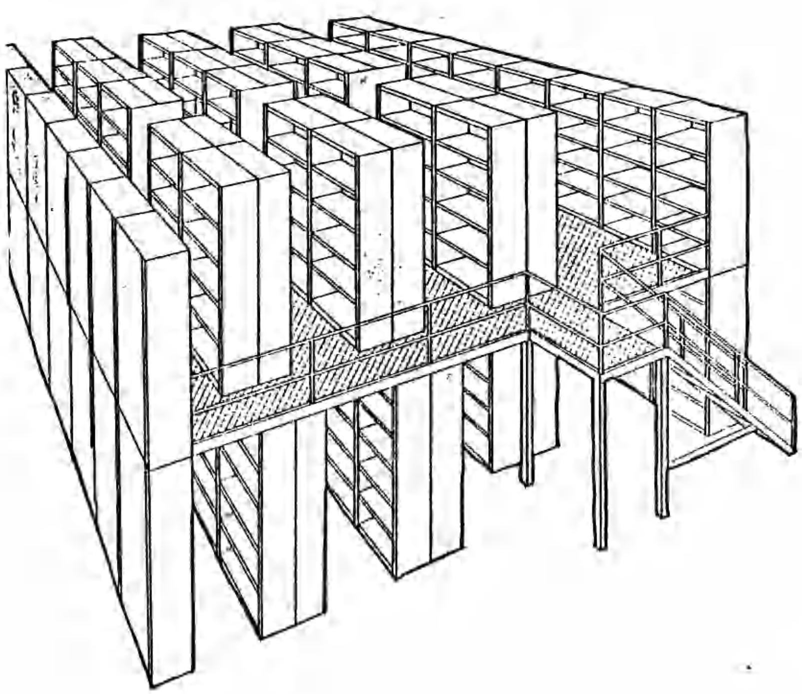
In this case, the floor levels in the Collections Storage would be independent of the building floors.



VERTICAL SCHEME



DETAIL OF VERTICAL SCHEME



The basic advantage of the vertical scheme is that it could project into lower exhibit and program areas within the building, thus providing the visitor visual access to the collections. The horizontal system, on the other hand, would be located on only non-exhibit floors.

The vertical system probably would require a higher initial building construction cost because of major structural changes. Also, considerable storage volume appears to be lost in vertical circulation among the stack levels.

The analysis of other differences between these two schemes reveals the following advantages of each as well as certain special features required by each scheme.

1. Internal Vertical Circulation for People and Artifacts

Stairs only: Circulation by stairs interior to Collections Storage would require carrying artifacts between levels, for either scheme. It was found that a horizontal scheme, exclusively occupying one level, caused severe compromises to other adjacent museum functions.

2. Large Elevators: A large elevator for staff and artifacts could be used in the horizontal scheme by providing a second access control point separate from the registrar. Because floor levels in the vertical scheme don't match that of the existing building, use of the elevator would be prohibited for artifact movement.

3. Dumbwaiter Elevator: Trays and/or carts could be transported vertically on a dumbwaiter, while staff circulation carts would be limited to stairways. This would mean that all small artifacts housed in the Collections Storage within either scheme could be serviced by a dumbwaiter, internal to collections space; and that larger objects must be limited to levels corresponding to existing building floors. The latter results in access problems and loss of flexibility for the vertical scheme.

4. <u>Dust Protection:</u> The collections being stored in a library stack arrangement of the vertical scheme may require special floor sealing to prevent dust generated by foot traffic on upper levels. In the horizontal scheme, a suspended ceiling would be installed to prevent dust accumulation from upper and lower floors.

5. <u>Fire And Environmental Protection:</u> Special layouts for fire and environmental protection systems would be required for the vertical scheme in contrast to the horizontal scheme which would use that similar to other building bays.

C. Collections Storage

Under the general function of the Collections Storage, objects will be housed in a variety of ways. The alternate means of artifact storage is dependent upon their physical characteristics, required level of environmental and security protection, and the type and frequency of access to the objects. The following subsection outlines the physical conservation criteria developed to date for storage and handling of various objects and its resulting impact upon the museums' program and building development.

B2. HOUSING OF COLLECTIONS

The design and/or selection of alternative housing systems will derive from collections-related museum operational, philosophical, and conservation goals; from economic considerations; and from the characteristics of the collections.

In some cases "off-the-shelf" catalog items may be appropriate housing solutions. In other cases, special design solutions which may incorporate "off-the-shelf" items will be required.

For purposes of this study, "collection housing" shall mean; the specific housing units (cabinets, shelves, trays, etc.) which support and contain the artifacts and "collections space" shall mean; the space, or "envelope", in which the specific housing units occur.

B2.1 IMPACT OF COLLECTION CHARACTERISTICS ON THEIR HOUSING

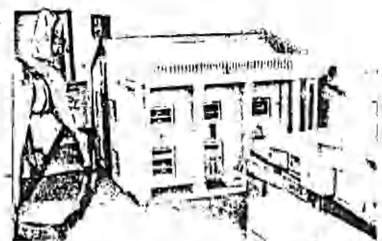
The characteristics of the museum collections will dictate the selection and design of housing systems. The physical characteristics of the artifacts (dimensions, weight, shape, texture, materials, etc.) will most significantly impact the storage unit design. The distribution by physical characteristic and quantity will significantly affect the housing layout and floor area required.

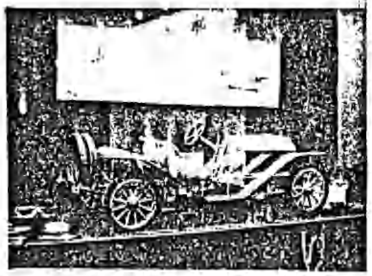
The overall dimensions of the artifacts and distribution by size are initial factors in determining a particular housing system. Artifacts from both TCM and MOT group themselves into four categories sharing common dimensional characteristics:

- small objects (1CF max.)
- medium objects (1-27CF)
- large objects (over 27CF)
- special objects (items with unusual shape or characteristics)

These artifact characteristics and dimensional categories were derived from general observation of the whole collections and from general museum collection descriptions (a description of the museum collections occurs in Section A). Therefore, the dimensional categories are approximate.

The majority of artifacts within TCM collections fit into the small and medium categories. The majority of objects in the MOT collections fit into the medium and large categories. In viewing both collections as a whole, the small object category is the largest grouping and is, therefore, the object grouping determining their major housing system.





A. Small Objects

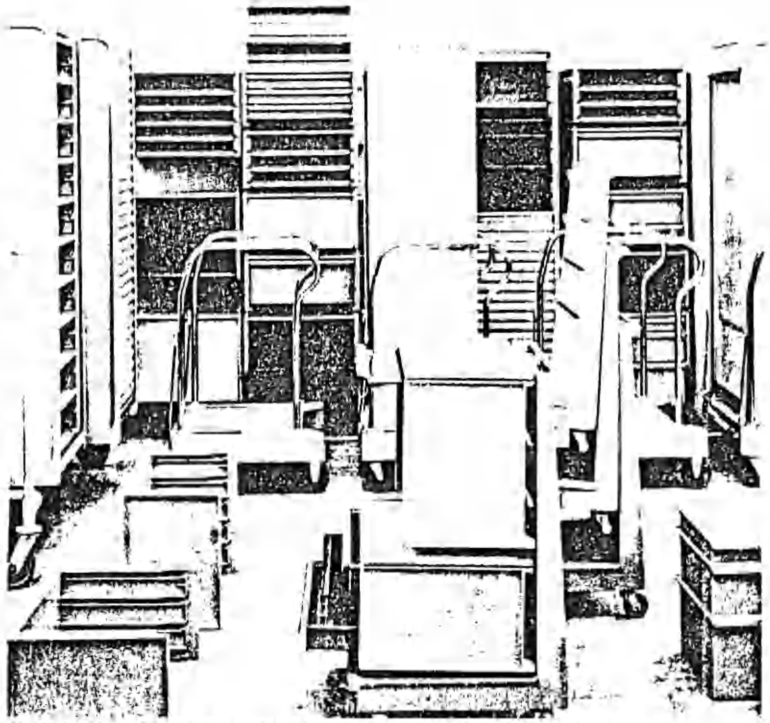
A system for housing small artifacts will include a modular framework into which will fit components to accommodate various housing conditions.

A few such total systems are currently on the market; they have been reviewed during the course of this study. However, they have the following limitations:

1. Inability to accommodate the specific needs of TCM/MOT collections (for example, most catalog systems are designed for hospital or office usage).

2. High initial purchase cost and potential increased cost for future needs (which may not directly reflect cost of materials and manufacture).

3. Potential inability to modify or replace system parts in the future as storage needs grow and change.



CATALOG MODULAR HOUSING SYSTEM (HERMAN MILLER)

4. Many possess a strong design statement which visually competes with collections objects.

A specifically designed system on the other hand has the potential for meeting all needs of TCM/MOT collections, as well as other related museum goals. Such a system will assemble standard available manufactured items and materials and/or may require some specially manufactured elements; however, the control of this process can be by the museums initially and in the future.

The present collection storage system employed by TCM is an example of a specially designed system for particular storage conditions. It consists of an ABS plastic tray (about 20" x 30" x 3"), and a modular framework of unistrut columns and texture 1.11 (grooved) plywood panels. The trays slide on stapled wood guides that are applied to the grooved plywood panels.

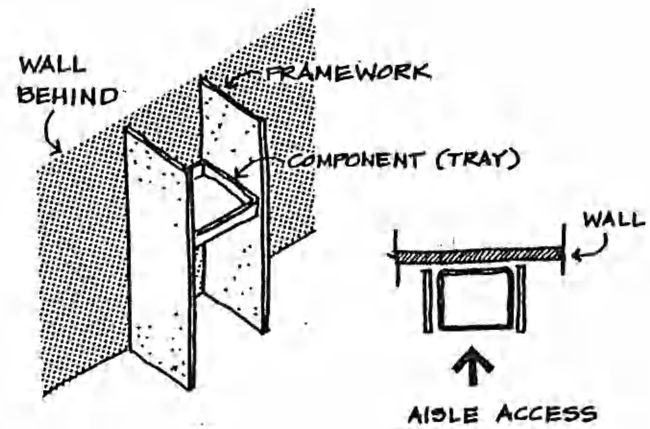
Modular Storage Framework

The "module" dimensions will result from the small artifact category dimensions, given as 1CF in volume maximum. Study of the small artifacts also indicates that generally they are compact in nature. Thus, they will probably fit into an area of approximately 18" x 36" (compact), rather than the extreme of say 6" x 48" (long). This dimension will be "pushed and pulled" by component requirements. For example, the distance spanned by the component may have to be minimized. Also, the "module" can be arranged as a single-face unit or back-to-back as a double-face unit.

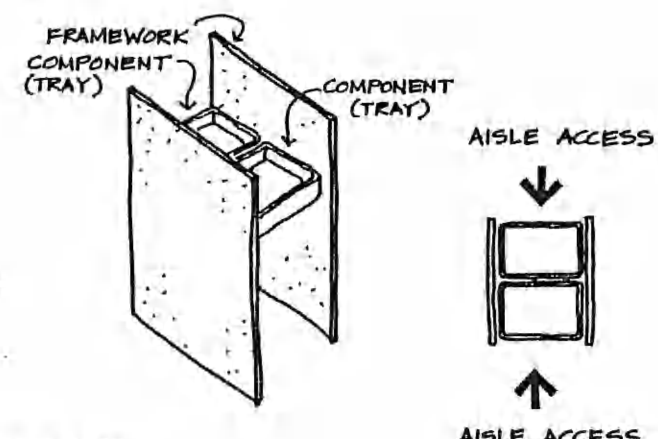
The modular framework for the small artifact housing system can be of three basic types: 1) a panel system; 2) an open framework system; 3) a cantilever system. Each of these framework systems support the components which actually hold or contain the artifacts.

- The Panel System would consist of solid side panels defining the system "module" or "stack". The panels would be grooved and/or receive hardware to support the components.
- The Open Framework System would consists of an open structural grid defining the system module. Channels and other hardware applied to the grid would support the components.
- The Cantilever System would consists of back panels or framework from which brackets would project and support the components.

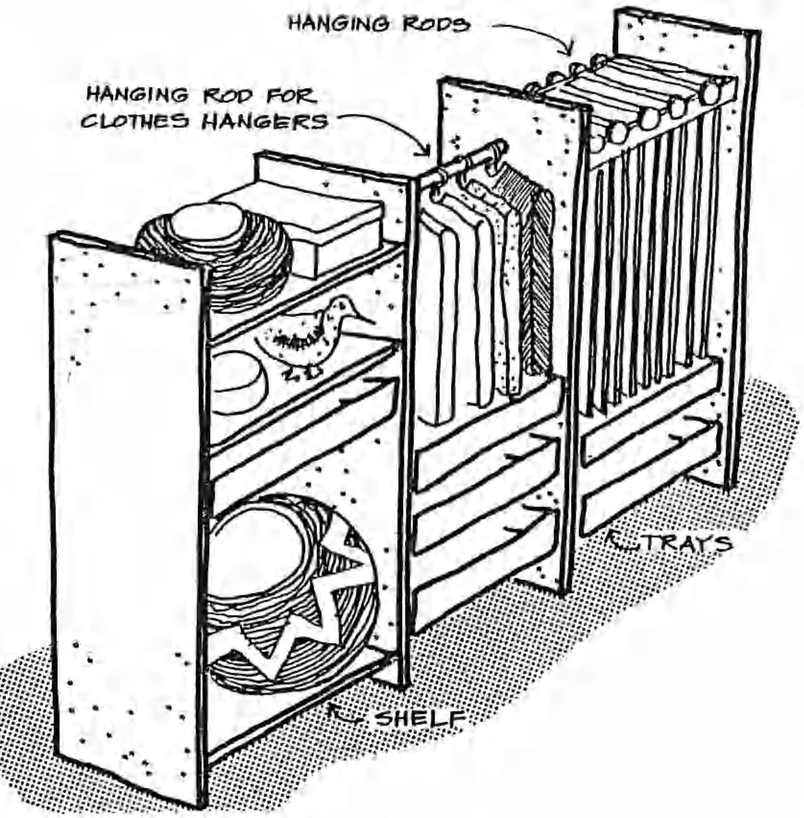
PANEL OPEN CANTILEVER



SINGLE-FACE



DOUBLE-FACE



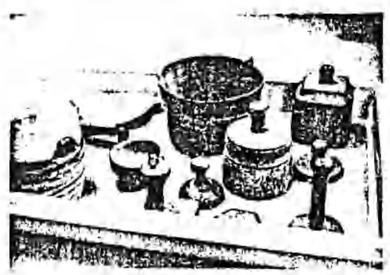
MODULAR SYSTEM WITH HOUSING COMPONENTS

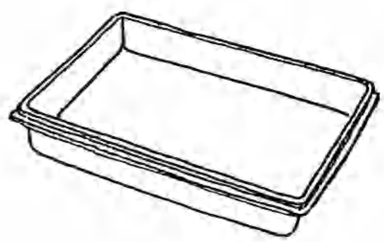
Various materials were studied for the panels and structural frame elements as to their ease of fabrication and installation. Each material was also evaluated from the standpoint of potential as a fire hazard, durability in terms of usage, and flexibility in terms of moving and cost.

A variety of housing components have been studied to accommodate the differing objects within the modular framework system. The characteristics of the artifacts will determine which components are used. From a basic analysis of artifact characteristics, four component types are suggested: A) tray; B) shelf; C) hanging rod with hanger; and D) hanging rods. Additional study of the collections may result in other components to be added to the system in the final design process.

1. Trays

Generally, items which lay flat (as opposed to those which rest on a small base or stand vertically upright) are appropriate for housing in a tray. Since the major proportion of the museums' collections will fit into this description, the major component of the module system will be the tray. Trays also have an additional use as containers which can be pulled out of the system and used to carry the artifacts.





The following performance criteria have been developed for the design and/or selection of a tray:

a. <u>Ability to fit into Framework System:</u> Trays must have "lip" edges or grooves in order to be self-supported on runners or channels on the modular framework. Trays must span the module dimension and support heavy artifacts.

b. <u>Weight:</u> Trays should be lightweight for easy handling and carrying.

c. <u>Fabrication Variation:</u> The tray material and fabrication should allow flexibility in dimensions and details, allowing special inserts, covers, or details.

d. <u>Durability:</u> The tray should be durable, resisting deterioration under normal use and from the fumigates used. It should also maintain dimensional stability.

e. <u>Ability to Protect Artifacts:</u> The tray should protect the contents from damage.

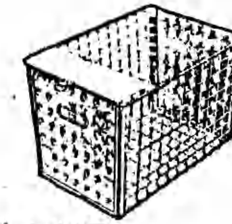
f. <u>Maintenance:</u> The tray should be cleanable and restorable over time.

Many options for trays and containers are currently available on the market. Manufacturers specializing in trays and containers will also modify their products for some increase in purchase price. In general, tray types vary by material, dictating the tray's overall characteristics and performance. Review of manufacturer's literature has revealed the following tray types: 1) metal wire; 2) solid metal; 3) wood; 4) cardboard; 5) fiberglass; 6) molded plastic; 7) baskets; and 8) glass.

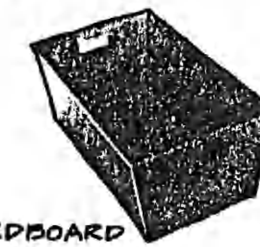
Basket and glass trays can be initially rejected for inability to fit into the modular system. The remaining types are compared in the following chart.

Of the foregoing materials, plastic was considered the most appropriate material for the tray unit. In addition further analysis of different artifacts within each museum indicated that two different tray depths (one of approximately 3" and the the other of 6") may more easily accommodate the range of small objects stored.

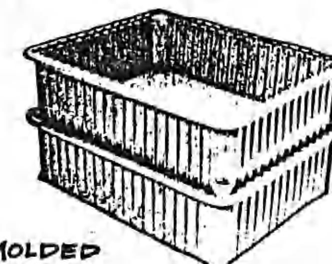
TRAY OPTIONS



METAL WIRE

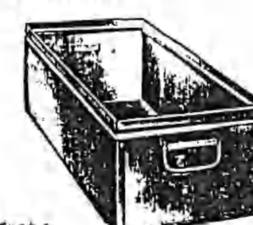


CARDBOARD



MOLDED PLASTIC

FIBERGLASS



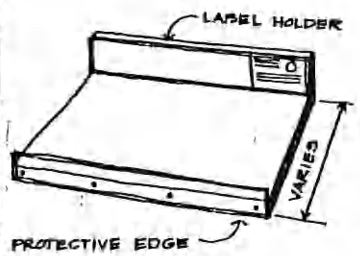
METAL

CHARACTERISTICS OF AVAILABLE TRAY MATERIALS

CHARACTERISTICS	WOOD	METAL	CARDBOARD	PLASTIC
IMPACT	not resistant to impact (box breaks apart)	will not break apart, but dents	not resistant - will not protect contents	will not protect as well as metal but "bounces back," good "cushioning"
MAINTENANCE	not easily maintained	paint scratches	throw away	easily washable
FABRICATION	reasonably "workable" can be made in sizes, routed for slots, etc.	limited in form & variations (large sizes become too heavy)	limited in form & variations (large sizes cannot support weight)	unlimited - can be formed in many shapes (integral)
COST	expensive/ unit pricing	expensive unit price	inexpensive	initial mold expensive/ lower unit price as quantity increases
DURABILITY	long-lasting with proper maintenance	long-lasting	deteriorates with wear	long-lasting (care must be taken to select correct plastics)
FIRE HAZARD	can be treated to be fire resistant	fire resistant	fire contributing	self-extinguishing plastics available
STABILITY	swells/contracts ith water & humidity	impervious to water (except over very long time - rust)	deteriorates with water	impervious to water, high thermal "creep" and weight deformation
VERMIN	can be affected	impervious	affected	material itself not affected, but insects ill go through
TRANSLUCENCY	opaque only	opaque only	opaque only	can be translucent/ transparent
FUMIGATION GASES	glues may be affected	not affected	not affected	some plastics are affected

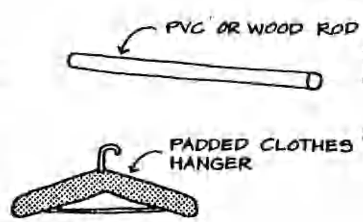
2. Shelves

Shelves are appropriate for storage of vertical items which should stand upright. If housed in a tray, these items would topple over when the tray was pulled out; use of a shelf will encourage lifting of the individual item, which in many cases is to be preferred. Pre-cut dividers set in grooves or mounted on spring held rods could be used to subdivide shelves for artifacts when necessary. Where more protection from wear is required, the individual artifact could be covered with a plexi-glass cover, and for larger areas could be protected by a pull down vinyl sheet.



3. Hanging Rod for Clothes Hanger

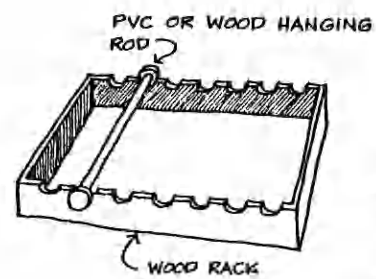
For artifacts which are most appropriately housed on a hanger, a clothes rod can be inserted into the module frame system.



4. Hanging Rods

For artifacts which are most appropriately hung in "towel" fashion, hanging rods can be inserted into the system.

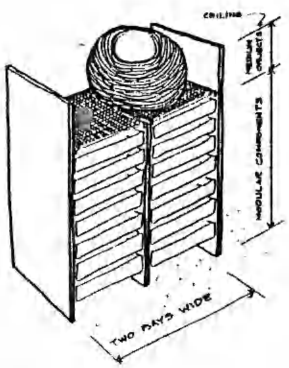
For both components 'C' and 'D', the rods can be incorporated in pull-out draw type frames.



B. Medium Objects

Medium objects, or those artifacts which are approximately sized 1-27Cf, require larger storage space than that provided by components of the modular system. Generally, because of their increased size, many of the objects tend to be heavier and less manageable and, therefore, are housed better at a level lower to the floor. However, when ample numbers of a particular type of medium objects occur they could be housed within the modular framework system.

Four housing options are proposed: 1) storage above the module system; 2) cubicles; 3) open shelves; and 4) rolling tub containers.



STORAGE ABOVE MODULAR SYSTEM

1. Storage above the Modular System

Objects which are lightweight and easily hand-manageable could be stored above the modular framework in a space equaling two modules in width. These artifacts must be of materials and construction to withstand the impact of a fall in case of mishandling, or must be placed in protected containers. Baskets, certain toys, children's furniture and plastics could be housed in such a way above the storage module system.

2. Cubicles

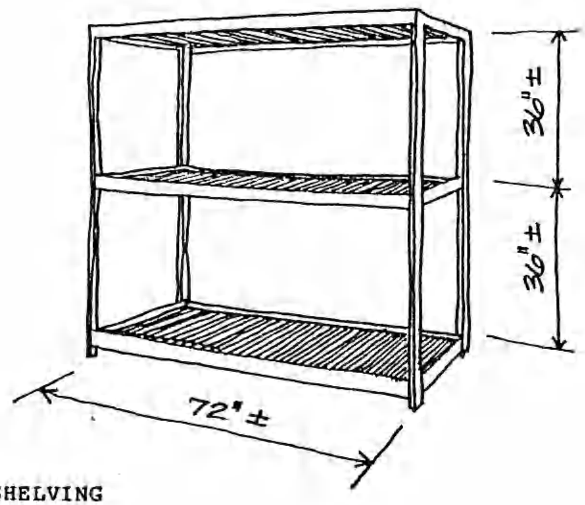
Cubicles, or spaces for individual objects, could be provided under counters, in units against walls or free-standing. Cubicle construction could be standard metal, or wood cabinet systems. These cubicles may be open or have doors depending upon security or other protection requirements. If visual access is required, the doors should be glass or acrylic.

3. Open Shelves

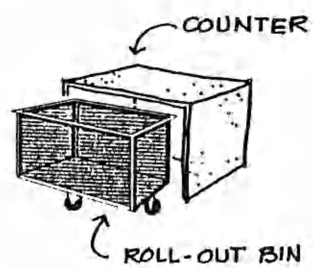
Open shelves can also be used to provide housing for medium-sized objects with the same provisions as stated for the small artifacts.

4. Rolling Tub Containers

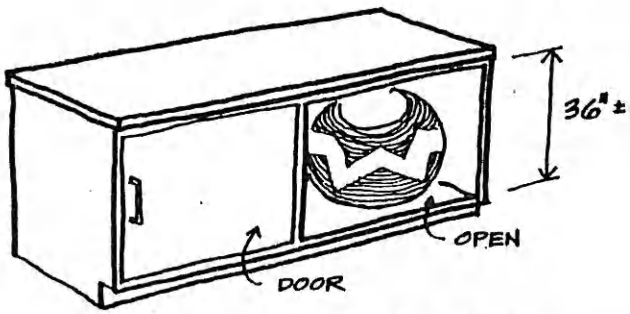
Containers with sub-divided storage compartment on casters could be provided below shelving and counters within storage spaces. They allow for easy access to artifacts stored in a vertical position.



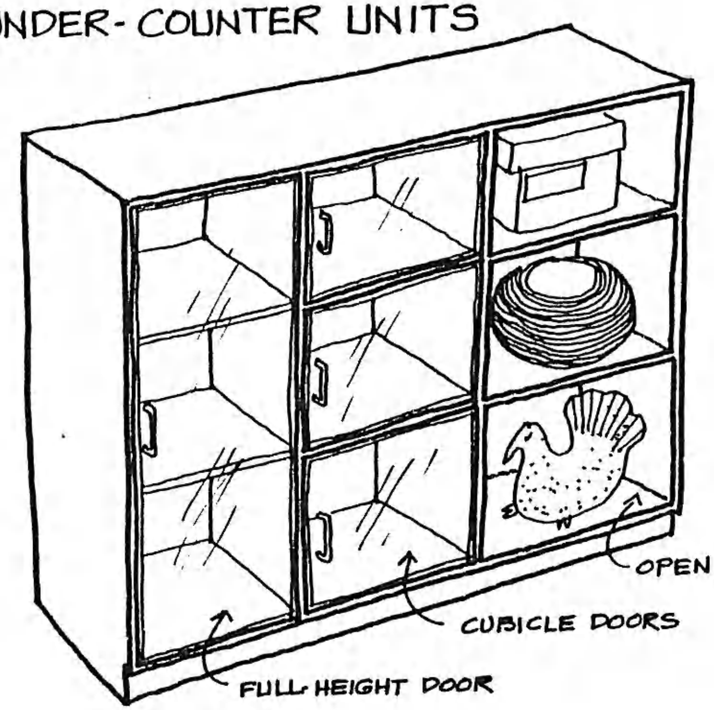
OPEN SHELVING



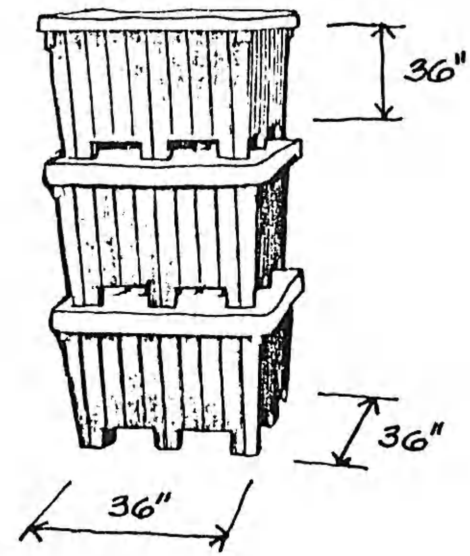
ROLLING TUB CONTAINER



UNDER-COUNTER UNITS



WALL UNITS

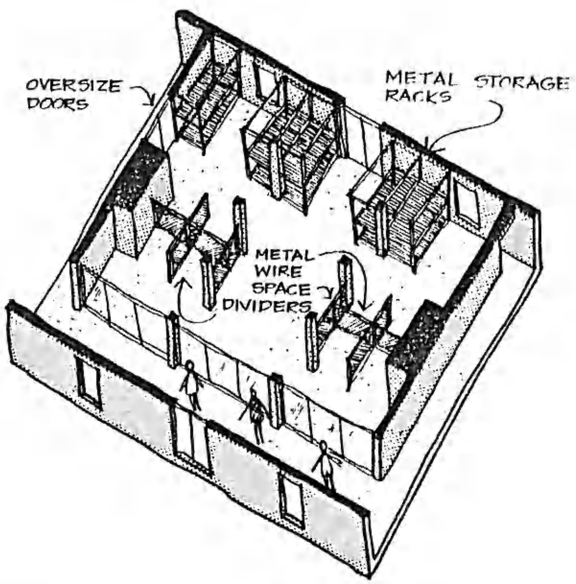


STACKING CUBICLES

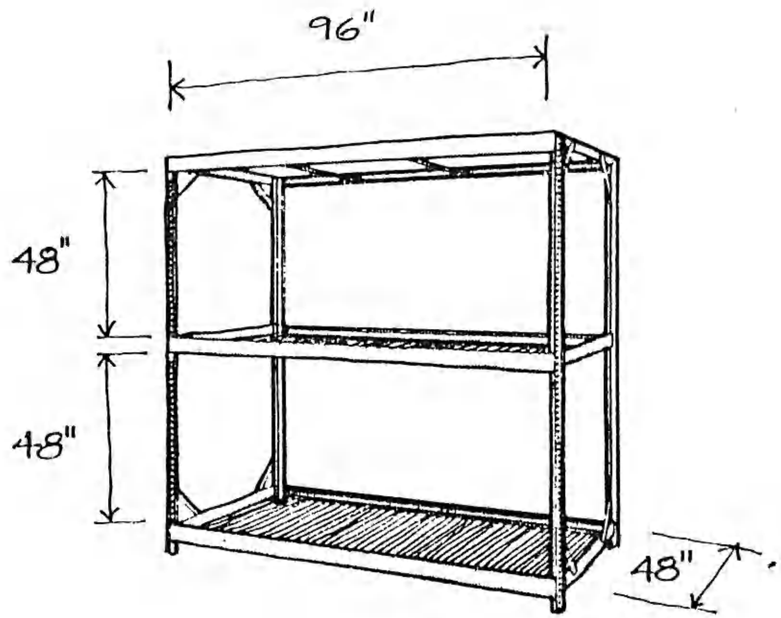
C. Large Objects

Large bulk artifacts, objects over 27CF in volume, are large enough that they can be housed appropriately in a space without necessarily requiring a specific "place". The space itself acts as the housing unit.

A very large storage space may require some definition of storage zones which could be accomplished by partitioning or other space dividers. In the case of vehicles, this zone definition could be accomplished with painted lines.



LARGE OBJECT HOUSING



METAL STORAGE RACK

D. Special Objects

Special objects are those which require unique housing solutions because their physical characteristics are not common to the major proportion of the collection. For example:

- Unframed posters, maps, photographs, documents, etc.
- Framed posters, maps, photographs, paintings, documents
- Spears and other long, narrow artifacts
- Rugs, tapestries, mats, etc.
- Books
- Photographic slides
- Signs
- Unusually shaped artifacts

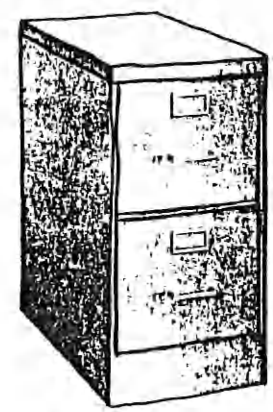
Special housing units selected for the above-listed special objects will be required, and they may be incorporated into collection housing spaces where needed. The following are examples of special housing units identified during this study; additional units may be incorporated during the Final Design Phase:

1. Flat File Units - Large, thin, flat objects (such as unframed posters, maps, documents) may be housed in flat file drawer units. These units are available from catalogs in wood or steel, or can be custom-fabricated.

2. Vertical File Units - Shelving, other than that provided in the modular system, can be used for bound papers, periodicals, and/or books (such as the MOT library). Standard library shelving is available from catalogs in steel or wood, or can be custom-fabricated.

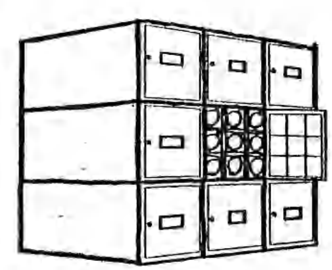
3. Tube Storage Units - Rolled artifacts (such as maps, drawings, tapestries) may be stored in racks, positioned horizontally (resting on their sides) or vertically (resting on end). Open or closed racks are available from catalogs in wood, steel, or fibreboard, or can be custom-fabricated. Individual tube containers are available in cardboard and/or clear acrylic.

FLAT FILE



VERTICAL FILE

OPEN SHELVES



ROLLED HOUSING

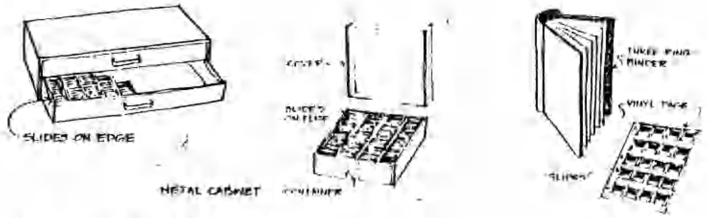
4. Photographic Slide Storage Units - A number of options for storage of photgraphic slides exists. Many types of metal container boxes for slides and metal cabinets with slide drawers are available from catalogs. Vertical slide racks consisting of transparent and partitioned leaves permit slides to be viewed on a light table without removing the slides. Slides can also be inserted in vinyl see-through pages and bound in notebooks for shelf storage.

5. Vertical Panel Units - Large, flat artifacts (such as framed paintings, photographs, metal signs) could be fastened to vertical panels. Panel materials of a metal grid which accepts tie-downs and hooks and/or board (plywood, for example) which accepts screw-in fasteners could be used. Panels could be mounted on hinged swing-arms, or on sliding tracks. Dividers or stops would be required with the swing-arm configuration for artifact protection.

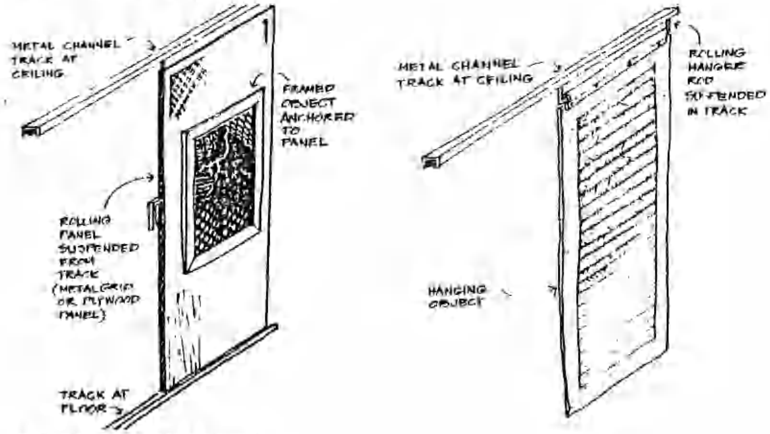
6. Vertical Hanging Units - Large, flat artifacts (such as tapestries, rugs) could be hung from metal rods and/or clips. The rods or clips would be mounted on metal swing-arms and/or sliding tracks similar to the vertical panel units described above. In addition, items such as metal signs could be hung from hooks in the ceiling above vehicle storage where floor to ceiling space permits.

7. Custom Storage Units - Long, narrow artifacts (such as arrows, spears, etc.) could be housed on end in racks. Protection for individual artifacts could be provided by containerizing each artifact in clear acrylic tubing.

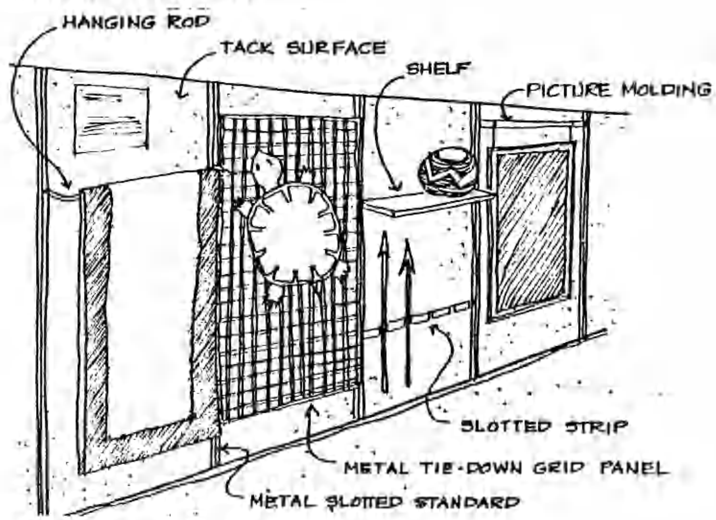
8. Special Wall System - In general, the above-listed storage units will probably be used at walls rather than free-standing in space (except for open shelving), for these units generally tend to be deep in dimension. Where the collection space cannot accommodate them individually, an alternative wall-mounted system which combines these units flat to the wall could be used. This wall system is more a display device and is well suited for study/storage uses. Such a storage system accommodates many special housing conditions but is less efficient than any of the individual systems described above. It would consist of slotted metal strips occurring on a standard horizontal dimension; the metal strips would accept removable, interchangeable components (such as hanging rods, hook strips, slip strips, shelves, picture mouldings, and grid panels for tie downs) which would either project from the wall or span between the metal strips. Tack surface panels would be inserted flush between the metal strips.



SLIDE HOUSING UNITS



VERTICAL PANEL UNIT



SPECIAL WALL SYSTEM

B2.2 IMPACT OF CONSERVATION CRITERIA ON COLLECTIONS HOUSING

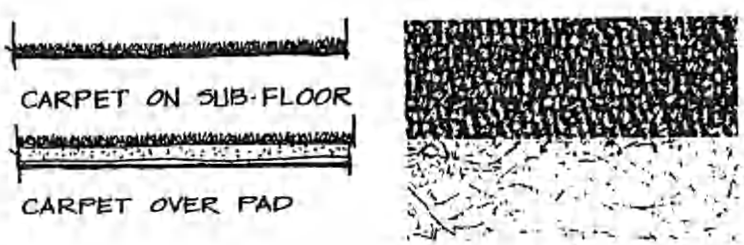
Conservation criteria will significantly affect the housing of collections. Unlike object characteristics (section B2.1) which primarily affected the housing units, conservation criteria will significantly influence both the housing units and the housing space. Elements in both the housing units and housing space can be designed to protect the artifacts from people-related damage such as theft (security), breakage and general wear from handling; and from other damage such as fire and related effects, environmental conditions (humidity, temperature, air content), and vermin.

A. Housing Space

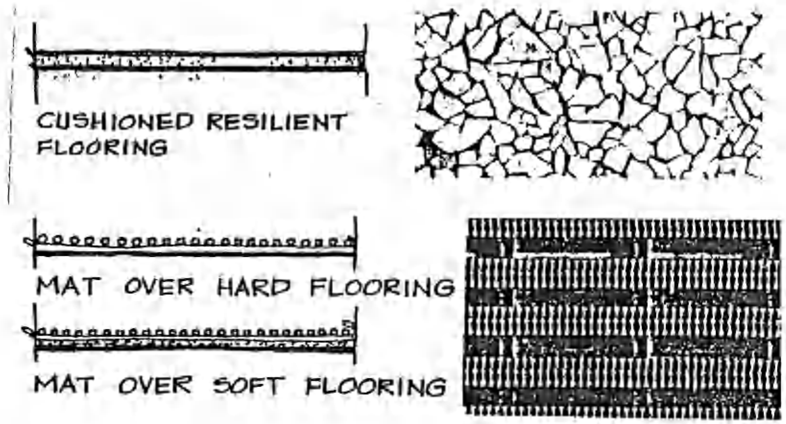
A basic decision was reached by the Museums to treat security, fire and related effects, and environmental conditions by treating the housing space, thus providing a general protected environment in which to place the housing units. (The specific elements of the security systems, fire-protection systems, and environmental systems are discussed in Sections B4 through B7).

In addition, finish materials in the housing space and plan arrangement of elements within the space can be used to protect the collections from breakage, dust and vermin. Criteria for dealing with these potential hazards to collections are discussed below.

1. Dust: In collections spaces dust should be minimized; finish materials used in the spaces can be used to minimize dust. Wall surface treatments should "seal" existing surfaces and/or should provide new surfaces such that no dust is generated by deterioration of the surface itself. Floor treatment will also affect settled dust. A soft, textured surface will "Catch" the dust and reduce movement caused by foot traffic.



2. Breakage: Breakage can be lessened by providing a soft floor material to cushion objects if dropped and by providing workable plan arrangements of storage elements within the space.



a. Floor Materials: Floor materials should be durable, cleanable, and should not generate "fuzz" or lint. Additionally, they should not absorb dirt, fluids, odors or attract and house vermin. Several types of soft floor materials will meet this criteria:

Carpet: Generally, synthetic carpets of continuous filament nylon material or needlepunch carpets (indoor/outdoor) will meet the above criteria. Cushion materials are more limited. Hair and foam type cushions would be unacceptable. However, a cushion material composed of polyester pneumatic cellular fiber (DuPont "pneumacel" or equal) will meet the criteria.

Cushioned Resilient Flooring: Sheet vinyl is available with cushion backing. This material will provide a smooth, easily cleanable, impenetrable surface.

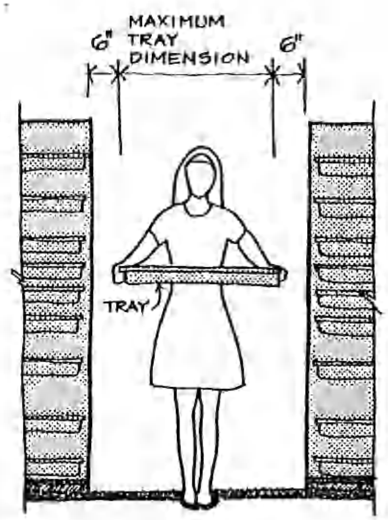
Protective Mats used over Finish Floors: Protective mats can be applied over the above-listed soft flooring or over hard flooring. This type of material is not permanently installed but set in place.

b. Plan Arrangement: A workable plan arrangement of the module storage system in a particular space, will provide unconstricted areas for use and transport of artifacts within the space.

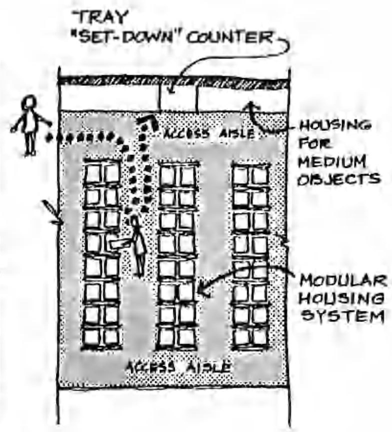
Aisle widths within the modular housing systems should allow the user to easily take artifacts or trays from the system and to carry them to work spaces. The aisle width will thus be determined by the tray dimension. Tests conducted by the Museums and Cambridge Seven Associates, Inc. have indicated that a minimum aisle dimension should be approximatley 12" greater than the maximum tray dimension. This aisle dimension assumes that only one person is in an aisle at one time. If aisle space were to allow two persons to pass carrying trays or artifacts, the potential of "bumping" still exists. Furthermore, allowing aisle space to accommodate two users carrying trays would result in excessive floor area devoted to circulation.

The plan arrangement can facilitate one-person use of the aisle by providing "set-down" counters where artifacts can be transferred to carriers for transport to other museum areas. Such a counter would also provide a "safer" place for handling the objects than could be accommodated within the modular system. The distance from modular system to "set-down" counters and aisle length should be minimized. Such "set-down" counters should not become a permanent work space as people should not be encouraged to stay in the housing space. The temptation to smoke or work on projects, both polluting activities, would be reduced if work space is not provided.

Major aisles outside the modular housing system which provide access to the modular system aisles will require greater width due to both passage of people, and dimensional requirements of



MINIMUM AISLE WIDTH



SET-DOWN COUNTER

rolling work/storage carts.

Obstacles in aisle circulation areas which must be gone through, passed over, or travelled around, will create the potential for dropping artifacts. Thus, changes in floor level (trip hazards) and doors should be minimized, or ideally eliminated in storage areas prior to transfer of artifacts to safe transport containers.

3. Vermin: Sealing of the housing space will be required for effficient operation of mechanical systems and to allow fumigation of these spaces without contaminating public areas. This sealing will also discourage penetration by vermin. In addition, vermin can also be discouraged through the use of materials which are not attractive to them, generally synthetics or treated natural materials.

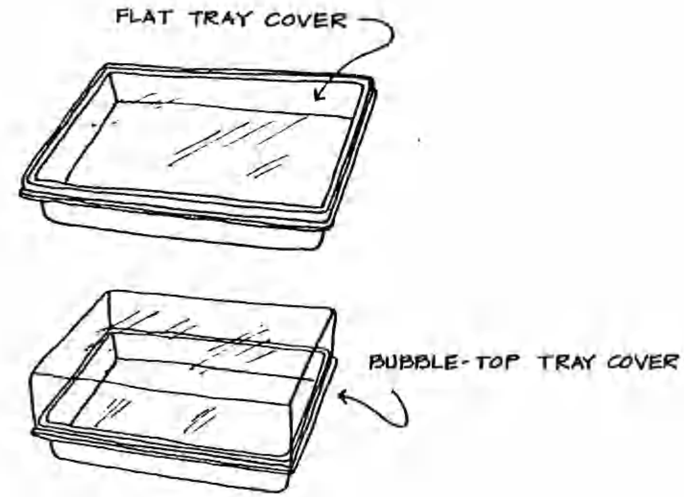
B. Housing Units

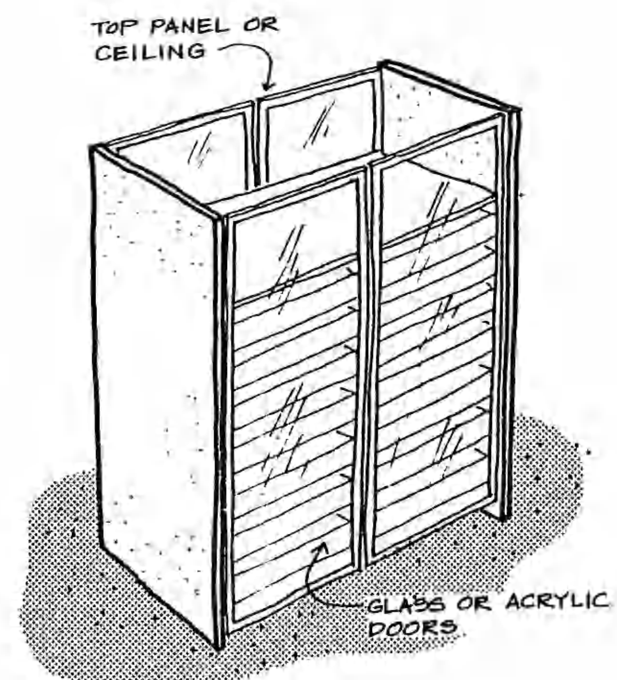
Design of the housing units should also reflect the following conservation considerations:

1. Security: Major security is provided by controlled, limited access to housing spaces. In addition, the housing units themselves can be secured further by providing locking doors on selected units. Although such doors provide additional safety if used only on housing units containing valuable artifacts, these doors "announce" the location of the objects. Random location of more valuable artifacts will also protect them from the untrained person.

All housing units located in public areas will require locking doors or mechanically fastened access panels.

2. Dust: Objects can be protected from dust by enclosing them in containers within the housing units. For example, trays in the module system could receive covers, or objects housed by tray or by other components could be enclosed individually in containers. Alternatively, the housing unit stack itself could be enclosed by adding a top and doors.

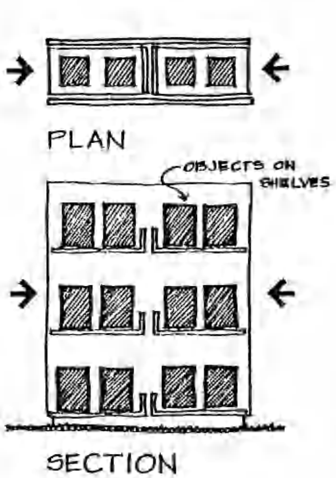


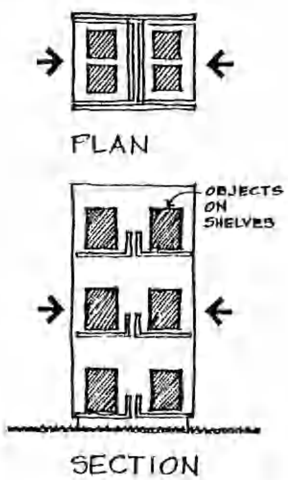


3. Breakage and Wear: Materials and fabrication details used in the housing units will provide protection from breakage due to impact while housed. Generally, materials, which resist penetration would be most protective, for example, solid, closed materials rather than open, perforated materials.

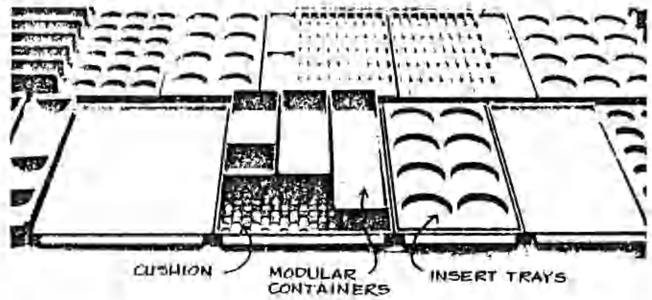
Containers which are resilient and/or absorb impact would protect the artifact from breakage if pulled from the housing unit and dropped. For example, plastic trays transfer less impact to the enclosed artifacts than a metal tray.
The housing units should be structurally stable. Removable components in the module system should be securely fixed in place. Trays which "pull-out" when in the module system (like drawers) may require "catches" to stop them before tipping or before falling off the end of supports.

A base added to the housing unit will protect artifacts at floor level from impact by cleaning equipment or from accidental kicking.



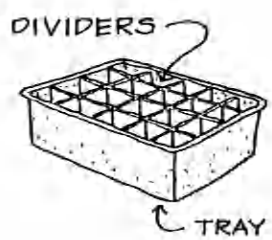


4. Object Density and Separation: Objects housed in a dense condition (for example, more than one layer deep or one layer high within a tray) may be self-damaging. Objects housed in this way are also subject to wear and potential breakage due to increased handling as artifacts in the top (or front) layer are sifted through to reach the ones at the bottom (or rear).



Therefore, housing units should be designed to make all objects immediately available. The modular system framework should, therefore, be a depth which accommodates visual access to the maximum quantity of objects from the aisle.

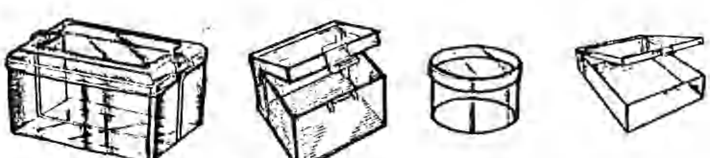
Trays which house objects in a top to bottom configuration should, therefore, be a height encouraging only a single layer. objects. Furthermore, separation of the artifacts within the trays could be achieved by inserting trays defining artifact spaces, modular containers, or dividers. These inserts would also protect the artifacts when the trays are moved and indicate when artifacts are missing. Soft pads placed in the bottom of the trays will also protect artifacts in the tray although will not separate artifacts or indicate missing objects.



5. Ease of Use: Making the housing units physically easy to use will result in less breakage. For example, objects located very high so that a person has to reach to handle them are more subject to dropping than artifacts located closer to waist level. Pulling trays out of a housing unit is particularly difficult above certain levels. The housing units should therefore, be a height which is manageable.

The weight and shape of the artifacts may affect the housing units. Preferably, heavy and awkward objects would be located low in a system. Generally, this means that provision for small bulk artifacts should be a low system and provision for small objects could be a higher system. MOT collections which tend to be heavier the TCM collections could be housed in a lower system.

6. Containers: Placing artifacts in see-through containers will allow visual examination without "touching". Very fragile artifacts could be housed in containers fastened mechanically; making valuable artifacts more accessible to view will reduce handling which will result in less breakage. Less fragile artifacts could be in easier-to-open containers.



SEE-THROUGH CONTAINERS

C. Transport of Objects

Objects, while being transported, are subject to the same conservation criteria as objects or artifacts in the housing units. Therefore, a "safe" means of transporting objects within housing spaces and in other museum areas should be provided.

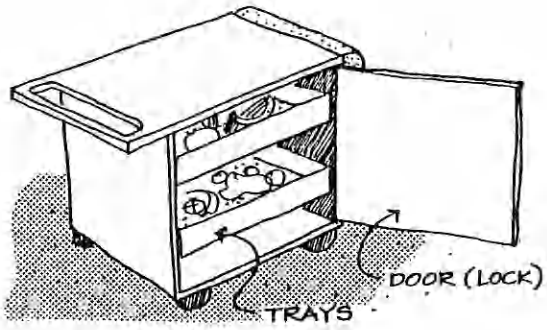
While the objects are being carried within the housing space, they will have the security and environmental protection provided by the space itself. Once outside the housing space, security precautions such as locking of storage units or mechanical fastening should be provided where possible. Environmental protection (temperature, HVAC, etc.) will not be possible in a moving system.

The type of carrier or transport device will be dependent upon the artifact to be carried. In some cases, it may be safest for the object to be hand-carried. As a general rule, however, transporting artifacts in an enclosed unit would provide more protection. The enclosed unit itself could be hand-held or on wheels.

All objects transported in containers, hand-held or wheeled, will require restraints which stop movement within the container. Inserts similar to those discussed earlier in "Object Density and Separation" would also be useful in this situation. Additional temporary "packing" such as "bubble-wrap" may also be required. Objects not transported in containers will require special, temporary packing as appropriate for the specific items.

One or two small objects could be carried in tubs or boxes. Hand "grips" should be provided so the container can be securely held. In order to protect the objects, the tub material should meet the same criteria as housing unit components.

For additional protection and security, the tubs could be fitted with tops. Locks may or may not be required. Hand-held transport containers should not project significantly from the body. This means that a maximum overall dimension not exceeding 16 inches is advisable.



CART FOR SMALL OBJECTS

When more than one or two small objects or larger artifacts from the modular housing system are to be transported outside housing spaces, the use of a cart is recommended. Because the cart would be used both in staff areas and in public spaces, it should be very stable, have lockable tops or doors and probably have "locking" wheels. In staff areas the carts can also serve as temporary storage units.

Carts provide more protection than hand-held containers because less potential for dropping occurs. Doors, for example, present a significant hazard to hand-held objects because of difficulty in supporting the container while operating the door. This difficulty can be alleviated somewhat by providing set-down space immediately adjacent to doors.

Also, doors through which objects frequently pass should close very slowly, providing adequate time to pick up the container or object and pass through the opening. Carts, on the other hand, will support the artifacts at doors; however, they may be difficult to maneuver in this situation. Care will have to be taken in all building spaces where carts will occur to provide clear and easy paths for cart usage. For example, during final building design, ramps or elevator access, compact floor surfaces, adequate circulation space, and "parking" places should be studied carefully.

Medium sized objects, large objects and special objects will require a variety of transport options, all of which are used only for transport. It will be assumed for these items that they will always be transferred to and from safe places and be carefully supervised while being moved. Transport options include: 1) dollies; 2) hand trucks; and, 3) large carts.

TRANSPORT OPTIONS FOR MEDIUM AND LARGE OBJECTS

D. Museum Policy

The collections housing spaces and system units can be designed to encourage and accommodate, but cannot guarantee, good conservation of artifacts.

The housing system has an intimate relationship with the people using it. The success of all of the previously listed design decisions related to artifact conservation are dependent upon museum operational directives gained from actual usage of the storage components and system.

For example, dividers are provided as tray inserts but only the user can "place" them. Heavy objects are recommended at low levels but they may in fact be placed high. It is suggested that no more than one person at a time be allowed in aisles, but nothing physically will stop additional people from walking in.

B2.3 IMPACT OF ECONOMICS ON COLLECTIONS HOUSING

A. Economic Objectives

Economic considerations will temper all components of the collections housing system. Evaluation of materials and detailing of the housing units and spaces will involve cost trade-offs. However, design of the system can also achieve economic goals, irrespective of the materials and detailing. For example:

1. Ease of Use

A housing system which is easy to understand and operate will result in less time spent by staff members, reduced chances of breakage and theft, and, thus, less operating cost. Staff size and time will also be reduced by developing conservational maintenance programs that are related to housing spaces rather than individual artifacts.

2. Flexibility

A housing system which allow interchanging of parts and/or moveable units will require fewer parts and less cost in future revisions. An additional benefit is staff participation. When the system is easy to use and adaptable, greater staff participation and responsibility will occur by incorporating the staff involvement with development of new storage components.

3. Minimum Number of Storage Spaces

Concentration of the maximum quantity of objects in one area of contiguous spaces as opposed to dispersion throughout the building may result in several savings. For example, time spent by staff in locating objects may be reduced; control over access, supervision of artifact condition is simpler; special architectural and mechanical requirements will be concentrated and, therefore, more economical.

4. Combined Collections

Objects with similar housing requirements from both TCM and MOT collections should be combined so that "dual" housing facilities are not required, thus reducing cost for both Museums. Presently, both museums are in agreement with shared storage but need separate access divisions for their own objects within common storage spaces.

5. Efficient Use of Space

Design of the housing units and their arrangement in the housing space can efficiently use space, reducing cost by reducing floor area required.
Generally, decisions as to use, conservation, goals, and other housing concerns must be made first. Then the housing spaces and units can be designed to use space efficiently with these "givens".

B. Use of Existing Storage System

TCM currently has a portion of their small objects housed in a modular tray system. Reuse of all or part of this system may result in a cost saving.

The existing system is comprised of approximately:

- 1,075 trays
  The existing tray is molded of ABS plastic and has dimensions of 30-1/4" x 20-1/2" x 3-1/8" deep. Presently the trays are supported on their long 30" side.

- 44 panels (double face) or 88 bays
  The panels are 3/4" thick texture 1-11 plywood. Double-face panels of approximate dimensions of 60" x 96" are comprised of four connected panels.

- Four 1 x 1 "unistrut" metal channels are used for each module bay to support the wood panels and are framed from floor to ceiling.

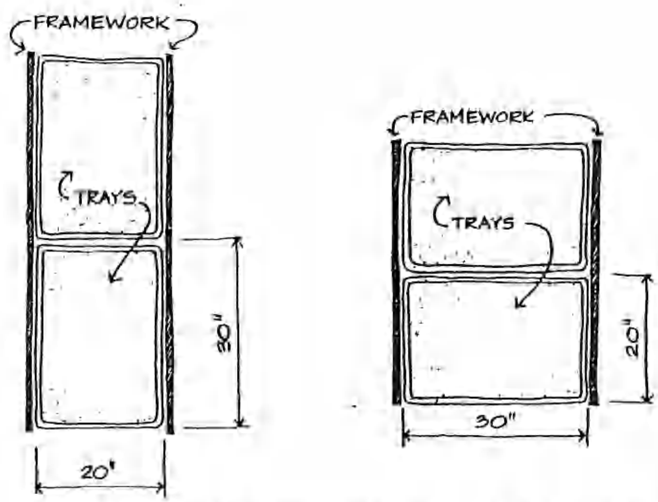
A bay of this system has an approximate current replacement of $14.00 for the side panels; $15.00 for the unistrut metal channel frame; $10.00 for tray guides and two hours of installation time at $13.00 per hour for a total bay unit cost of $52.00. Trays cost approximately $7.00. At the present storage density of approximately 12 trays per bay, trays required for one bay cost $84.00.

The total tray storage replacement cost is then approximately $12,000.00.

If the existing tray system is reused, it will only be part of the total housing requirements for the Museums' small artifacts neods. However, use of the existing tray system will affect the final design of the new system because of its dimensional size and means of support.

Several options are possible:

1. The existing system could be duplicated. This option would result in a cohesive system throughout both museums. Whatever limitations come with the existing system would continue; however, modifications could be made such as change in fihish color, addition of components, and decrease in system height.



DEEP TRAY CONFIGURATION   SHALLOW TRAY CONFIGURATION

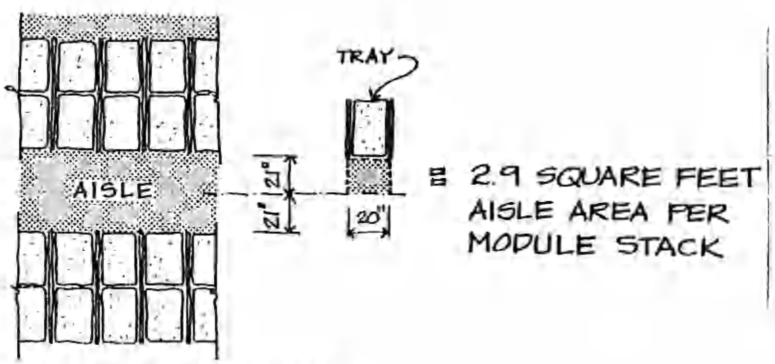
2. The existing system could coexist with a new system of different design, thus resulting in two different systems within the museums. By isolating the existing system in a separate housing space, no visual or use conflict would result; however, interchangeable components would be limited to within each separate system.

3. The trays, or a portion of the existing system could be incorporated into a new system design. This option could allow the design of a cohesive total system, the only limitation being, that of the tray, which would dictate the "module bay" or "stack" dimension. Also, the 20" x 30" tray could be placed in the module so that the 30" dimension faces the aisle (shallow configuration) instead of the 20" dimension stack width now being used (deep configuration). The advantage of this arrangement is that the shallow configuration does make more artifacts immediately visable and available (as discussed in Section B2.2).

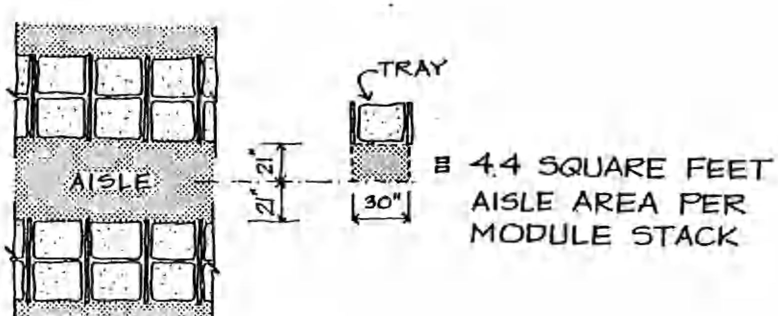
The shallow tray configuration requires more aisle length area but less aisle width per stack served. The deep configuration is slightly more space efficient. Also, if the tray is turned to the shallow configuration, the tray should be tested to determine if the tray will deflect due to the 10" increase in span. The mold for the existing tray has been destroyed so that a new design will be required for additional trays.

By keeping or modifying the existing system, additional benefits to the museums could be:

- the continual expansion of objects into the storage system prior to moving to the Wharf since occupancy is probably two years in the future;
- joint collections could be housed in either current museum facility; and
- the objects would be kept in the same trays, thus reducing the handling, packing and restoring procedures during the actual move to the new building.



DEEP TRAY CONFIGURATION



SHALLOW TRAY CONFIGURATION

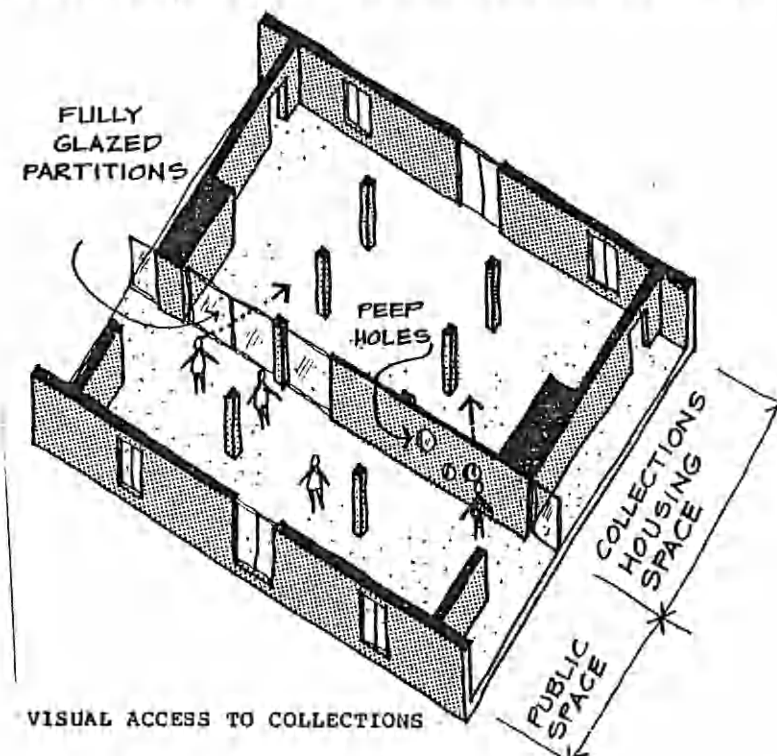
A. Collections Storage

The museum philosophy, or goal, of encouraging public knowledge of the extent and resource value of the collections will affect design of the housing system. In order to achieve this goal without sacrificing security, visual access to collections storage spaces rather than physical access should be provided.

The two general options for the collections storage which have been previously discussed under Section B1.2 are horizontal and vertical arrangements.

Both horizontal and vertical solutions will require vision panels so that the public can see into the collections housing space. The extent of these panels can vary from "peep holes" to fully glazed partitions.

Where collections housing shares space with other functions within a building area, objects will be exposed, almost in a display fashion (see Section B2.1). Large artifacts in this situation would be to-



VISUAL ACCESS TO COLLECTIONS

tally exposed to view. Public visual access to other collection support functions such as restoration or conservation areas, would show the public another aspect pf the Museum collections.

Generally, one will see "glimpses" of objects within a tray module system, although the shelf and hanger components may expose more objects. Clear containers and/or doors on the system units should be used if possible. so that enclosed objects are not further obscured. To further expose collection artifacts within the modular system, the exhibit display of representative objects from the housing units behind could be provided at the glass partition separating collections and public. Also, housing units could be backed up to the glass partition, providing a "cut-away" view of what is occuring in the housing units behind.

Opening the housing spaces and housing units to public view has visual implications because the space and its contents become a type of exhibit case. Therefore, the selection of materials and design of housing units should make the space attractive and complement the artifacts.

B. Satellite Housing

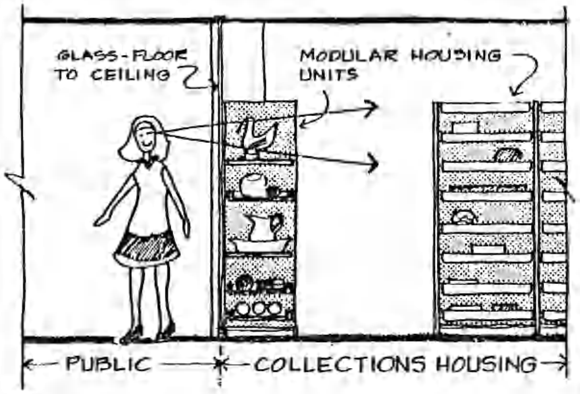
Another method to make collections more visible to the public is to provide small collection units in public spaces. In order to accomplish this, several options are available: a) collections closets; b) display units (collection "mini" closets); and c) carts.

1. Collections Closets

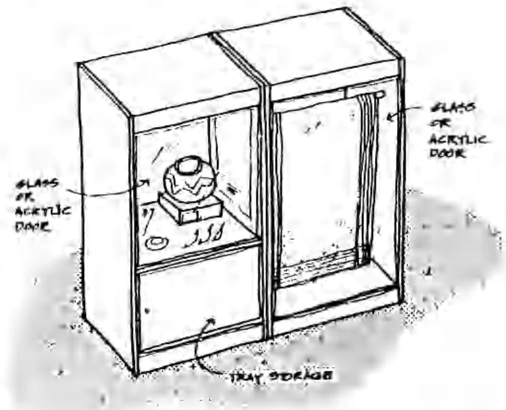
Where a large portion of collections is desirable in a public area, separate spaces with separate access control and environmental protection (or collections closets) could be provided. These spaces would accept the same housing units as found in the central storage area.

Collections closets could be fixed or could be a demountable system. Fixed collection closets (i.e. fixed partitions and "hard" connections to building systems) would be an integral part of the public area.

Demountable collections closets would be "knock-down boxes" comprised of connecting partition, ceiling, and flooring components which would plug in to building systems. These boxes would be variable in size and could vary with collection requirements.



VISUAL ACCESS TO COLLECTIONS



DISPLAY UNITS ("MINI" COLLECTIONS CLOSETS)

2. Display Units (collections "mini" closets)

Where a small portion of collections is desirable in an exhibit or public area, display units could be provided. Each display units would be a separate entity with individual access, locking doors (or mechanically fastened access panels). Since these units would not be connected to the same environmental systems as central storage, they would not be advisable for long-term housing of objects However, they would be appropriate for collections housing related to changing exhibits.

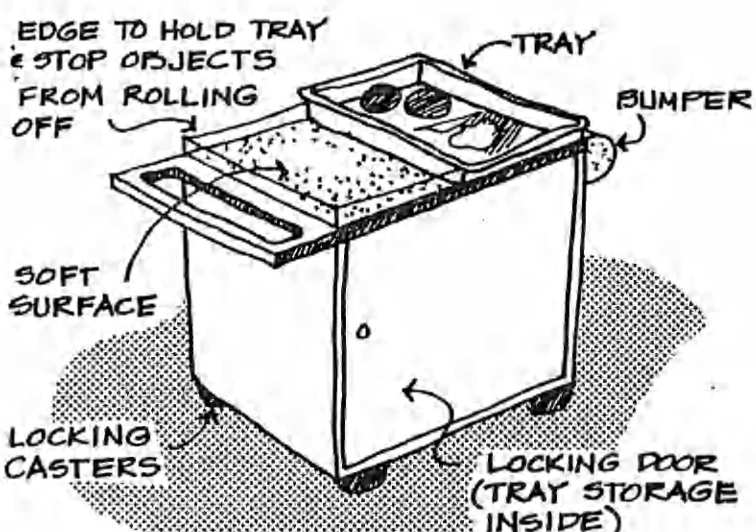
The display units should be designed to be stable when in place, but movable so that they can be redistributed throughout Museum areas according to need. The units could join together in quantities as required and they could do "double-duty" as room dividers within large public areas.

For further flexibility the units should be designed to accept components from the modular system in the central housing space. However, additional components and the "case" itself should be designed in keeping with its display and program use functions.

3. Carts

Supplementary to their transport functions throughout the entire Museum (discussed in B2.2) carts could be used as demonstration aids for staff members.

Trays, or other components, from the modular system would be housed inside the cart. The top of the cart could serve as a counter from which visual and/or "hands-on" demonstrations could be made. The top should provide a secure base for the tray and a cushioned surface (with an edge to protect rolling objects) on which to place the individual objects.



DEMONSTRATION CART

During the course of this study, a physical inventory of the objects and artifacts was conducted by storage type category (small artifacts, small bulk, etc.). This inventory in conjunction with the proposed modifications to the storage systems and the projected growth in collections area demand, has been used in developing the storage area program for the building.

A. Present Collections

1. Small Objects - The Children's Museum

At current storage levels of object density per tray, a total of 3,852 trays would be needed to accommodate the small artifacts collection. In a separate study conducted by the Children's Museum, an experiment was conducted on the tray storage density of one particular cultural artifact group. The densities were varied to determine the optimal storage condition for access, visibility, and physical protection. From data developed for artifact handling generated by this study and through the actual testing of different tray densities, a tray density goal for housing just the current collections could be accomplished by twice as many trays. Therefore, for this study a tray count of 7700 has been used to determine storage space needs.

In order to determine the total number of storage bays required, studies to establish the maximum bay height for storage of objects within trays were conducted. Presently, the objects are stored up to eight feet in height which means many trays must be removed in order to view the object and there exists a high probability of dropping trays when removing or replacing them.

Using the existing tray storage system at the Children's Museum, a maximum height of a top tray was set at five feet and is used in this study as the criteria.

Based upon 7,700 trays, a total storage demand of the total number of storage module bays to a height of five feet is 856. This figure provides for nine trays per module bay.

The storage tray determines the module bay area, approximately 24" x 30". Therefore, the total net area for storing the objects to a five foot height at a reduced tray density is 4,300 square feet. The area required for circulation within the modular storage system (allowing a 42" aisle width) is approximately 3.5 square feet per stack when the 20" tray dimension is on the aisle (deep configuration) and 4.4 square feet per stack when the 30" tray dimension is on the aisle (shallow configuration). The total floor area required for housing of small objects is therefore, 7296 square feet for the deep tray configuration and 8066 square feet for the shallow tray configuration. These areas do not include perimeter circulation and temporary work counter areas.

2. Small Objects - The Museum of Transportation

Since the Museum of Transportation does not now employ a tray storage system, the staff inventoried their own collections and, based upon the same criteria, set as their storage area demands including aisles a total of 2,500 square feet.

3. Medium Objects Storage

Part of the Children's Museum medium objects storage occurs within this present tray storage system, (approximately 10 to 15%) and therefore will be removed when adequate provisions are made.

The Museum of Transportation has identified approximately 1,000 square feet for medium objects storage. The approximate total area required is then 5,000 square feet to accommodate these portions of the Museums' collections.

The space remaining above the five foot storage height of the small object storage module can house a portion of the medium size objects. Assuming a nine foot clear ceiling height and a double module storage bay of five feet by four feet, 5,500 square feet or 22,000 cubic feet of storage space is available for this use. However, at this point of the study, storage area demands for floor level storage have not been developed. In future work, these items will need to be inventoried and storage either developed at the bottom or top of the small artifact storage system, along the perimeter of the collections housing spaces, or in a specifically assigned separate area.

4. Large Objects Storage

The demand for storage of large objects is primarily for the vehicle collection of the Museum of Transportation. Presently, thirty-five cars are being stored in one 4,500 square foot bay of the Wharf Building. Ultimately, the number of vehicles that are to be stored as collections will probably be about 35 although the present storage density is too high. The Museum recommends that the vehicles should be stored at approximately half this density for use in collections; this would require approximately 9,000 square feet of space.

B. Growth and Change in Collections Storage Area

The impact of the increase in collections will in part be dictated by museum policy and their changing roles as community resources over time. It will also be dictated by the constraints of the building and site. A change in museum program development will probably change the emphasis of the collections both in terms of usage and accessibility.

A flexible building program must be developed to respond to change in how objects are used by the public and staff, and the degree of integration of object storage with exhibit and other related programs. The intensity of use of artifacts in program development has changed and increased substantially in the past five years. Also, the increased need to protect objects from abuse and theft, due to their scarcity and unique role in exhibit programs, has for the museums required greater staff and expenditures in terms of artifact conservation.

As an example, within the Children's Museum, the historical program development and growth of cultural collections, and in particular the Japanese, was reviewed in order to determine a pattern that may be applied to the building program development. The Japanese collections has doubled in its size in the past ten years due in part to the Children's Museum's unique ties with Boston's sister city of Kyoto. In addition, future plans call for similar cultural program development related to other nationalities within the next five years. Close use of these collections to supplement cultural exhibit programs will become more desirable; therefore, access to as well as protection of them must increase.

However, unlike cultural collections such as the Japanese collection, the use of certain portions of the collection, for example the Natural History Collections, has become less significant in the museums' program and, therefore, the requirements for access and program development are not as critical. In fact, certain collections may be de-emphasized to the point where remote storage within the building or at a completely different location might be warranted.

An additional possiblilty is a change in museum policy, where those collections that have been de-emphasized could be used to gain objects for program related cultural areas through an exchange with other museums.

The tools required in developing a strategy for the museums' changing use of collections consist of the storage component, the storage system unit, and the development of collections storage spaces. Therefore, the museums should be capable of expanding their collections storage capacity in each area by expansion a) within the storage component, b) within the storage housing system and, c) into new spaces of the building. Within the storage areas to be developed by the museums as described in this study, the collections components tray count is approximately 159 in excess of the necessary count. This excess will allow for both an initial level of unused storage compartments within the individual trays and unused trays within bays of the modular storage sytem. In addition, based upon the museums' future policy objectives for additional storage requirements, excess area will be provided within cultural storage spaces during the initial building construction, or additional space within the building will be upgraded for collections use at a future date.

To accommodate the requirements of the conservation criteria in spaces where future collections may be housed in the building, the museums will develop the Wharf to a level whereby changes in equipment and finishes will be all that is required to maintain the objects in storage. This will require the placement of an infra-structure of services and utilities to each museum building bay during the initial building renovation. Therefore, to change a typical museum bay into a collections storage facility will require 1) capping of the water sprinkling system and the installation of the Halon gas system, 2) installation of a finished ceiling and walls, 3) increase in security to the space with introduction of an automated access door system, 4) change in the flooring and lighting systems and, 5) additional environmental controls to the air treatment mechanical systems.

B3. OPTIONS FOR GENERAL BUILDING CONSTRUCTION

Numerous options have been studied for the restoration of and renovation to the Wharf for the Museums' usage. Restoration work involves the necessary repair work to the existing shell of the building, while renovation work includes the conversion of the building to its new public usage. Major areas of work are reviewed in terms of the original feasibility study and alternative options developed during this study.

Exterior Building Shell

The original study called for chemical cleaning of the masonry on three sides of the building with the remaining side cleaned at a later date. In addition, twenty percent of the exterior was to be repointed, patched, and/or replaced.

Criteria developed during this study have determined the necessity to minimize 1) air infiltration, 2) vapor penetration, 3) additional brick deterioration, and 4) water penetration. Also, in order to design the smallest practical mechanical system and maintain an acceptable air quality range, the rate of outside air infiltration must be minimized and vapor transfer through the exterior wall prevented.

This criterion requires treatment to the entire exterior shell and therefore eliminates the option for restoration work phased time. The alternative treatments reviewed included 1) sand blast cleaning or wire brush cleaning, 2) surface applied water retarding sealers, and 3) repainting and mortar types.

The original study called for clear tempered insulated glass in a fixed sash. It has been learned from this conservation study that ultra-violet light is unaffected by clear glass; however, it must be filtered out to the greatest extent possible. The ultraviolet range of natural daylight deteriorates many types of objects and artifacts.

This study has reviewed 1) use of applied ultraviolet light screens to the interior face of the glass, 2) treated glass (including solar bronze with a transmittance factor of 26%, solar array with a transmittance factor of 34% and gray lite #14 with a transmission factor of 73%), and 3) use of opaque panels in lieu of transparent glazing in certain locations. These various alternatives were reviewed in terms of their durability, color rendition and visibility.

The existing roof and portions of the roof sheathing will need to be replaced as part of the general construction work for the building. The new roof will need to be studied to ascertain which of the roofing systems provide the highest light reflective levels and insulation value. If collections are housed at the sixth floor, additional insulation will need to be installed to reduce the heat gain to a managable level.

Interior Building Spaces

The original study called for steam or sandblasting of all interior masonry and timber construction. The control of air and vapor through the masonry wall, as described in the preceeding section, was determined to be an important factor in controlling the interior environment. Since sealants in old masonry wall create greater problems due to hydroscopic pressure and required a frequent recoating, alternative interior treatments to the inside face of the wall were studied. The alternatives included 1) a mastic compound applied to the masonry wall with a furred brushed wall, 2) an integral stud-foam insulation system applied directly to the masonry wall with a finished sheetrock wall, 3) a furred foil-backed gypsum board wall with two coats of plaster finish, and 4) a furred wall with either rigid foam insulation or batt insulation.

The alternatives were reviewed in terms of initial cost, transmittance, degree of isolation of the new wall from the masonry and the need for an air cavity.

The interior masonry wall can be for maintenance and dust generation purposes. To minimize the amount of dusting from the joints of the tongue and grooved floor above, a new ceiling can be installed under the existing joists or the exposed underside of the wood structure sealed with a urethane sealer.

The issue of moisture and vapor migration from the crawl space under the first floor and its magnitude is unclear at this point. The two intervening floors resulting from housing the museum from the third floor upward may be adequate. If the spatial separation proves to be inadequate then a vapor barrier and an automatic exhaust fan system may need to be introduced.

The interior doors were specified as hollow metal, glazed metal or wood and solid wood core doors, with hardware to be "Best in Quality" cylinder type locks.

The security criteria have outlined the issues of a key lock system versus a more sophisticated card reader and electronic access system. Ultimately the museums will want to control the most important doors with a constantly monitoring card reading system. Therefore, to recue phased installation costs over time, doors that are apt to serve in the future as a controlled access point will be installed with special jambs and conduit to allow for the future installation of card reading devices.

Building entry vestibules were originally planned as small air locks for the interior spaces to reduce the problem of drafts. Because people are the largest contributor of dust, lint and dirt to a museum's space, the environmental control of these pollutants becomes an important part of the conservation criteria. Alternatives investigated included negative air pressure at vestibules, air curtains at entry points, special floor grating treatment, and dust collecting devices. The most appropriate system to handle large numbers of people at one time is an oversized enclosed vestibule with an open grate floor and air curtains at both ends.

Glazing for interior walls as part of the see-through collections area was specified as plate glass. With the introduction of a gas type fire extinguishing system for collections areas, wire glass with sealed joints will need to be used, so that the collections can be adequately sealed to contain the gas during a fire.

Lighting for the collections area was specified as either incandescent or fluorescent. With the necessity of limiting ultraviolet light transmission, all fluorescent lights will need either U.V. screening by shelved tubes or the prismatic lens diffuser.

The original study called for a lightweight concrete leveling slab with the installation of wood sleepers in the exhibit areas only. With the increase in storage demands and the possible need to anchor a more extensive system of partitions and storage unit components to the floor, this system of sleepers or bolt-through anchoring devices should be introduced throughout other museum spaces.

Floor finishes vary by their usage demands; criteria include impact absorption, acid resistance, lint and dust elimination, and ease of use of wheeled objects.

B4. SECURITY DEVELOPMENT

The concepts of security systems design for the Children's Museum and Museum of Transportation are based on the planned space dedications and occupancies set forth in the Dec. 2, 1975 Schematic Design.

The requirements have been reviewed with staffs of both Museums. Site visitations and physical surveys of present locations have provided opportunities for an appreciation of the clients' requirements.

During the study, guidelines were identified which detailed the parameters of an appropriate application of devices and procedures. The end-product goals of the study were defined by the directors and staffs of both museums. As areas of operation and occupancy were identified, the means were explored by which the goals could be most efficiently and economically reached.

A. Security Overview

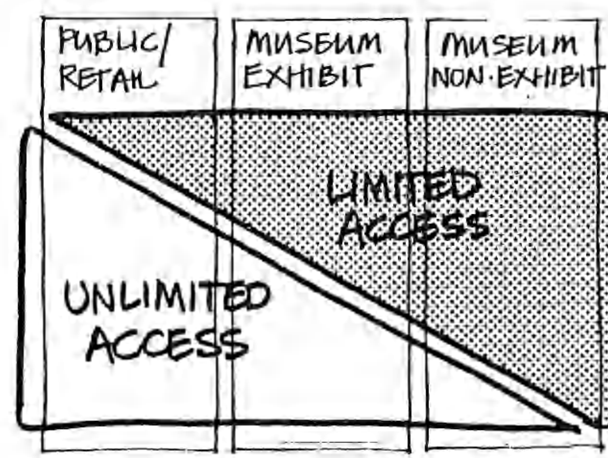
Surveys at areas occupied by the Children's Museum and the Museum of Transportation disclosed that while there are not posted guards or security patrols moving through public spaces, each employee contributes to the preservation of displayed and stored objects and looks to the safety of visitors. Much of the visitor activity at both Museums involves interacting with staff who are well instructed in security precautions. Exhibits not requiring staff are designed to encourage a high level of visitor participation without unreasonably exposing the objects to vandalism or theft.

An initial phase of the study required an evaluation of the effectiveness of general staff involvement in the security program. The extent to which a new staff member, specifically assigned to security matters, might relieve other professional staff of some security responsibilities, was weighed against the cost effectiveness of such a plan.

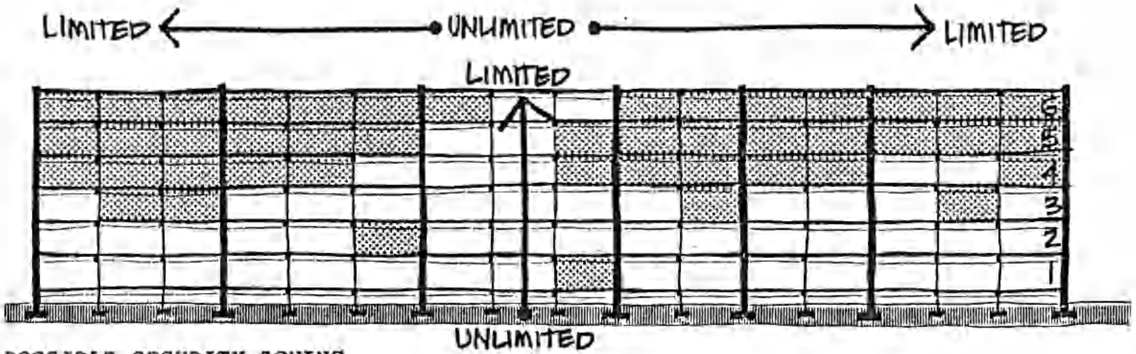
The December Schematic Design statement describes various types of occupancy which in turn suggest various levels of exclusitivity or ease of access appropriate to each space assignment. Opportunities for tenant adjustments in access will be essential to the growth and expansion phases expressed in the Design Statement. Spaces related to these occupancies are now seen as the following:

- Public entrances
- Staff entrances
- Truck dock, shipping, receiving
- Staff offices, staff storage
- Exhibit areas
- Collection storage
- Library
- Classrooms
- Workshops
- Studios/shops
- Mechanical equipment rooms
- Retail stores
- Retail storage

An important consideration was the extent to which automatic equipment would interact with, or impose upon, staff functions and the ongoing security dialogue. The Children's Museum presently owns a PDP-11/40 computer with an in-house developed program package, expandable memory and peripheral equipment including interactive terminals, printers, and mass disk storage, as well as data retrieval potential. The extensive use of the computer in exhibition programs, visitor information, internal accounting, collections cataloguing, etc., has involved staff to the extent of participation in data entry and updating and frequent employment of the computer center's capabilities. Additionally, the Children's Museum staff includes a full-time computer systems analyst/designer/implementor.



SECURITY CRITERIA



POSSIBLE SECURITY ZONING

B. General Criteria

The study disclosed the adequacy of existing personnel in areas of decision making and implementation of security concepts. It was seen that staff would benefit by the application of some security devices and equipment selected to respond to identifiable needs in the wharf building.

The opportunities to engage staff in a program of automated security equipment application was examined from the view of cost effectiveness. The Security Consultants examined computer and program packages offered by Honeywell, Johnson Service, ADT and others. It was determined that acquisition costs for such a computer ranged from $23,710 to $42,940. Charges for software program preparation and computer loading of the program would range an additional $18,000 to $37,310.

Utilization of the Children's museum existing computer and programming capabilities will not exceed $10,000 for programming and a redundant processor. Further, it was established that an adequate portion of the existing computer's data base could be devoted to security equipment control and monitoring without threat of disruption by other programs on the computer.

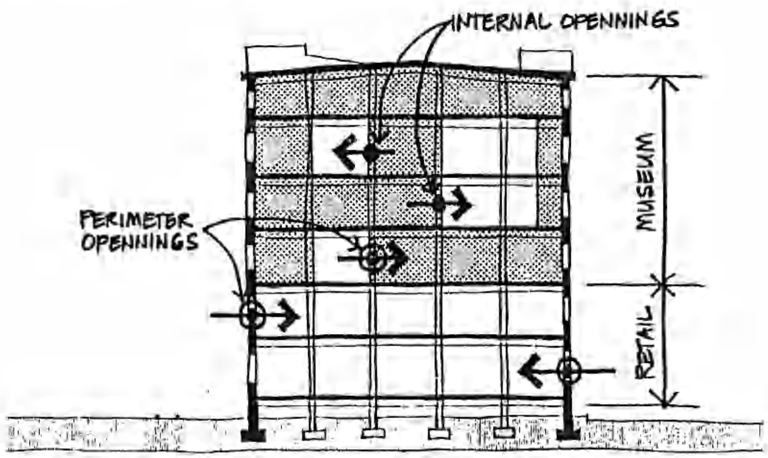
The utilization of the existing computer's mass storage, printers, terminals, etc., will provide a single central location for automation of a security program capable of serving the Museum of Transportation and the Children's Museum, as well as shared areas.

The potential of expanding a computer-based security system will provide both museums greater flexibility in uses of space and degree of protection. Each museum will be able to program space protection without diminishing, or affecting, the levels of security established at other or adjacent spaces. As the professional staffs of the museums will determine the security levels appropriate to exhibition, storage, etc., and program the equipment applications to achieve automatic control and monitoring, there will not be need for a security force.

The study disclosed a basic requirement to establish a high level of perimeter security in order to deter and detect intrusion efforts. The unique configuration of the wharf with shared, tenant and retail spaces established that the security perimeters follow the contours of the museums and shared spaces and permit easy access from within and without to tenant and retail spaces.

The study identified the need to control and monitor access at both perimeter and internal openings. Programmable card readers were considered for access control. It is now envisioned that staff will use coded cards to gain access to perimeter doors and selected interior doors on the basis of each card being programmed according to the frequency and degree of access necessary to the employee's duties. As such systems can record the date, time and identity of the person using a space, a guard or watchman making value judgements as to needs for access and logging odd-hour entries will be unnecessary. An automated program of access control will maximize existing equipment aho will permit access levels to be established in advance of occupancy and staff assignments.

Doors leading from exterior and from internal tenant spaces will have the capability of being programmed to provide access and detect unauthorized entry attempts. The circuitry between the card reader protected doors and the computer will have a capability of transmitting alarm signals from detecting devices. It is anticipated that selected interior spaces, such as collection storage, workshops, etc., will be additionally protected with human motion detectors. As each protected door and interior space will exist on a separate and distinct zone of alarm control and monitoring, levels of access can be established for each area without compromise to the other areas then under protection. Each change in operating status of detecting equipment will be recorded, and changes will be tolerated by the computerized system only on the basis of the agreed-upon program.



POINTS OF CONTROL AND ACCESS MONITORING

C. Collections Storage Criteria

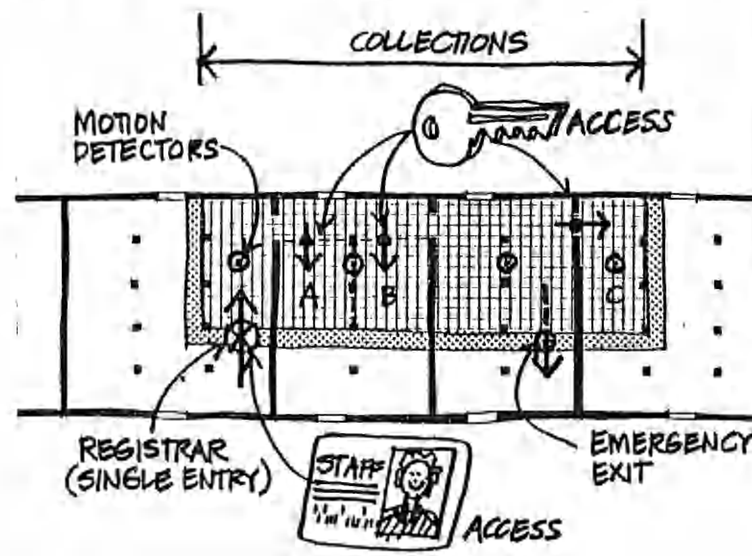
The design and constructions of the collection storage areas should establish that ordinary or emergency activities occuring in adjacent spaces will not affect conditions in storage. Vibrations, noise, etc., generated externally should not penetrate storage areas.

The positioning of any equipment within collections requiring servicing should be such that equipment, wire closets, pull boxes, telephone strips, lighting panels, do not require access to storage.

Access to each storage area should be exclusive to that area and not provide passage to any office, other storage room or any staff or visitor activity. Any items placed in the area should be for the use of staff and others authorized to use the space and no items intended for use in adjacent spaces should be in the collections storage rooms. Pedestals, stanchions, custodial materials, etc., should be prohibited from these areas regardless of the convenience of location and the degree of security afforded.

Dimensions of any storage area should be such that a secondary exit, except for emergencies, is not required.

Authorized access to storage should be restricted to a limited number of staff.



CONTROL OF COLLECTIONS STORAGE

Areas equipped with motion detecting devices are seen to number 20 and it is estimated each such area will be provided this capability at an equipment cost of $12,800.00. Such areas have been identified as "Type C" spaces.

The need to provide each floor level the capability of incorporation in the access control and security program will require the placement of signal transmitters and conduit risers for connection to the microprocessing units as described in Section B6.6 (identified as "Type D"). It is anticipated extensions of conduit and conductors from such a location to a door or area requiring "Type A", "Type B", "Type C" protection and the placement of devices at the areas will be included in the costs of renovating such area for exhibition or other purposes.

E. Electric Hardware Associated with the Security System

The proposed card access and motion detection for special areas may be a stand-alone automated system. It is also compatible with the building automation system investigated under Section B6.6 of this report. The cost estimated under Section B6.6 includes integration of 24 security points or stations into the building automation system.

Regardless of the overall implementation approach (whether independent or integrated with the building automation system) electric hardware, such as magnetic contact switches, power terminals, conduits, conductors, etc. must be provided at each security point. These hardware and services will be furnished under the electric contract and will be coordinated as to quantity and locations during the design phase.

It is anticipated that doors requiring security protection will be provided with a terminal box in the door frame; power will be supplied from a central transformer source, in code grade conduit. A separate conduit will be provided for the control wiring to data transmission points and a conduit riser system will tie all the data transmission points to the central control panel located in the Security Room. Such a conduit network will be similar to the building automation system scheme.

Note: in an integrated building automation system, data transmission points on each floor and the conduit riser network will not be necessary, since the network of data collection panels and conduit network of the building automation system will be shared. The power distribution for the Security System will still be required.

Electric service and hardware to be furnished under the electric contract for the security system was estimated on the following basis:

- A conduit riser and wiring system for data transmission similar to Diagram 8-1 with 4 #19 conductors in 1" conduit.
- A transformer at each riser location on each floor, and power distribution network from each transformer location to serve each security station with 2 #16 conductors in 1/2" conduit.
- At each security station will be a 24 volt power terminal.
- All necessary wiring at each security station.
- A total of 24 security stations assuming on the average of four stations per floor for this estimate.

The cost estimate for the above is summarized in the following table.

Security System Electric Service

1. Elec. strike/mag. contactors/ power terminal	$12,000
2. 18 Transformers	1,350
3. Data Transmission Network	17,520
4. Power Distribution Network	5,400
TOTAL	$32,670*

*Above costs include labor, materials and 15% profit and overhead.

Security Hardware Cost and Special Door Frames

1. Type 'A' Door - 15 units @ $1,080 =	16,200
2. Type 'B' Door - 35 units @ $220 =	7,700
3. Type 'C' Motion Detectors 20 units @ $640 =	12,800
4. Special Door Frames	
Present - 40 units @ $160 =	6,400
Future - 20 units @ $160 =	3,200
TOTAL	46,300

Area protection capable of detecting internal motion should exist in each storage room as a guard against unauthorized entry, stay-behind, or failure of the door mounted devices. This internal system of detecting, microwave, ultrasonic, audio, infra red energy should be on an engaging and reporting zone separate from the door device zone.

Early warning of conditions developing in a storage area, or adjacent space affecting the storage area, should be accomplished with detecting devices reporting to a central location and annunciating alarms when predetermined thresholds are reached. Detection of indications of fire should be through use of ionization, or products of combustion, units, mounted internally and in the duct system supplying the space. Changes in temperature and humidity in the storage areas should record as alarm conditions when thresholds are not maintained. The detecting devices used for these functions should be installed within the spaces and not only in the supply ducts or air handling systems.

Access by key, card reader, combination dial lock or other method should not be a general "access to all storage rooms" application. The physical instrument or code granting access to an area devoted to one distinct collection should not grant access to another collection area unless restriced to Director, Registrar, particular curator of broad responsibilities, or unless the identity of the entrant is approved for access, verified and recorded at each occurrence.

Doors to collection storage areas should be equipped with inaccessible means of recording alarm in the event of unauthorized entry. Recessed, or internally mounted magnetic contact switches are adequate to achieve annunciation of unauthorized opening of a door.

D. Recommendations

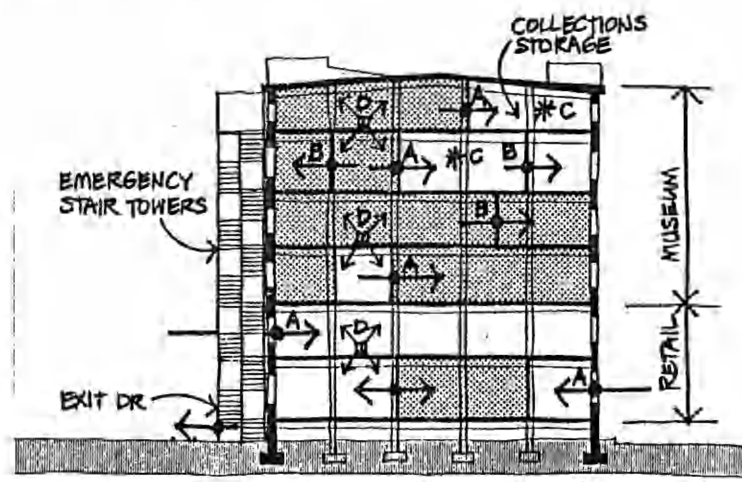
Protected openings will be equipped with magnetic contact switches, photo-electric beams or other devices appropriate to the design and placement of openings as resolved during design development. Such a protected opening, a "Type A" door, will exist with a card reader, an electrically operated door lock and a means of detecting unauthorized entry or opening.

It is estimated that the equipment costs necessary to prepare an opening to function with the desired level of control and interface with a computer is $1,080.00.

At this time a total of 15 openings warrant this degree of protection. While this one-time cost appears high, the expenditure is offset by the fact that it is a one-time cost providing control of access, detection, monitoring and recording without a guard force demanding on-going costs.

It is anticipated that other openings and internal spaces will be prepared with appropriate conduit and electrical connection boxes to accommodate this level of protection in the future. It is estimated that 20 areas will be provided this potential at a cost of $160.00 per area. These "Type A-a" spaces will be capable of incorporation into the total access control and security program as occupancy and space dedication require.

"Type B" doors are envisioned as internally located with a degree of control essential to protection of contents but not warranting the higher level of exclusitivity provided by an electric lock and card reader. A card-operated mechanical lock or high security key lock will provide the appropriate level of access control while detecting devices will alarm on forced entry attempts. It is estimated some 35 "Type B" areas will exist at an equipment cost of $220.00 per location.



PROPOSED BUILDING SECURITY SYSTEM

85. FIRE PROTECTION/DETECTION

The requirements for fire protection systems are dictated, in general, by the Mass. Building Code and more specifically by the City of Boston Fire Department. Compliance with various codes, standards and local regulations sets the minimum design necessary to obtain building permits. This minimum design carries with it a bottom line life cycle cost and a certain rating for insurance premiums.

Any departure from the minimum design will result in increased cost and therefore must be dictated by special protection necessity, improved protection and/or lower insurance premium costs to justify the increase in life cycle costs.

Various code requirements were reviewed with the Building Department, Fire Prevention Bureau and Fire Alarm Division, all of the City of Boston. Their comments and inputs are considered in the preparation of this section.

In this section, the minimum fire protection system for the wharf Project will be developed; additions thereto due to special requirements (collections storage), options available and their relative costs will be presented.

A. Minimum Code Requirements:

Under the Mass. Building Code:

1. The museum proper is classified as use group F-3.

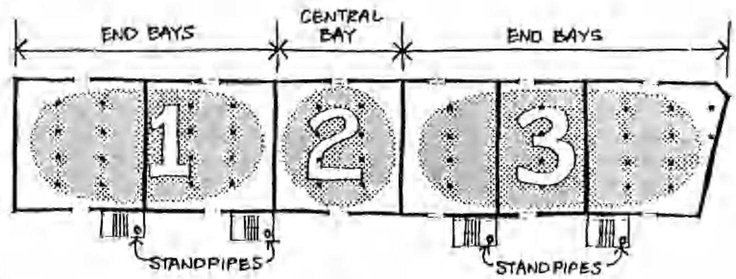
2. The rental area - use group C.

3. Staff and office spaces - use group E and,

4. Classrooms - use group F-6.

Use group E and F-6 have more stringent requirements than use group F-3. Hence, effort should be made to obtain a ruling to treat all spaces as an integral part of the museum. The basic strategy for developing fire zones in the wharf is to identify three basic zones (see drawing); fire separaton requirements between each zone will be more stringent than space separation within a particular zone.

For the wharf project such a waiver is assumed obtained. The fire protection system is designed to meet code requirements for use group F-3, whereby the



BUILDING ZONING FOR FIRE PROTECTION

following minimum shall be included: an approved automatic sprinkler system; a standpipe system of at least 4" must be provided (four standpipes required per Dec. 1975 layout); for a wharf or pier structure, special fire walls are required extending above the roof and below the low water level (a waiver should be requested on this requirement citing different use category and the internal fire zone construction); an automatic Halon 1301 system for the collection areas.

A total automatic Halon 1301 system will be acceptable by both the Boston Fire Department and the Boston Building Department as an alternative to the automatic sprinkler system.

B. Monitoring and Alarm:

The code requires a zoned alarm interpreted as the area where sprinkler heads have been activated, plus the area immediately above which requires waterflow monitoring devices for each such zone. For the wharf Building, this would mean providing 36 (one for each bay) waterflow monitoring stations in addition to those required for the fire pump and main sprinkler supply shut-off valves. Activation of any of the waterflow monitoring devices must automatically activate a voice alarm system with controls at the central control station so that a selective or general voice alarm may be manually initiated. For the City of Boston, the voice alarm shall be a "slow whoop" generated by a slow whoop generator.

In lieu of the above, a waiver should be requested for an alternate monitoring and alarm system. This alternate system will be consistent with the museums' policy to evacuate the whole building during any fire emergency. The alternate shall have a waterflow monitoring device at the base of each sprinkler riser. This will isolate the building into six vertical bays. The alternative alarm system will be a general building evacuation alarm instead of selective floor by floor evacuation. This general alarm would consist of a standard fire alarm system of horn and flashing lights, with the voice alarm "slow whoop" distributed throughout the building via a speaker system, whenever a monitoring device is activated. Alarms for each fire zone may be manually controlled from a central control station.

C. Accessories:

1. Standpipes must be equipped with a 2-1/2" valve, a 1-1/2" valve, 100 feet of 1-1/2" hose, and a 1-1/2" nozzle in an approved cabinet or rack on each stair landing.

2. A two-way telephone communication at each of the above hose stations.

3. A fire department Siamese connection.

4. Manually operated pull stations.

D. Water Supply:

Although the Wharf Building has access to both the high pressure water in Congress Street and the low pressure main in Sleeper Street, it became apparent in our investigation that the High Pressure main cannot be relied on for pressure or water supply. It is estimated that the standpipe system would require a minimum street pressure of 82 psi at all times. Our investigations indicate that the high pressure main in Congress Street could drop to as low as 65 psi during hot summer days. In addition, this main is a transition main, which means that it is frequently shutdown for cleaning and backflushing. For the above reasons, a 1,000 gpm fire pump should be installed for the Wharf Project for the fire protection system, with the water supply connection from the low pressure main in Sleeper Street.

E. Fire Suppression type:

For the Wharf Project, the following fire suppression types are applicable and will be listed in order of low first cost and less desirability for artifact preservation.

1. Conventional sprinkler heads which will open upon a rise in temperature and must be manually shut off at the riser valve. (These heads will deposit the equivalent of 1/2" water per square foot in three minutes and must be replaced after each activation.)

2. An automatic ON-OFF sprinkler head with the same rating as (1) except it will automatically shut off, reseal and be ready for use again. It does not offer better fire fighting capability, but minimizes water damage.

3. An automatic flood of Halon 1301 at 5% concentration. This provides efficient fire suppression without being toxic unless exposed for prolonged duration; there is no residue, no clean up and no damaging impact on artifacts. The drawback is the high cost of such a system and gas replacement cost. For the Wharf Building, assuming a typical module as a compartment, the replacement gas is estimated at about $10,000 per activation per bay.

4. Other gas systems such as carbon dioxide or Halon 1211 and other Halons were eliminated because they offered no better fire suppression for this type application, but are more toxic and more expensive.

The accompanying diagram shows the existing typical module layout and the new layout required for the Wharf Project.

F. Fire Protection System Options:

Summarized on the accompanying table are the estimated costs for the various options. These options are, briefly, as follows:

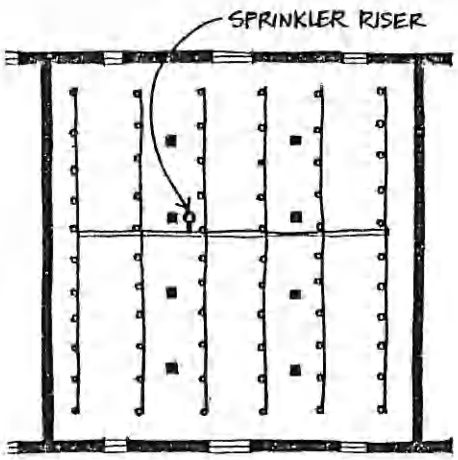
1. Remove the existing sprinkler system and install a complete new system with standpipes, fire pump, conventional sprinkler heads and appurtenances required by code.

2. Same as option 1, except with automatic ON-OFF sprinkler heads.

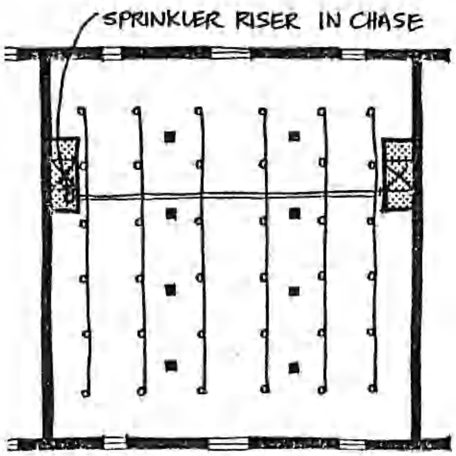
3. Refurbish the existing sprinkler system, to meet current code requirements and identical layout as option 1.

4. Same as option 3, except with automatic ON-OFF sprinkler heads.

5. Abandon the existing sprinkler system in place and install a total dry gas system of Halon 1301.



EXISTING SPRINKLER LAYOUT



PROPOSED SPRINKLER LAYOUT

Cost estimates are based on the December, 1975 building layout and meeting minimum code requirements. The apparent lower cost for refurbishing the system to minimum code requirements must be weighed against the soundness of the existing piping system. Even after detailed inspection and testing, the extensive conversion work necessary to upgrade the system may introduce unpredictable damage and leaks. A final point of consideration should be guarantee. It is not likely that a sprinkler contractor will guarantee either the project cost or the system reliability. For these reasons, the estimated cost differential may be used up quite easily.

The museum directors feel that two new sprinkler systems should be installed throughout the entire building. In the special areas (collections, storage) where Halon will be used, the sprinkler heads will be plugged. This will give added flexibility to changes in the space usage over time.

Although the gas system is ideal for the Museum application, there must be overwhelming reasons to justify its cost, since it is doubtful insurance premium credits (if any) can recover the additional cost.

Any of the above fire suppression systems is sufficient to make the Wharf Project a candidate for insurance as a preferred risk.

G. Detection

Since the air handling units will be provided with smoke detectors, areas covered by the sprinkler system will have, in addition to sprinkler heads, supplementary smoke detection capability via the air handling units and ionization detectors within the space. There will also be manual pull stations located throughout the building, per code requirement. The introduction of the ionization detectors within the general building spaces provides an early warning system prior to activation of the sprinklers. Thus, it is anticipated that most fire emergencies can be resolved before the sprinkler system is set off.

Special spaces covered by the Halon system will be provided with ionization detectors. In addition, in isolated spaces (either due to partitions, or operational requirements) where the air handling unit detection system may be rendered inadequate, ionization detectors will be used.

H. Recommendation

With concurrence of the museum directors, the fire protection/ detection system should be designed to cover the entire building (including rental spaces) so that the museum can control and maintain the overall integrity of the system, even though each rental space may require some modification from the basic scheme. scheme. Manually activated fire reporting stations will exist to supplement the automatic detectors in a total warning system. It is envisioned that evacuation will be for the entire museum which is appropriate to the age and background of visitors.

The systems of automatic detection and fire reporting will be connected directly to the Fire Department. The system will exist as separate from the security and access control devices and wiring in conformity with the code and connections to the computer's printer will exist only to create a record of alarms.

Selected interior spaces equipped with automatic detectors will be provided means of automatic fire extinguishment. Such spaces will include designated collection storage areas and Halon 1301. In Halon protected spaces, the sprinkler heads will be capped.

It is also the consensus that Option 1 be adopted for the Wharf Project. The additional cost may be justified by eliminating all uncertainties associated with the conversion option. Moreover, a complete new sprinkler system would afford total flexibility with respect to installation, allowing pipe mains to be located as desired.

Other than its self-closing capability, the automatic ON-OFF sprinkler heads do not show economic benefits in terms of insurance. On the contrary, the insurance company has indicated reservations as to their reliability since they require a high level of maintenance and are prone to clogging. In view of these reasons, standard approved sprinkler heads should be used for the Wharf Project.

FIRE PROTECTION SYSTEM COST ANALYSIS

	Option 1 Complete New System w/Std. Heads	Option 2 opt. 1 w/ On-Off Heads	Option 3 Refurbished System w/ Std. Heads	Option 4 Opt. 3 w/ On-Off Heads	Option Halon 1301 System	Option 1 Museums' Requirement
Head House Demolition						
Install New Mains/ Fire Pump	27,000	27,000	27,000	27,000	-	22,700
Remove Sprinkler Piping	16,500	16,500	-	-	16,500	13,900
Install New Sprinkler System	100,000	100,000	75,000	75,000	-	84,000
On/Off Heads	-	25,000	-	25,000	-	-
Install 4" Standpipe w/Accessories	25,000	25,000	25,000	25,000	-	21,000
Testing/Flushing	-	-	5,000	5,000	-	-
Risk Allowance	-	-	10,000	10,000	-	-
Halon 1301 for Collection Stor.(1)	63,800	63,800	63,800	63,800	-	63,800
Sub Total $	232,300	257,300	205,800	230,800	16,500	205,400
Ionization Detection(2)	93,800	93,800	93,800	93,800	-	61,900
TOTAL	326,100	351,100	299,600	324,600		267,300
2800 lb. Halon bottles					81,000	
Install./piping					96,000	
Detectors					97,500	
Door holders/controls					21,600	
Total for Halon					312,600	

NOTES:

1. COLLECTION STORAGE PROTECTION USING HALON 1301

	Dec. Study	Conservation Study
3 x 325 sq.ft. units @ $2000 per unit =	$ 6,000	
2 x 650 sq.ft. units @ 3400 per unit =	$ 6,800	48,400
1 x 1250 sq.ft. unit @ 6200 per unit =	$6,200	
CONTROLS AND DETECTION LESS SPRINKLER CREDIT		
3 units @ $500	1,500	
2 units @ $700	1,400	11,000
1 unit @ $1300	1,300	
Sub Total $	23,200	59,400
Tank Storage Spaces		4,400
		63,800

Above costs include 15% Profit and Overhead for Subcontractor.

2. IONIZATION DETECTION SYSTEM

295 Detectors @ $250 =	73,750
Wiring to control system =	20,000
	93,750

B6.1 Environmental Criteria (Air Treatment)

Introduction of fresh air into a building is required by local building codes to dilute odors given off by people, smoking and other internal air contaminants. The amount of fresh air required is generally determined by population density, building usage and exhaust air requirement, whichever is greater.

In this section, fresh air requirements relative to the Wharf Project will be established, including the need for air treatment, the treatment techniques and air quality monitoring.

VENTILATION AIR REQUIREMENTS

1. Building Exhausts Requirement based on Dec. 1975 Plans:

a. 2300 sq. ft. toilets @ 2 CFM/sq. ft.=		4,600 CFM
b. 450 sq. ft. storage @ 1 CFM/sq. ft. =		450 CFM
c. Misc. Exhaust* =		1,400 CFM
	Sub Total	6,450 CFM
	or	6,500 CFM

*Misc. exhaust includes kitchen, studio, meeting rooms with local control, therefore, exhausts are not simultaneous.

2. Infiltration:

Windows (av. wood sash)		
6150 sq. ft. @ 0.17 CFM =		1,045 CFM
Doors (av. use) Levels 1 and 2		
392 sq. ft. @ 6.5 CFM =		2,548 CFM
Other doors (min. use)		
440 sq. ft. @ 1.0 CFM =		440 CFM
	Sub Total	4,033 CFM
	or	4,100 CFM

3. Leakage Through Walls:

Levels 1, 2 and 3: 20" brick =		
26,100 sq. ft. x 14/60 x 13"/20" =		3,960 CFM
Levels 4, 5 and 6: 15" brick =		
26,100 sq. ft. x 14/60 x 13"/15" =		5,280 CFM
		9,240 CFM
Assume wall as good workmanship:		
Leakage = 1/3 x 9300 =	Sub Total	3,100 CFM

4. TOTAL (1) + (2) + (3) =	13,700 CFM

A. Ventilation Air Requirement

Ventilation air requirements for the Wharf Project were investigated for various applicable codes and standards to comply with minimum requirements. Based on the ultimate design peak attendance of 750 plus 125 museum staff, fresh air requirements by local codes and ASHRAE standards for museums give the following minimums:

1. schoolhouse: 875 x 5 cfm/occupant = 4375 CFM

2. schoolhouse-grade children: add 25% = 5465 CFM

3. ASHRAE std. Museum: 875 x 7 cfm/occupant = 6125 CFM

Investigation of exhaust air quantity based on December 1975 plans shows a minimum exhaust air requirement of 6500 CFM. Refer to accompanying table. (This does not include exhaust for paint room and rental areas, which must be considered separately and locally.)

From the above, it becomes apparent that the minimum fresh air requirement for the Wharf Project will be established by the exhaust air requirment. In addition, it is desirable to introduce adequate fresh air to offset infiltration through doors/windows and other anticipated air leakage. For the Wharf building, infiltration through doors/windows and leakage through walls (brick--rated good workmanship) is estimated at 7200 CFM, making a minimum fresh air requirement of 13,700 CFM for the building.

B. Wharf Project Fresh Air Quantity

Excluding areas requiring special exhausts like paint room and rental areas, the minimum quantity of fresh air for the Wharf building should be equal to or greater than 13,700 CFM. For this study, 14,000 CFM outside air will be used in air treatment plant and energy analysis. This represents slightly less than 0.1 CFM per gross square foot, which is considered a reasonable minimum consistent with energy conservation and the possible crowds of schoolchildren.

C. Air Filtration

The accompanying table summarizes the air quality that may be expected for the Wharf Project, the level of filtration desired by the museums and the performance of various filters. Air quality data for the

AMBIENT AIR QUALITY DATA FOR 1975
(Monitoring Stations, Federal Standard and Museum Target)

Content	Kenmore Sq.	J.F.K. Bldg.	Boston South Bay	Federal Std.	Museum Target(1)	Remarks
1. Total Suspended Particulates						
a. Max. 24 Hrs. Mgr/m^3	206	145	150	260	20 micron Size	Farr 44 Mz. 96% Eff. Farr 30/30 99% Eff.
b. Annual Geom. Mgr/m^3 Mean	99	61	63	75	20 micron Size	Farr HP15 99.9% Eff. at 20 micron size
2. Ozone						
a. Max. 1 Hr. ppm	.056	N.A.	N.A.	.08	5-10	Carbon Filter Excellent
3. Sulfur Dioxide						
a. Max. 24 Hr. Mgr/m^3	157	117	91	375	30	Carbon Filter 95% efficient at concen-
b. Annual Arith. Mean	34	29	19	80	30	trations up to 900 Mgr/m^3
4. Nitrogen Oxides						
a. Annual Arith. ppm ean	.053	.035	.028	.05	5-10	Carbon Filter 95% Efficient at Concen- trations up to .35 ppm
5. Saline	N.A.	N.A.	N.A.	N.A.	Desired	Farr 44Mz Filters Used by Navy

NOTE:
(1) Recommended by W. Young, Boston MFA.

N.A. = Not available.

project location are not available and special sampling analysis is not contemplated. Rather, the ambient air quality for the Wharf building location may be deduced as equivalent to those of the J.F.K. building on the basis of geographic proximity (see diagram). The air quality data for the J.F.K. building will be used to determine the air filtration need of the Wharf Project.

From the table, air filtration is necessary to reduce overall particulate/saline content and sulfur dioxides to the desired level. In addition, odor abatement may be necessary due to the possibility of highly objectionable odors that may occur during low tide conditions.

D. Filtration Techniques

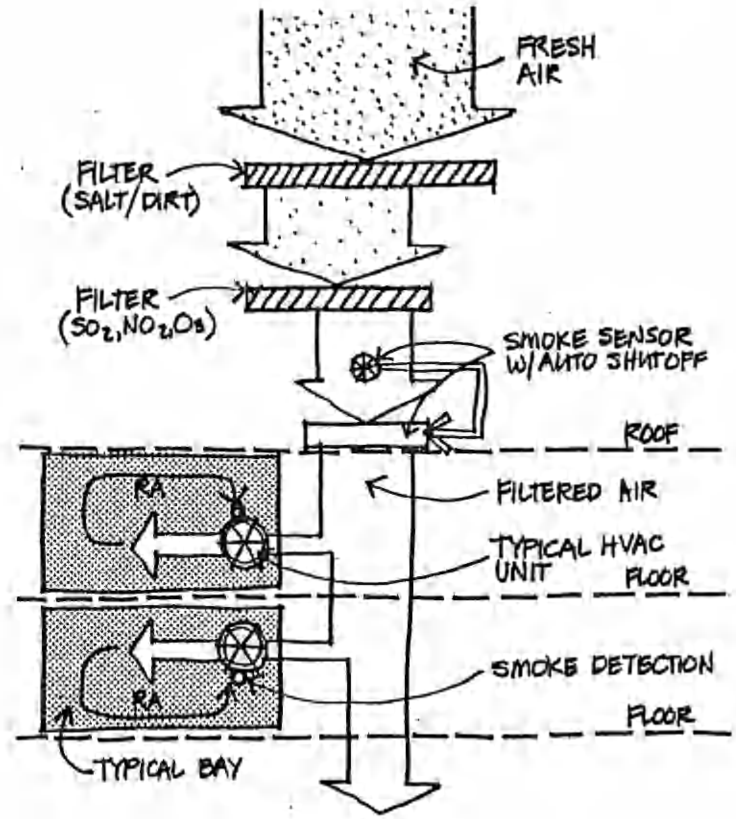
Wet scrubbers and a combination of impingement filters in series with adsorption filters were investigated for air purification. At this low contaminant concentration (Wharf Project air quality data), air washers or scrubbers application is not encouraged by manufacturers. Considering the non-availability of wet scrubber performances at this level of contaminants and the physical requirements of freeze prevention, its application was eliminated from further consideration.

A system of dry filters was selected which appears more than adequate to meet the required objectives. The carbon filter and high-efficiency filter is expected to have a service life of 1-1/2 to 2 years provided the prefilter system is well maintained. The service life of the prefilter will depend on the ambient air conditions, but generally, the filter gage will indicate need for cleaning or replacement.

This filter system consists of a washable metallic prefilter (salt and atmospheric dust), followed by an activated carbon filter (odors, sulfur dioxides, nitrogen oxides and ozone) and a final filter medium of at least 50% NBS efficiency. The table gives expected performance of the filters.

E. Air Quality Monitor

The fresh air intake will be monitored for sulfur dioxide level after the carbon filter. If the acceptable level (established in section B6.B) is exceeded, the outside air intake will be closed until corrective action is taken.



Smoke content of the fresh air intake after the filter system will be monitored to shut down the outside air intake if a set level is exceeded. This will be accomplished by an ionization detector.

Particulate content must rely on filter gages downstream of the final filter media to alert the need for filter changes to maintain the filtering efficiency.

During low tide conditions, when the ambient air odor may be highly objectionable, the discriminating odor sensing ability of the staff must be relied upon. Provision will be made in the outside air intake system to manually shut off fresh air intake into the building during such situations.

B6.2 ENVIRONMENTAL CRITERIA (TEMPERATURE AND HUMIDITY)

The need for climate control and its influence upon artifact preservation was demonstrated by the experience of the London National Gallery (1). The progressive reduction in damage to the collections was credited to temperature and humidity control. The peripheral benefits included increase in the number of visitors, improved staff morale, increased cleanliness requiring less cleaning and better preservation of museum collections.

Fortunately, the temperature and humidity levels which are best for museum collections, generally fall within the human comfort range except for operational differences. Nevertheless, according to Browne (2), museums should be conditioned with regards to the artifact collections rather than staff comfort.

Control and maintenance of temperature and humidity is interpreted as maintaining tham at a uniform level. Rapid changes in temperature and humidity such as a rate of 10°F or 10% R.H. per hour are considered harmful to museum artifacts (3).

Air conditioning systems for museums must be operated 24 hours a day, if full benefit is to be gained (4), and an effective climate control system for museums shall perform all of the following:

- control and maintain temperature.
- control and maintain humidity.
- provide means to clean the air.
- provide adequate ventilation.
- provide uniform air circulation.

(1) "Airconditioning at the National Gallery, London, its influence upon the preservation and presentation of pictures,", T. R. Keeley and F. Ian G. Rawlins.
(2) "The New Museum", Michael Browne.
(3) "General Criteria, Libraries and Museums", ASHRAE.
(4) "Air Conditioning for Museums", L. L. Lewis.

A. Criteria Development:

Design guides from various sources relating to museum climate control systems were reviewed and summarized herein, including those furnished by Dr. Young of the Boston Museum of Fine Arts. These were analyzed relative to the eventual implementation for the Wharf Project, including energy conservation considerations.

A set of temperature and humidity levels consistent with the above objectives was presented during one of the working meetings and the final design objective guides were agreed to as acceptable to all concerned.

B. Climate Control Guidelines from Various Sources:

1. General guidelines (2):

a. Safety zone for archives: 60-76°Fdb, 48-62% RH.

b. Safety zone for paintings: 59-64°Fdb, 56-62% RH.

c. Safety zone for diverse collections: 60-76°Fdb, 62-66% RH.

2. General Design Conditons (3):

a. Museums: 70-74°Fdb. 40-50% RH year round.

b. Rare items/storage, 70-72°Fdb, 45% RH

c. Art storage, 65-72°Fdb, 50% RH

d. Stuffed fur bearing animals, 40-50°Fdb, 50% rh

e. Air cleanliness, 85% NBS efficiency.

f. Acidic fumes containing sulfur dioxide etc. should be removed.

3. Conditions suggested by Dr. Young, Emeritus Head of the Research Laboratory of the Boston MFA:

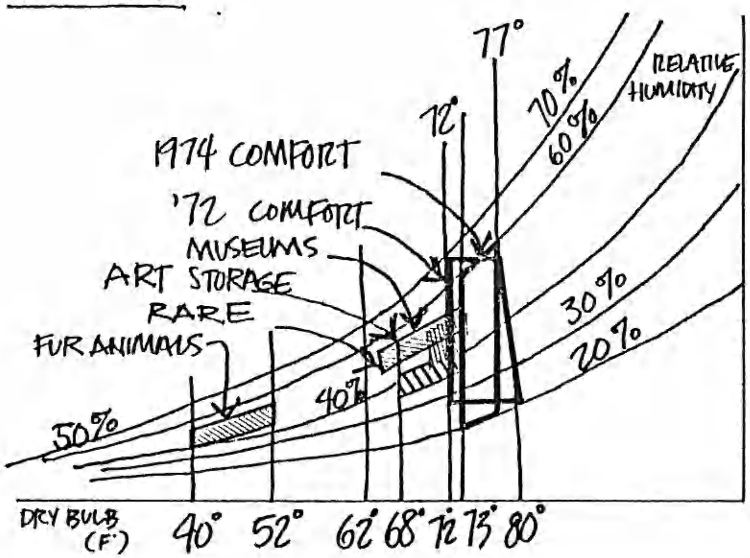
a. Summer: 72°Fdb, 55% RH, 7°F day/night variation, 10% RH daily variation.

b. Winter: 65-68°Fdb, 45% RH, 10°F day/night variation, 10% RH daily variation.

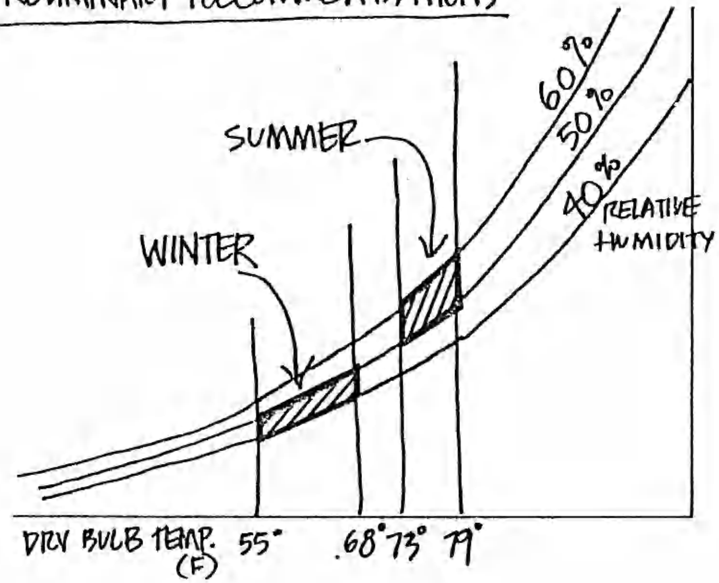
c. Ozone 5-10 ppm

d. Nitrogen oxides 5-10 ppm

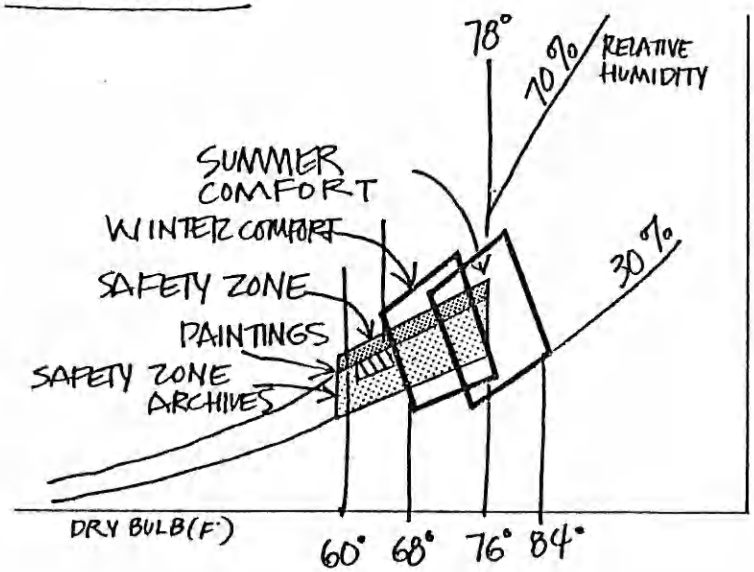
ASHRAE



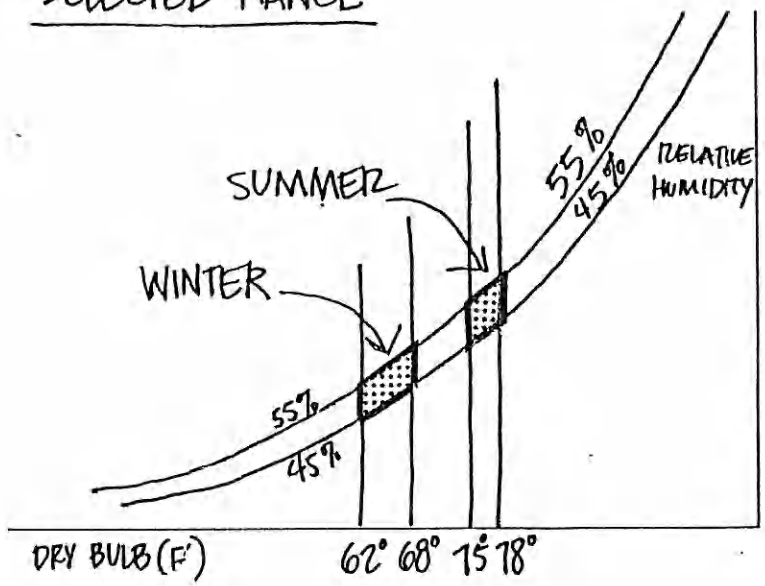
PRELIMINARY RECOMMENDATIONS



BRAWNE



SELECTED RANGE



e. Sulfur dioxide 30 Mg/cu.m.

Temperature and humidity ranges of the above are depicted in the diagram, and the final design objective range superimposed to give the relationship with respect to the general guidelines. Air quality and treatment will be included under "Air Treatment", section B6.1.

4. Temperature/humidity levels suggested for the Wharf Project. Review of the artifact inventory furnished by the Children's Museum and the Museum of Transportation shows a diverse collection covering metal, wood, leather, fur, stone, shells, woven materials, paintings, etc., too diverse to be classified under any one group covered by the guidelines given above.

It was therefore necessary to arrive at a set of criteria that would be compatible for the diverse collection, acceptable to both institutions and not overlook the energy conservation objective, including the desirable characteristics of climate control systems for museums. The following temperature and humidity levels were suggested by R. G. Vanderweil for consideration at one of the working meetings:

a. Summer: 76°Fdb, 50-55% RH to be maintained 24 hours a day with 2°F and 5% R.H. variation.

b. Winter: 68-70°Fdb, 40-45% RH to be maintained 24 hours a day with same variations as above.

c. Changeover from summer/winter levels should be manually adjusted over a 5-7 day duration to minimize thermal/humidity shock.

d. The climate control system should be operated 24 hours a day year round.

C. Selected Climate Control Criteria for the Wharf Project

After reviewing the above guidelines with Dr. Young and the Museum Directors, the following temperature-humidity ranges were selected as the design criteria for the Wharf Project, to be maintained uniformly year round.

Summer: 75-78°Fdb, 45-55% RH.
Winter: 63-68°Fdb, 45-50% RH.

These differed slightly from the various guidelines but the compromise was considered acceptable relative to the objectives for the Wharf Project and also consistent with maximizing energy conservation (as best as possible within the stringent museum requirements).

D. Overview of Ideal Museum Climate Control System Characteristics

1. Control and maintain temperature and humidity levels 24 hours a day, year round, and avoid rapid changes.

2. Maintain good air circulation to avoid stagnant air.

3. Provide means to clean the air including treatment of outside air as necessary.

4. Relative to 1 and 3 above, it becomes necessary to minimize the ventilation air requirement to avoid an extensive air treatment plant, when such treatment is necessary; minimize infiltration and air leakage to optimize benefit of air treatment equipment.

5. Provide a reasonable degree of system reliability without excessive standby equipment.

6. Provide a seasonable degree of system flexibility to accomodate changes in space utilization.

7. Avoid extensive water-steam piping to prevent possible damage due to leakage.

8. Resort to energy recovery measures to minimize energy consumption due to year-round operation and temperature-humidity levels maintained.

The final design objectives for the Wharf Project should include all or most of the above characteristics when physically and economically feasible.

B6.3 HUMIDITY CONTROL

In order to maintain the environmental conditions established in Section B6.2, the HVAC systems must be capable of both dehumidification and humidification when space conditions call for it. Humidity control as discussed in Section B6.B is necessary for artifact preservation, while secondary benefits include lowering of odor level and eye irritation of cigarette smoke, as well as a positive aid toward plant growth and reduction of static electricity buildup.

A. Influence on Building Structure

Certain limitations are imposed on the building structure by the level of humidity desired for museum artifacts. For practical and aesthetic reasons, it is necessary that double glazing be used to prevent surface condensation during low ambient temperatures. For operational economy, it is necessary to minimize infiltration and air leakage since they impose a load on the air conditioning plant and the heating plant. It was estimated that air leakage through the exterior walls of the Wharf building will be somewhere between 9200 cfm and 3100 cfm depending on what coating we give to the brick wall. These translate into annual energy costs of $12.000.00 and $4,000.00 respectively, based on 5¢ per kwh for cooling energy and 40¢ per gallon of #2 fuel oil for heating and humidification. (Note that in Section B6.1, the lower figure was used to minimize outside air requirements.)

As a comparison, two coats of plaster on brick will reduce the leakage by 96%, reducing the air quantities to 370 cfm and 123 cfm respectively, and proportionately, the annual energy cost to $480.00 and $160.00.

Against this highly desirable treatment, the effect of such treatment on the existing wall material must be considered. Suffice to say that from the environmental control point of view, reduction of leakage with simultaneous reducation in infiltration will provide better controls and operational economy.

B. Dehumidification/Humidification Method

For the Wharf Project, dehumidification will be achieved by chilled water coils in air handling units, controlled by a space humidistat. Atomizing spray type humidifiers in the air handling units are selected for use due to low initial cost and the anticipated utilization of domestic hot water which may be produced by solar collector and heat recovery processes when available.

B6.4 SMOKE CONTROL

Smoke control provisions as outlined in this section relate to the main building alone, since by code, at least one smoke-proof stairway enclosure must be provided for the WHarf Project per sub-article 618.

The main building, which, under Mass. building codes, is classified as USE GROUP F-3, does not require smoke control provisions. The staff and administrative Spaces, however, will be classified as USE GROUP E, which falls into the category where smoke control will be required.

Our recommendation for a smoke control system for the Wharf Project is directed at minimizing smoke damage potential to artifacts. It is consistent with other preservation measures accorded to artifacts in this Project. It will also provide a secondary but equally important benefit in the form of safer occupant evacuation in case of fire emergencies.

A few options applicable to the Wharf Project are briefly discussed herein with relative costs tabulated in the accompanying table.

A. Options

Each typical module of the Wharf Building, together with the air handling system, could constitute a smoke compartment. The air handling units continue to operate in all other modules except those serving the emergency compartment.

Option 1: Provide 20 square feet of operable or breakable panels or windows at 50 ft. intervals along the exterior walls for each level. Smoke evacuation and seepage will be unpredictable depending on prevailing wind conditions at the time.

Option 2: Same as option 1, except, provide automatic louvers in lieu of manually operable or breakable openings. Smoke evacuation and seepage same as option 1. In addition, some infiltration-exfiltration will occur.

Option 3: In lieu of perimeter openings, provide mechanical smoke evacuation via a smoke shaft. If strategically located, three smoke shafts will serve the whole building. This will allow a positive smoke evacuation path and smoke seepage to other parts of the building will be minimized due to the pressure differentials between the affected and unaffected bays.

Option 4: Same as option 3 except all the air handling units (with the exception of those serving the affected compartment) will revert to smoke control mode, introducing 100% outside air (unfiltered). This will provide larger pressure differential further minimizing smoke seepage but subject to untreated air for the emergency duration.

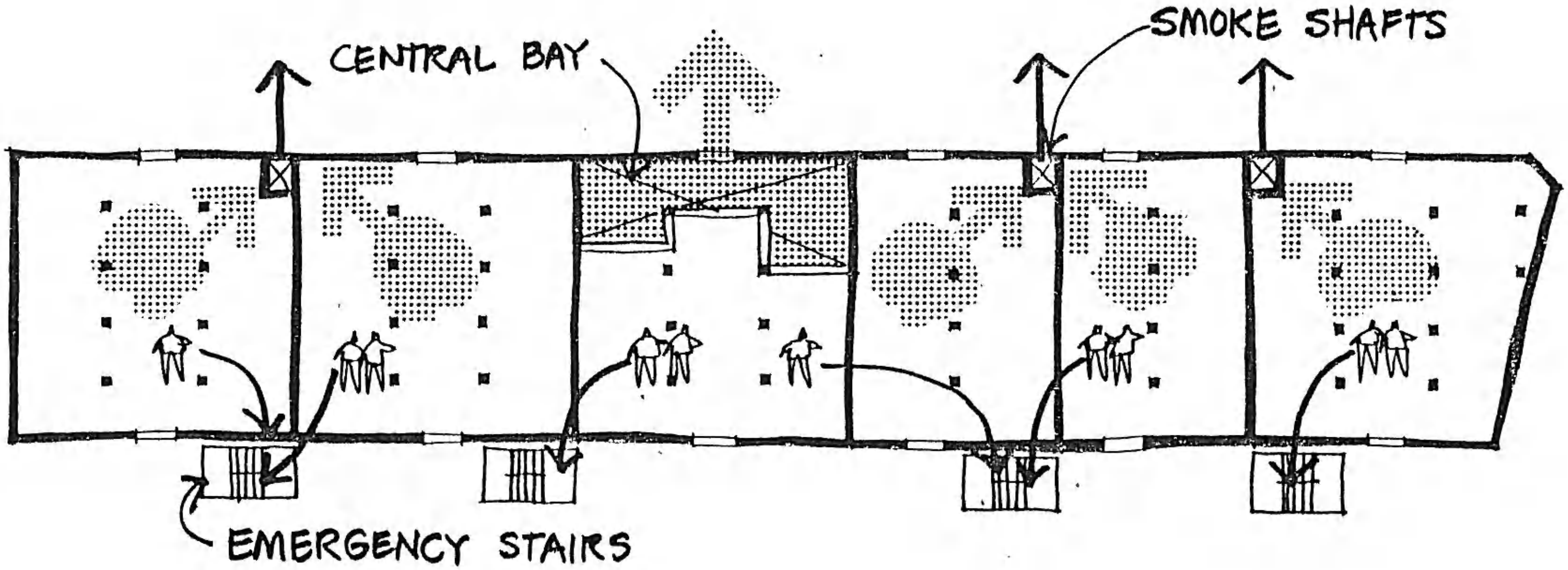
The above options happen to be in the order of increasing effectiveness with attendant higher first cost.

B. Recommendation

Option 3 in our opinion should provide an adequate degree of smoke control with a lower first cost than Option 4. In addition, the supply air in the recommended option will not exceed the filtration capability of the mechanical equipment and, thus, the supply air quality to the unaffected bays will be maintained.

SMOKE CONTROL SYSTEMS COST ANALYSIS

	Option 2	Option 3	Option 4
Perimeter Openings	21,600	-	-
Auto. Controls	3,600	3,600	3,600
Smoke/fire dampers	-	9,000	9,000
3 fans @ 7500 cfm 1/2" S.P.	-	12,000	12,000
3 40x30 smoke shafts	-	21,000	21,000
O. A. Intake	-	-	36,000
Sub-Total $	25,200	45,600	81,600
15% P & O	3,800	6,800	12,240
Total $	29,000	52,400	93,840


CENTRAL BAY
SMOKE SHAFTS
EMERGENCY STAIRS

B6.5 ENERGY CONSERVATION (CLIMATE CONTROL)

It is important that climate control be achieved with a minimum of energy consumption. For the Wharf Project, the environmental objective developed under Section B6.2 requires that the climate control system be operated 24 hours a day, year round to maintain desirable conditions. This increases the incentive to design a climate control system for maximum energy economy.

This section is directed at investigating systems compatible with the Dec. 1975 concept of a decentralized air handling scheme with centralized chilled water and hot water plant. Additional requirements include objectives developed under both Sections B6.1 and B6.2 must be considered in these investigations.

Energy conservation methods such as free cooling during low ambient temperatures and heat recovery applications compatible with the above scheme are included to develop a system first cost and operating cost to aid in the selection of an optimum design for the Wharf Project Climate Control System.

A. Preliminary Equipment Sizing

Bsed on the Dec. 1975 plans and design objectives, the building cooling and heating/humidification loads were estimated. On the basis of projected museum operation, building occupation was established as from 8 am to 8 pm daily, 9 pm to 7 am as unoccupied. Using this criteria, the building load profiles were developed against ambient temperature for a whole year (see accompanning table) to obtain system costs. Although our investigations showed some economy in using a single chiller as compared to multiple chillers for the Wharf Project from a system reliability point of view, similar system reliability will be afforded by a modular boiler system including part load efficiencies. The air handling scheme offers a high degree of system reliability and thus provides a total environmental control system offering a more than adequate degree of reliability.

B. System Options

The options consist of different types of chiller plant selection, provision for free cooling capability and heat recovery capability. The estimated system initial costs and annual operating costs are summarized in the table.

Option 1. Based on installing 3 x 130 ton high efficiency packaged air-cooled chillers to supply chilled water to the individual air handling units. Free cooling and heat recovery not available with this scheme. Phasing possibility--in 3 stages.

Option 2. Based on installing 2 x 200 ton centrifugal chillers with open towers. The chiller plant will supply chilled water to the individual air handling units. Free cooling not available. Heat recovery not provided (possible with modification). Phasing possibility--2 stages.

Option 3. Same as option 2 except one chiller equipped for heat recovery. Free cooling not available..

Option 4. Same as option 2 except with closed circuit cooling towers. Free cooling available. Heat recovery not available. Phasing possibility--2 stages.

Option 5. Same as option 2 except replacing cooling towers with heat exchangers using channel sea water. Free cooling not provided (possible with modification). Heat recovery not available. Phasing --in 2 stages.

Option 6. Based on water cooled self-contained air handling units. Condenser water supplied by two closed circuit cooling towers. Free cooling not available. Heat recovery not provided (possible with modification). Phasing--in 2 stages.

Option 7. Same as Option 2 with addition of economizer cycle (free outside air cooling). Heat recovery not available. Phasing--in 2 stages.

C. Discussion

The operating costs developed in the table represent estimated energy cost to maintain year round climate conditions established under Section B6.2. On the basis of first cost and operating cost, Options 3, 4, 5, and 6 should be eliminated from consideration.

Option 1 offers the lowest first cost and the lowest operating cost (except for the economizer cycle represented by Option 7).

Option 7 has the highest first cost but offers the lowest operating cost. Compared with Option 1, the differantial in first cost is about $160,000, while the annual operating cost saving amounts to $7,720. This amounts to a present worth of about $70,000 at 10% interest rate over a 25 year period, (the normal life of chiller plants) which makes it a poor investment.

For all intents and purpoeses, Options 1 and 2 are identical in first cost and operating cost. While Op-

LOAD PROFILE AND FREQUENCY OF OCCURRENCE IN TEMP. RANGE IN HOURS

Temp. Range	Jan Hour Group 08-20	Jan 21-07	Feb 08-20	Feb 21-07	Mar 08-20	Mar 21-07	Apr 08-20	Apr 21-07	May 08-20	May 21-07	Jun 08-20	Jun 21-07	Jul 08-20	Jul 21-07
95-99											1		3	
90-94									2		8		15	
85-89							1		9		20		37	
80-84							2		15		50	4	74	7
75-79							4		29	2	64	12	75	39
70-74					1		11		49	4	62	49	69	81
65-69					3		18	2	68	21	61	78	55	100
60-64	1		1		4		31	6	49	54	40	69	31	79
55-59	1		2		10		49	14	54	70	31	74	11	47
50-54	4		6		18	5	52	36	45	83	18	46	2	15
45-49	10		10		40	4	66	61	29	68	5	21		3
40-44	36	7	31	6	74	29	72	93	19	47		6		1
35-39	62	34	67	41	92	94	37	79	4	16		1		
30-34	69	66	68	67	69	108	14	51		6				
25-29	70	58	58	64	39	68	3	13		1				
20-24	45	58	42	51	14	38		4						
15-19	41	50	27	36	6	15		1						
10-14	22	40	13	26	2	7								
5-9	9	33	8	22		3								
0-4	2	15	3	15		1								
<0		1		8										
	372	382	336	336	372	372	360	360	372	372	360	360	372	372

Temp. Range	Aug 08-20	Aug 21-07	Sep 08-20	Sep 21-07	Oct 08-20	Oct 21-07	Nov 08-20	Nov 21-07	Dec 08-20	Dec 21-07	Total 08-20	Total 21-07	Load Profile Tons 08-20	Load Profile Tons 21-07
95-99	1										5		405	106
90-94	9		2								36		400	101
85-89	29		10		1						107		388	88
80-84	59	5	26		4						230	16	372	73
75-79	74	28	45	4	13						304	85	348	50
70-74	76	57	56	33	20	1	3				347	225	326	28
65-69	59	99	64	50	40	4	10				378	354	308	10
60-64	39	85	57	61	50	30	20	4	4		327	388	292	-64
55-59	18	56	48	64	75	54	37	14	6	1	342	394	272	-26
50-54	6	27	31	67	69	66	49	34	12	2	312	381	252	-45
45-49	2	13	14	42	49	68	62	51	23	4	310	335	236	-61
40-44		2	5	22	28	62	64	59	45	15	374	349	218	-80
35-39			2	12	16	48	57	61	52	37	389	423	199	-98
30-34				5	6	28	40	65	65	73	331	469	182	-115
25-29					1	10	12	46	62	70	245	330	164	-133
20-24						1	6	20	45	59	152	231	144	-152
15-19								5	26	45	100	152	127	-167
10-14								1	16	32	53	106	109	-187
5-9									13	17	30	75	88	-208
0-4									3	9	8	40	70	-225
<0										8		27	53	-242
	372	372	360	360	372	372	360	360	372	372	4380	4380		

tion 1 has the advantage that the equipment is installed outdoors, thus freeing valuable building space, Option 2 offers a more flexible plant capacity without appreciable cost increase (Option 1, 390 tons max.; Option 2, 400 tons +/- 10%). Therefore, the final selection will depend on the final building load calculations and plant capacity requirement.

Free cooling as offered by Option 7 is offset by substantial humidification cost required to maintain conditions established under Section B6.2. The increase in first cost is due to air treatment requirement and larger supply ducts and relief ducts.

Heat recovery shows a poor return for the Wharf Project. The annual recovery reflected in Option 3 represents humidification cost saving. The reason is that when heat rejection is available (when there is a cooling load needing chiller operation) there is little or no heating required and vice versa. Additionally, the air handling system itself affords some heat recovery in the sense that the perimeter air (which normally would be cooler) is mixed with the interior air resulting in an air to air heat transfer. Another potential source of heat recovery is the building exhaust air through thermal wheel application. Based on the Dec. 1975 plans, the exhausts are somewhat isolated making its recovery economically unattractive.

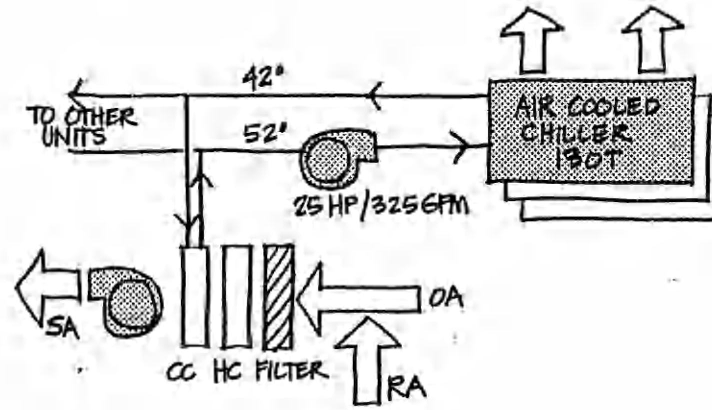
All cost figures are based on the entire building considered as 36 modules less 2 service modules. Utility services could be capped and provided with meters for rental spaces.

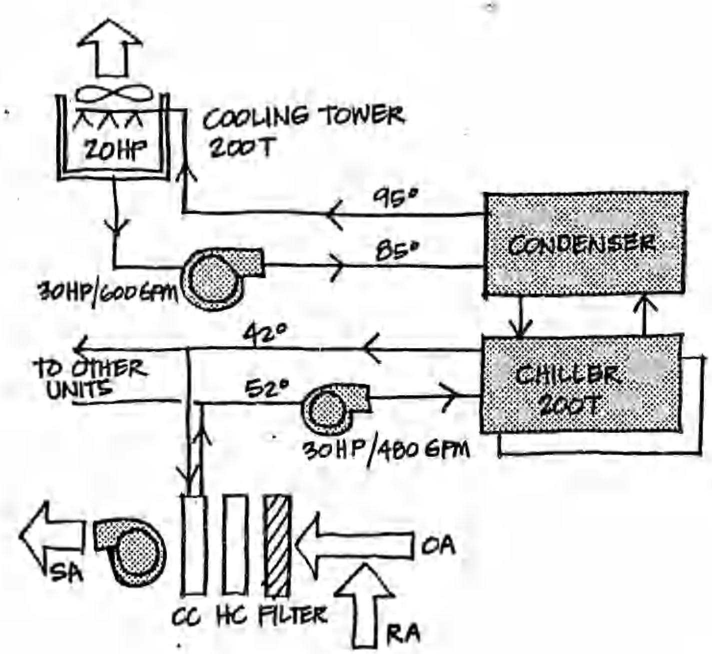
A further measure of energy conservation may be achieved by isolating the center bay from the rest of the building and operating the climate control system there on a basis of "as required".

D. Recommendation:

On the basis of the above analyses, we conclude that, for the Wharf Project, free cooling and heat recovery processes do not show economic feasibility due to the building operational requirements as described previously.

From the system first cost and operating cost, we would recommend either Option 1 or Option 2. The final selection will depend on the final building cooling plant requirement. For example, the analysis was based on load estimates for the whole building; if services for the rental spaces should be excluded, it may prove to be a major factor in the final selection of the system and equipment.





SYSTEM FIRST COST AND ANNUAL OPERATING COST SUMMARY

System Options Cost Items	Air Cooled Chiller w/ F.C. Units	Cent. Chiller Open Tower w/F.C. Units	Opt. #2 w/Heat Recovery	Cent. Chiller w/C.C. Tower & F.C. Units	Opt. #2 w/Sea Water Ht. Exchanger	C.C. Tower w/Unitary A.C. Units	Opt. #2 w/100% Outside Air	Dec. 1975 Cost	Reductions for Museum Requirements Only Option 1	Option 2
Chiller System	112,500	86,000	98,000	112,000	98,000	45,000	86,000		112,500	86,000
Cond. Water Piping	0	15,000	18,000	18,000	20,000	19,000	15,000		0	15,000
Chilled Water Piping	16,000	16,000	16,000	16,000	16,000	0	16,000		16,000	16,000
Chilled Water Risers	16,500	16,500	16,500	16,500	16,500	9,000	16,500		16,500	16,500
Chillers Controls	4,500	6,000	7,500	7,500	9,000	3,000	6,000		4,500	6,000
Air Handling Units (124)	148,800	148,800	148,800	148,800	148,800	403,000	173,600		125,000	125,000
Outside Air Risers	12,600	12,600	12,600	12,600	12,600	12,600	68,000		10,600	10,600
Supply Air Distribution	230,000	230,000	230,000	230,000	230,000	203,000	230,000		193,000	193,000
Water Treatment System	1,000	3,000	3,000	1,000	1,000	1,000	3,000		1,000	3,000
Hot Water System	60,000	60,000	60,000	60,000	60,000	60,000	60,000		50,400	50,400
Air Filtration System	6,000	6,000	6,000	6,000	6,000	6,000	51,000		6,000	6,000
Instrumentation	7,500	7,500	7,500	7,500	7,500	7,500	7,500		7,500	7,500
Temp. Controls	37,200	37,200	37,200	37,200	37,200	0	37,200		31,300	31,300
Equip. Install - Elec. Inclusive	38,900	47,900	49,400	49,400	45,900	30,200	47,900		38,900	47,900
Sub Total	691,500	692,500	710,500	722,500	708,500	799,300	817,700		613,200	614,200
10% Contingency	69,100	69,200	71,000	72,200	70,800	79,900	81,800		61,300	61,400
15% Profit & Overhead	114,100	114,260	117,225	119,200	116,900	175,900	134,925		101,200	101,300
Total $	874,700	875,960	989,725	913,900	896,200	1,055,100	1,034,425	775,000	775,700	776,900

Annual Operating Cost (Operating/Maintenance Personnel Not Included)

Cooling Per Year @ 5¢/KWH	70,000	68,670	68,670	82,340	74,670	105,670	68,670	65,620		
Heating Per Year @ 40¢/Gal.	13,500	13,500	13,500	13,500	13,500	13,500	13,500	12,500		
Humidification/Year @ 40¢/Gal.	2,450	2,450	2,450	2,450	2,450	2,450	2,450	0		
Filtration System Maintenance/Yr.	1,200	1,200	1,200	1,200	1,200	1,200	6,000	0		
Chiller Plant Maintenance/Yr.	3,000	4,000	4,000	4,000	6,800	2,000	4,000	4,000		
Heating Plant Maintenance/Yr	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000		
Fan Optg. Cost/Yr @ 5¢/KWH	27,000	27,000	27,000	27,000	27,000	16,000	27,000	25,800		
Water Cost/Yr. @ $5/1000 ft^3	0	930	930	930	0	930	660	660		
Sub Total	118,150	118,750	118,750	132,420	126,620	142,750	123,280	109,580	99,246	99,750
Free Cooling/Yr.	0	0	0	-9,850	0	0	-20,400	-13,000		
Heat Recovery/Yr.	0	0	-950	0	0	0	0	0		
Additional Humidification/Yr.	0	0	0	0	0	0	+7,550	0		
Sub Total	118,150	118,750	117,800	122,570	126,620	142,750	110,430	96,580	99,246	99,750

B6.6 BUILDING AUTOMATION AND METERING

The feasibility of a building automation system for the Wharf has been studied with the objective of determining the appropriate types of building support equipment to permit proper allocation of climate control costs, functional and adaptable building security, and flexibility to meet the future needs of the museums and other tenants. The immediate purpose of this investigation is to determine the feasibility, cost and compatibility of several potential approaches to the building support requirements, including an overall integrated automation system and individual stand-alone components.

A. System Identification

An examination of the expected use of the Wharf building and the services required to support those uses has led to an identification of the following systems as essential components of the overall building scheme:

1. Fire Suppression and Detection
- detection and suppression-initiation circuits
- zone isolation and annunciation
- automatic temperature controlled fan/damper control interface
- evacuation alarm
- suppression control circuits

2. Security System
- authorized building entry control
- surreptitious entry detection
- individual exhibit protection
- internal access control
- tour group/crowd control

3. Environmental System
- temperature monitor/control
- humidity monitor/control
- HVAC units status
- fans start/stop
- outside air quality monitor
- filter status monitor
- boiler/chiller safety alarm
- energy conservation

4. Metering
- electric consumption
- electric demand limiting
- cooling effect consumption
- heating effect consumption

5. Lighting system
- yard lighting on/off supervision
- corridor/toilet room lighting control

B. Automation System Options

There are varying degrees of automation available to provide the above-mentioned facilities, ranging from simple independent automatic system controls to the more complex, totally integrated building automation system. Much of this investigation is directed at this latter system, particularly involving the use of the existing Children's Museum computer facility with additional data gathering and pre-processor equipment supplied by Digital Equipment Corporation, as opposed to a manufactured automation package. This approach suggests itself because of the relationship that has developed between the Museum and Digital over the past five years, leading to a contribution by Digital and the Hayden Foundation of a sophisticated PDP-11 timesharing computer system in 1974 on which an automation system could be based, and because the Museum has on-board an experienced computer systems analyst/developer.

The fire alarm system, unlike the others, is mandated by local codes and regulations which also define most of its functions and requirements. One such requirement is that all fire alarm components be UL approved. Digital's equipment does not meet this test and therefore the fire alarm system could not be integrated into a building automation system built around the Museum's computer. The potential does exist for "tapping" some of the various fire alarm system sensors so that the automation system could be used to gather and analyze data related to the operation of the alarm system; this capability, however, falls into the realm of "gravy" and has thus not been analyzed for this report.

Of the commercially available total building automation systems, only a few (e.g., Honeywell, Robert Shaw) are currently UL approved. Others expect to obtain such approval in the near future. The City of Boston accepts the use of the Honeywell system for fire alarm purposes on the proviso that a separate channel be used for the fire alarm mechanisms. This has the effect of requiring a duplication of wiring for the fire alarm detection circuits and HVAC control circuits, but they can be run in the same conduit.

C. System Capabilities

In an effort to define the issues involved in the development and programming of an integrated automation system based on the Children's Museum's computer resources, we will outline in some detail the capabilities required of such a system. Cost analysis and

TOTAL BUILDING SENSOR/CONTROL NEEDS

	ANALOG		DIGITAL (ON/OFF)		SERIAL COMMUNI-CATIONS
	SENSORS	CONTROLS	SENSORS	CONTROLS	
Central Facilities					
Chillers					
Supply Water Temp.	1	1			
Return Water Temp.	1				
On/off				2	
Boilers					
Supply Water Temp.	1	1			
Return Water Temp.	1				
On/off				2	
Air Handling Units					
Per-Bay:					
Supply Air Temp.	34	34			
Space Air Temp.	34				
Space Humidity	34				
Per-Unit:					
On/off				126	
Filter Status			126		
Outside Air (7 locations)					
Filter Status			7		
SO_2 monitor	7				
dampers close/open				7	
smoke detection	7				
Metering System					
Watt-Hour Meters	8				
Supply Water Temp.	34				
Return Water Temp.	34				
Air Flow	34				
Security System					
Card-Access Points					24
Intrusion Alarms			24		
Ionization Detectors			295		
TOTALS	230	36	452	137	24

evaluation will compare the Museum's automated package with both stand-alone automatic controls and a commercially-available integrated package.

The HVAC control system is the largest portion of a building automation system. The HVAC concept for the Wharf Project is a hybrid composed of a centralized boiler/chiller equipment plant and decentralized air handling units. Each air handling unit is equipped with a heating coil, a cooling coil, a humidifier, a filter bank and a fresh air intake. Heating water, cooling water and a humidification medium will be supplied from the central plant. Detailed control sequences will need to be finalized during the design phase, but the automation system must provide the following essential capabilities:

1. Temperature control -- to maintain general space temperature in each individual building bay, through a system of valves and sensors, and secondary temperature control of the supply temperature of the hot and chilled water sources. The automation system must monitor space temperature and allow remote adjustment of the control valve set points to maintain space conditions.

2. Humidity control -- the building bay humidity level will be controlled by a manual room humidistat controlling the humidifier with the automation system monitoring the level of humidity. The automation system based on the Museum's computer will have the capability to be expanded to automatic remote setting should that prove desirable and cost-effective.

3. HVAC units -- monitor and log the operational status of all HVAC units.

4. Fans start/stop -- remote start/stop capability for all HVAC equipment.

5. Outside air quality -- monitor and alarm/log outside air quality status including shutdown of affected units. Elements to be monitored include sulfur dioxide level, smoke concentration and filter pressure drop, which indicates the filters need to be cleaned or changed.

6. Filter status -- monitor and alarm/log of filter status for each air handling unit.

7. Boiler/chiller safety -- monitor and alarm/log boiler/chiller safety alarm.

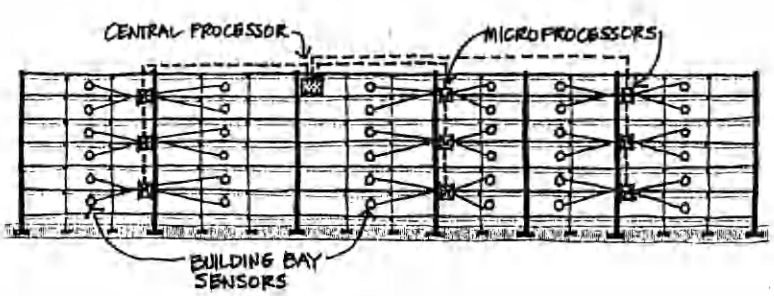
8. Energy conservation -- through close matching of space conditions, turn equipment on/off and/or compensate by adjusting set points.

9. Electric power demand limiting -- through supervision of on-line equipment at all times including start/stop of central equipment.

10. Metering -- remote metering/log of electrical power consumption; monitor/log temperatures and flow of hot and chilled water system for each individual building bay. This will be of greatest utility in the commercial areas of the building.

11. Lighting control -- supervise the on/off status of yard and other lighting systems in support facilities during off hours.

12. Security system -- integrate all functions of the security system outlined under B4. The card access system proposed therein is compatible with an automated building system. Most of the unauthorized entry detection methods reduce to a switch type operation and/or sounding an alarm. The issue of crowd and tour control is extremely nebulous, and no system has been evaluated that can satisfactorily resolve the problem of a strayed child facing unopenable doors. It was therefore concluded that a crowd/tour group control facility is not a feasible inclusion.



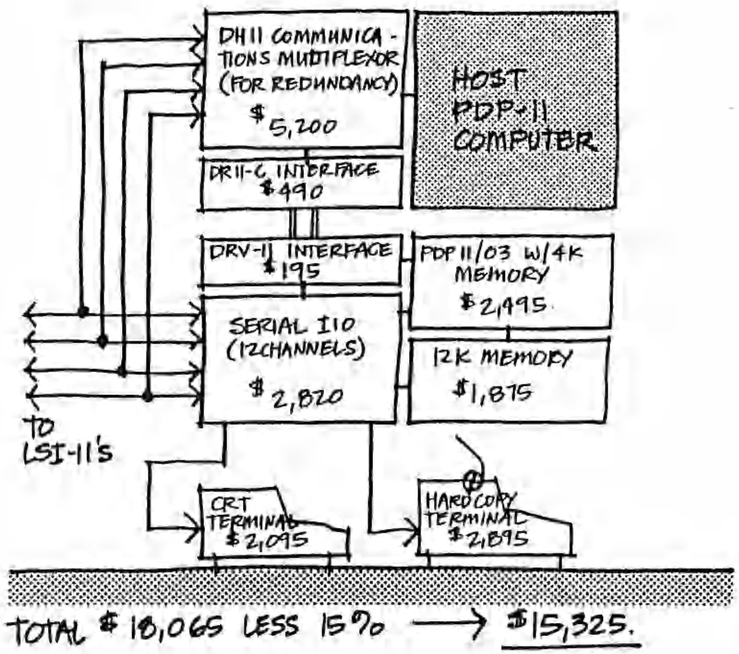
D. Automation System Design

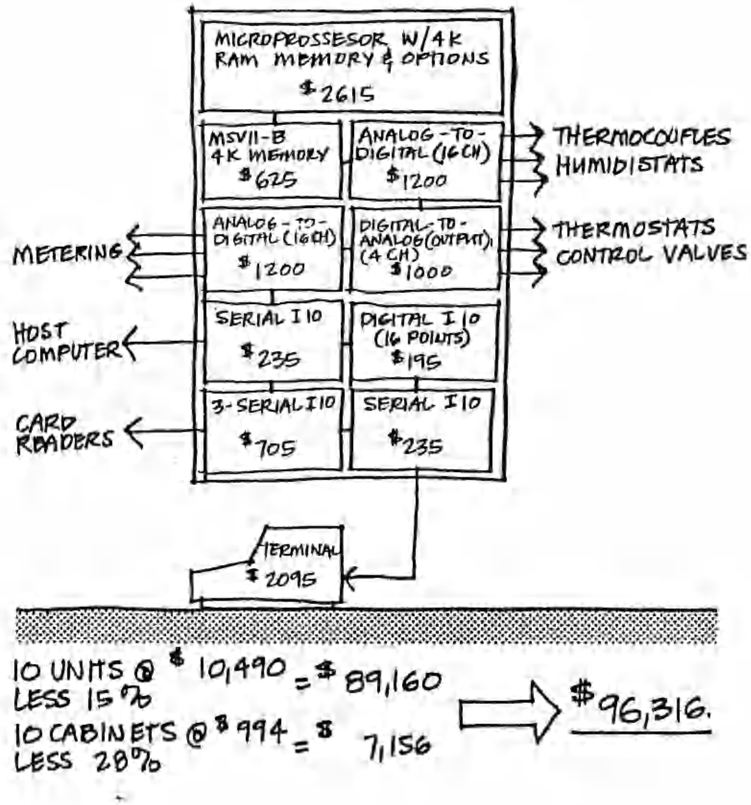
Analysis of the above-mentioned capabilities leads to the identification of the total building sensor and control needs shown in the accompanying table. Clearly, there are a very large number of points to be dealt with. Wiring all of these points to a central control module would be very expensive, inflexible, and cumbersome; hence, it was determined early in the study process that a system of multiplexing the various signals should be provided.

For the purposes of the study, the building has been divided into nine units of four building bay modules each, with each unit being monitored and controlled through one multiplexing/data collection device.

In the evaluation of appropriate multiplexing and data-collection strategies for a building automation system taking advantage of the Children's Museum's existing PDP-11 timesharing computer facility, it soon became clear that the most cost-effective mechanism was to distribute computing power throughout the Wharf building using a network of microprocessors communicating with the central host computer system.

Each microprocessor would provide analog-to-digital data conversion facilities and multiplexing capabilities, and would, additionally, possess computational powers enabling it to maintain a basic level of building service even in the event of a complete failure of the host computer. The microprocessors would be Digital Equipment Corporation LSI-11 units, which utilize the same instruction set and many of the same peripherals as the Museum's PDP-11 timesharing system; thus, equipment and programming development and installation can be begun virtually immediately at the Museum's existing site using existing facilities, minimizing potential problems at moving/installation time. Each LSI-11 communicates with the host PDP-11 over a high-speed, asynchronous serial communications line physically configured as a dual twisted pair cable. Each LSI-11 is equipped with its own terminal for interactive monitoring and adjustment of any sensor or control in its four building bay module unit (or, with appropriate software, anywhere in the network) at the LSI-11's installation site. Additionally, the LSI-11's have expansion capability that could permit them to better facilitate the efficient operation of the Museum's overall data-processing facility by acting as terminal multiplexers as well.





Communications with the host processor is actually envisioned as not direct, but rather through a PDP-11/03 front-end processor which would act rather like a "multiplexer multiplexer" and provide sufficient computational ability to completely operate the system, using the host computer as a redundant backup system and for the ongoing storage and analysis of collected data over the long term. In fact, this ability of the system to provide redundant operation in the event of any failure at the system level is one of its most important features. (Failures at the individual multiplexer level will affect only those modules governed by that multiplexer, can be easily detected and alarmed by the host computer, and will be resolved by simply plugging in a spare microprocessor kept on hand for such contingencies.)

The configuration of a typical LSI-11 as envisioned at this early stage in the design of an automation system and the entire network is shown in the accompanying diagrams.

E. Cost Analysis

With the many variables involved, it was found necessary to develop costs on the basis of a complete building automation system providing the above-mentioned capabilities, and then identify the deviations with reference to this base cost as a plus or minus quantity in evaluating the relative merits of stand-alone systems. The cost of the system utilizing existing and expanded Digital Equipment facilities was derived from the bottom up to meet or exceed the proposed requirements, as described in the previous section.

Under the basic system development cost shown in the table, all of the capabilities listed above would be provided. Not included are the costs of the sensors, control valves, dampers/damper operators, etc., which are essentially the same for all alternatives, and found in the costing options of Section B6.5. Thus, the base costs shown reflect the cost items associated with automating a system, e.g., data conversion and collection, processor units, related software packages and installation.

It should be noted that there are several ways in which the cost of a Digital Equipment-based system might be reduced. For instance, there is no reason why the power of the LSI-11 microprocessors needs to be limited to governing four building modules; six or eight is a far more reasonable and cost-effective number, and the total system cost is reduced correspondingly. The cost-effectiveness of filter status monitoring can be questioned; it might be more advantageous to simply clean/change the filter units at prescribed intervals, "whether they need it or not"; the cost of monitoring so many points is substantial. Finally, the need for a computer terminal at each LSI-11 location for monitoring and control could be questioned. It is anticipated that a minimal but complete system (excluding the fire alarm package, which, as noted earlier, must be implemented separately under this scheme), in view of expected future declines in computer equipment costs, could be assembled and installed in the $100,000-$120,000 range.

F. Conclusion

The table shows that a packaged building automation system is about 25% more than a stand-alone system, while a system built around the Children's Museum's computer facility offers substantial cost savings over either of those approaches.

If an automated system is contemplated, it appears that a totally integrated system including security, environmental control, etc., should be considered. On the other hand, the operational requirements of the building as establisned under Section B6.B, wherein the building will be maintained under the same conditions and operated 24 hours a day year round, suggest that the need for allocating expenses on a metered basis needs to be carefully reassessed. As shown, the metering aspect of a building automation system is very expensive in terms of the number of analog sensors it presents for constant monitoring. It might well be argued that a more cost-effective approach would be to simply charge users on a flat-rate basis, with the rates governed by the results of occasional metering. The metering system constitutes a minimum of $8,400 in equipment costs alone; additional costs of course appear in the load able to be withstood by the individual microprocessors (and thereby the number of them required), programming costs, and the 110 sensors themselves.

Finally, a series of advantages to the in-house-developed automation system that do not appear in the cost figures also suggest themselves. Among these are:

- The flexibility potential inherent in a timeshared computer network approach to the problem;
- The possibility of other uses of the computer camping on the automation system microprocessors at negligible cost;
- The fact that all equipment in the system is produced by the same manufacturer and the inherent servicing benefits resulting from such an arrangement;
- The potential for easy on-the-spot isolation and servicing of failures because the system design and implementation are understood by Museum personnel; and, of course,
- The Children's Museum's long-standing relationship with Digital Equipment Corporation, its equipment, and its personnel.

BUILDING AUTOMATION SYSTEM COST COMPARISON

	Approved Fully Automated Package	Digital Automated System	Independent 'Stand-Alone' System	Stand-Alone System Summary	Museums' Requirement for Digital Automated System
Fully Automated Package Base Cost	250,000[1]				
Components:					
Central Processor/Software Packages	50,000		-50,000		
HVAC Control	85,000			55,000	
Data Collection Panels			-38,000		
Increased 'Legwork'			+3,000		
Energy Conservation			+5,000		
Security System	18,000			11,000	
Separate Annunciation			+2,500		
Additional Wiring		136,800*	+2,500		90,300
Power Supply, Data Interface		30,000[2,3]	-12,000		20,000
Metering System	57,000			65,200	
Individual Meters			+5,500		
Data Collection Interface			-6,500		
Separate BTU Meters			+5,700		
Software Integration			+3,500		
Fire Alarm System	40,000			54,800	
Separate Conduit		55,000[3]	+3,000		36,300
Halon System Selective Discharge			+2,500		
Fan/Damper Control			+9,300		
Total Cost[3]	$250,000	$221,800	$186,000	$186,000	$146,600

Digital Equipment annual hardware maintenance - $8,000 (upper limit; service strategy for bulk of system calls for maintaining spare modules on-site. Substantial reductions in this figure may be expected after the first one or two years.)

*DIGITAL EQUIPMENT (base system cost)

Microprocessors and cabinetry (10)	96,400
Central Processor Enhancements	15,400
Software (upper limit)	25,000
TOTAL	$136,800

Notes:
1. Price includes 15% Profit and Overhead: Honeywell or Robert Shaw Building Automation System.
2. Conduit/wiring between sensors/panels and panels/processor.
3. Includes 15% Profit and Overhead for subcontractor

The tasks outlined included investigation of acclimatization chambers. One was to delint and dehumidify visitors prior to entering exhibit areas. The other was to gradually adjust visiting exhibits to the museum's ambient climate. The latter was dropped in favor of fumigation chambers which would also include acclimatization of artifacts to the museum's ambient conditions.

During the various working sessions, Dr. Young recommended two possible fumigation systems, one using paradichlorobenzene and the other using ethylene oxide.

We have assembled additional information regarding these two systems. They are presented for final consideration as to their application in the Wharf Project. The delint and dehumidification room will also be briefly discussed.

A. Fumigation System (Passive Method)

This involves the use of paradichlorobenzene, a solid which sublimates into a heavier-than-air gas at ambient conditions. Long exposure period is required to be effective. Some specimens and materials tend to retain the gas thus making subsequent nandling by personnel somewhat unpleasant. Moth crystals may be used in display cases, sealed chabers or rooms, or sealed in polyethylene bags. The climate control system in collection areas will have to be designed to provide sealing and isolation which would not be too difficult to accomplish. Large volume disposal would necessitate active air purging by exhausting to the outside. This system is anticipated to be used in collection storage areas roughly once a year.

B. Fumigation System (Active Method)

The active method involves the introduction of fumigant gases into chambers, bags or sealed rooms. Gases frequently used are ethylene oxide and proplylene oxide. Since the latter is mainly used for food sterilization and more difficult to use at ambient conditions, it was not actively investigated. Pure ethylene oxide is mainly used in small medical sterilizers and requires specimens to be subject to elevated temperatures 100°-160° F and a vacuum of 29" Hg. It is both toxic and explosive. In small volumes, it presents no disposal problem. However, in walk-in-size chambers, it would be extremely hazardous and therefoure not advisable for the Wharf Project application.

Ethylene oxide in dilute mixtures is also used for fumigation purposes. In this dilute form and under ambient conditions, the sterilization period is necessarily longer, 16-18 hours.

Two of the more common mixtures are Oxyfume 12 and Carboxide. Oxyfume 12 consists of 12% by weight of ethylene oxide and 88% Freon 12. The mixture is only slightly flammable and not explosive. Typically, it is used in sealed chambers, rooms or in conjunction with bags of 6 mil polyethylene. Although residuals must be limited to 50 ppm, with approval of the Mass. Dept. of Environmental Quality Engineering (DEQE), it may be exhausted directly to the atmosphere. The long term use of Oxyfume 12 is not encouraging, since DEQE has expressed that Freon 12 may be banned in the near future due to its potential threat to the ozone layer.

Carboxide may be a better alternative. This consists of 10% ethylene oxide and 90% carbon dioxide. It is rated nonflammable as long as the gases do not separate. (It must be used with caution and manufacturers' recommendations should be followed.) In its liquid form the mixture attacks rubber. Carboxide is used in the same fashion as Oxyfume 12 and the same disposal is required, i.e., with approval from DEQE, it may be exhausted directly to the atmosphere.

This system is anticipated to be used in a fixed location to fumigate new or returning artifacts to the collection storage areas.

Typical usage of the above mixture is 15-24 lb. per 1000 cubic feet for a duration of 16-18 hours. Oxyfume 12 currently sells for about 80¢ per lb. and carboxide about 50¢ per lb.

C. Chambers

As mentioned previously. fumigation may be accomplished in chambers, bags or sealed rooms. Chambers may be custom built or adapted from sterilization chambers made by American Sterilizer Co. (AMSCO) for hospital use. by deleting the temperature, vacuum and steam services. Use of such chambers engineered for fumigation/sterilization would be more reliable.

Dr. Young suggested that Army Supplies Stores may be contacted for ethylene oxide fumigation units. Up to this writing, such contacts have not been fruitful. We will pursue this further.

Temporary containers for fumigation may be made from 6 mil polyethylene. Such bags may be used for awkward shaped items or immovable objects.

Polyethylene may be used to seal off rooms or parts of rooms for fumigation purposes.

Since with approval, these gases can be exhausted directly to the atmosphere, disposal systems need not be complicated. Exhaust systems with explosion-proof fans would be used to dispose of the gas from the chamber or room to the outside.

D. Cost Estimate

Costs for commercially available packages of different sizes are shown below.

FUMIGATION SYSTEM COSTS

Fumigation System (without climate control)
Packaged fumigation chambers (Kewannee) using Oxyfume 12 or Carboxide:

a. 5'-3"Wx5'-0"Dx6'-6"H (inside dimen.)	$16500.00
complete exhaust system	1950.00
TOTAL	18450.00
b. 2'-7"Wx5'-0"Dx6'-0"H (inside dimen.)	$ 5500.00
exhaust system (per location)	750.00
TOTAL	6250.00

Note: (b) is portable; equipped with rubber tired swivel casters

E. Discussion

Availability of a packaged fumigation unit from Army Surplus Stores as suggested by Dr. Young needs to be investigated. The cost figures given in this report are for complete commercially available units by Kewanee Scientific Equipment Corp.

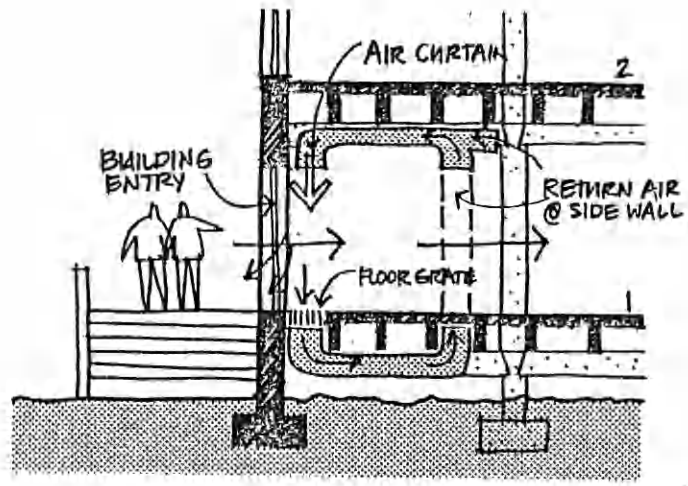
It should also be noted that the fumigation systems should be operated with caution and it would be advisable to furnish safety masks to personnel closely associated with operating the systems.

F. Recommendation

After consulting with Dr. Young it was decided that Carboxide should be used as the fumigant due to its long-range applicability. The size of the chamber required needs to be decided.

G. Delint/Dehumidification Room

An acclimatization entry space for the public would be desirable but not absolutely necessary from temperature and humidity maintenance standpoints. It may be more desirable for dust and lint removal. Such provisions would mean restricting visitors to one en-



try point, or to provide acclimatization chambers at all entry points, in order to be effective. Obviously the latter system would mean increased cost. Based on the Dec. 1975 plans for the Wharf Building, the main vestibule would be the logical location for such a room if all other entrances are restricted as entry to exhibit areas. The diagram depicts such a scheme which may require minor architectural modifications; attendant cost estimates are shown below.

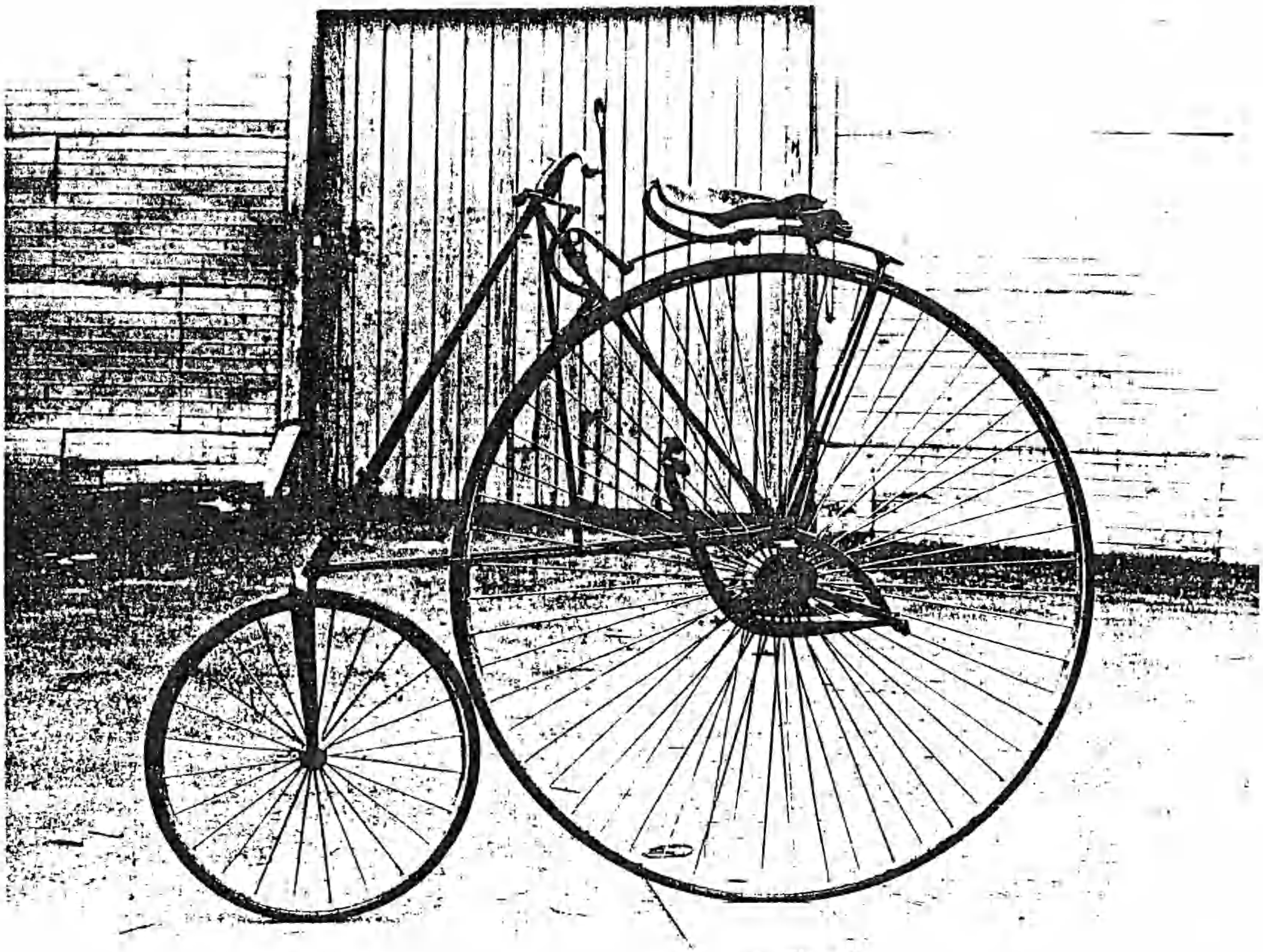
DELINT/DEHUMIDIFICATION SYSTEM

a. Single chamber (chilled/hot water from building system)

Equipment housing	$ 7800
Grating	3000
Structural Modification	2000
3000 CSM F/C Unit	2150
Controls and Electrical	1100
Sheet Metal Work	850
	$16900
Subcontractor Mark-up	2500
TOTAL	$19400

Any of these schemes would perform the objectives satisfactorily, and would be an asset for the climate control system.

Application of Construction Systems to the Wharf



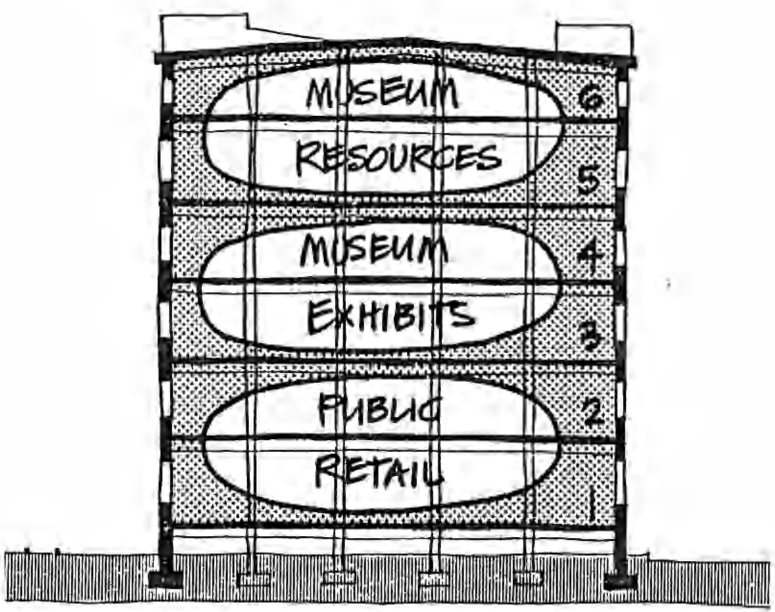
C. Application of Conservation Systems to the Wharf

This section applies the results of the study discussed in Section B to the actual building and its spaces. The following description of the program and area development orchestrates the individual study recommendations into a usable building program. Although modifications to this study will undoubtedly be made and the recommendations can be developed into more than one solution, the objective of this study is to provide the museums with an understanding of the effects these conservation efforts will have upon their programming and future development.

C.1 GENERAL BUILDING PLAN

The lower two floors of the building will be developed to provide commercial space for retail uses separate from museum functions; a portion of the first floor will also function as the service area and central mechanical plant for the building. Due to this commitment to provide service and retail space on the first floor and the need to separate visitor foot traffic from probable vehicle traffic in front of the building on the apron area, the main building entry will occur at second floor. The common museum orientation area will occur at the third level of the building directly over the building lobby; it will be both visually and physically connected by a generous stair access between the two lobby spaces. Passenger elevator access throughout the total height of the building will also occur off these central lobby bays.

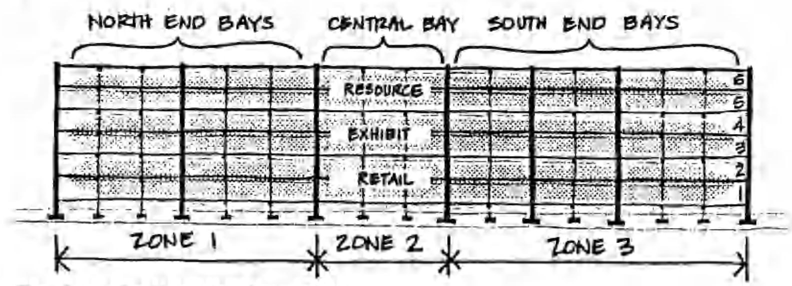
The middle two floors of the building will be developed for museum functions with heavy public usages, i.e. exhibit and program space. Finally, the upper two floors will be devoted to museum staff, support, and resource functions - those activities requiring less public use.



SECTION SHOWING BUILDING ACTIVITIES

A. Vertical Building Zones

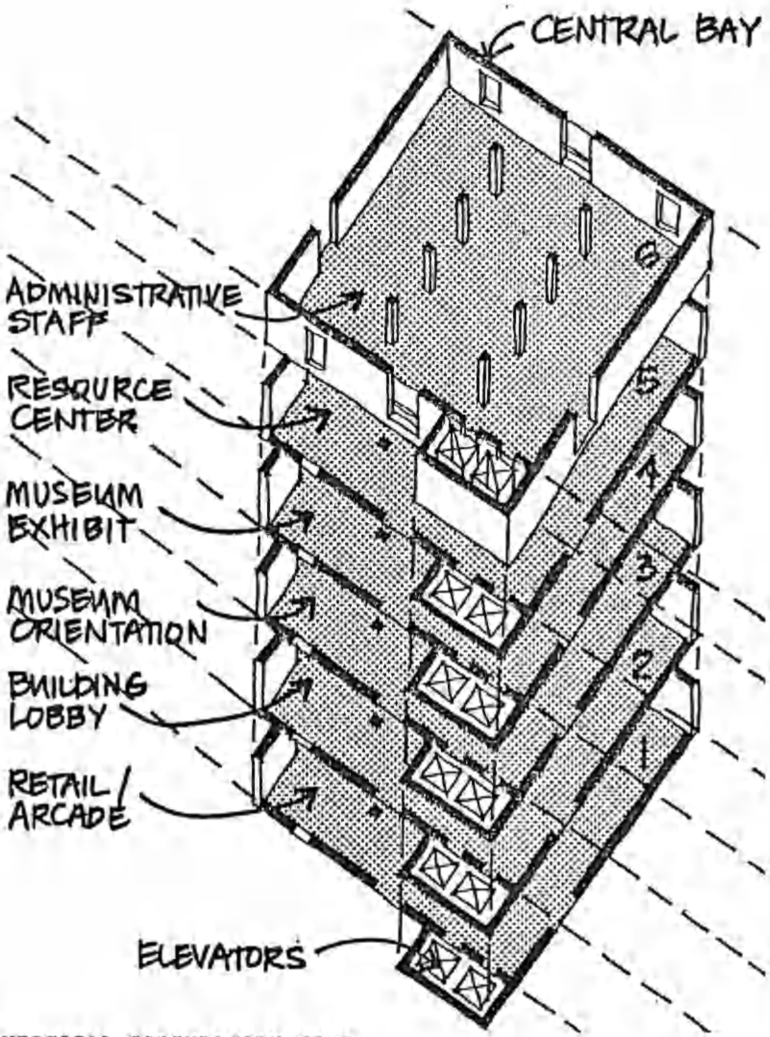
The circulation demands on these lobby areas, combined with the main stairway and passenger elevator access to the upper levels, dictates a central location for these access and control functions within the length of the building. Therefore, overlaying the three horizontal divisions of the building described above (retail, exhibit and non-exhibit) will be three vertical zones. These zones are reflected in nearly every discipline area of this study. At present, the two end or outer zones of the building (the northern two building bays and southern three building bays, respectively) are very similar in their programmatic, environmental and security requirements, while the center zone or central vertical series of bays will be developed to a different set of functional requirements.



VERTICAL BUILDING ZONES

Functionally, the central bay will be the building's main vertical circulation core, containing reception areas and lobbies to control public access north or south to the outer zones. Building security will become more restrictive as one moves up through the building and out from the center core.

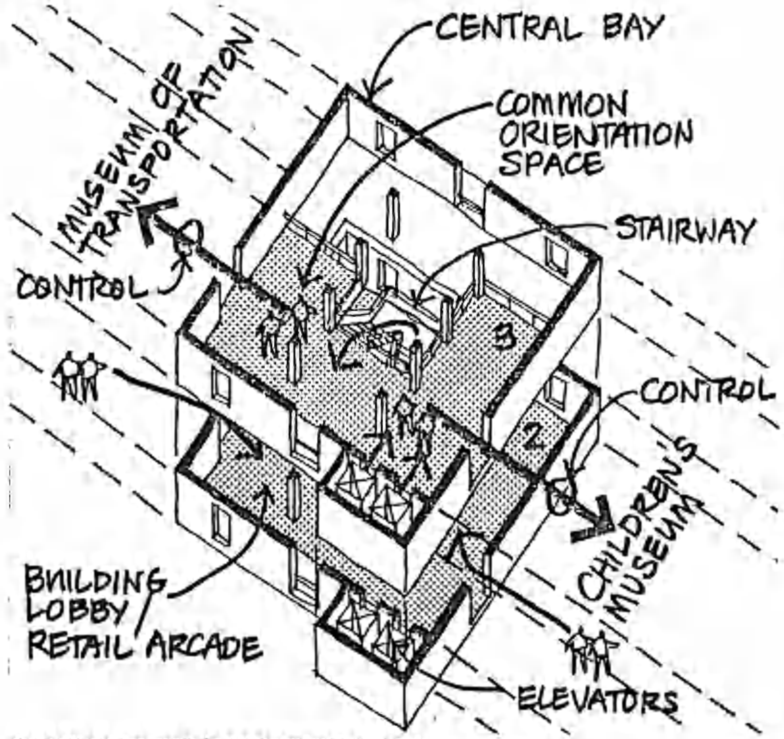
The central bay will contain functions that necessitate separate security, environmental and architectural requirements from those uses and functions located in the outer zones. Therefore, in part, the location of uses within the building will be determined by the the design criteria developed for these vertical zones.



VERTICAL CIRCULATION CORE

B. Museum Orientation and Exhibit Areas

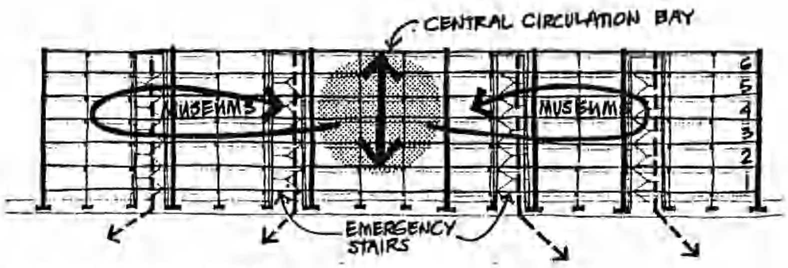
From the common museum orientation area the public will enter the "Front Door" of each individual museum. In addition to orientation, admission control, ticket sales and public services occur at this location. Access to various exhibits will occur from these orientation spaces horizontally on the third level and/or vertically to the fourth level.



MUSEUMS ENTRY/ORIENTATION AREA

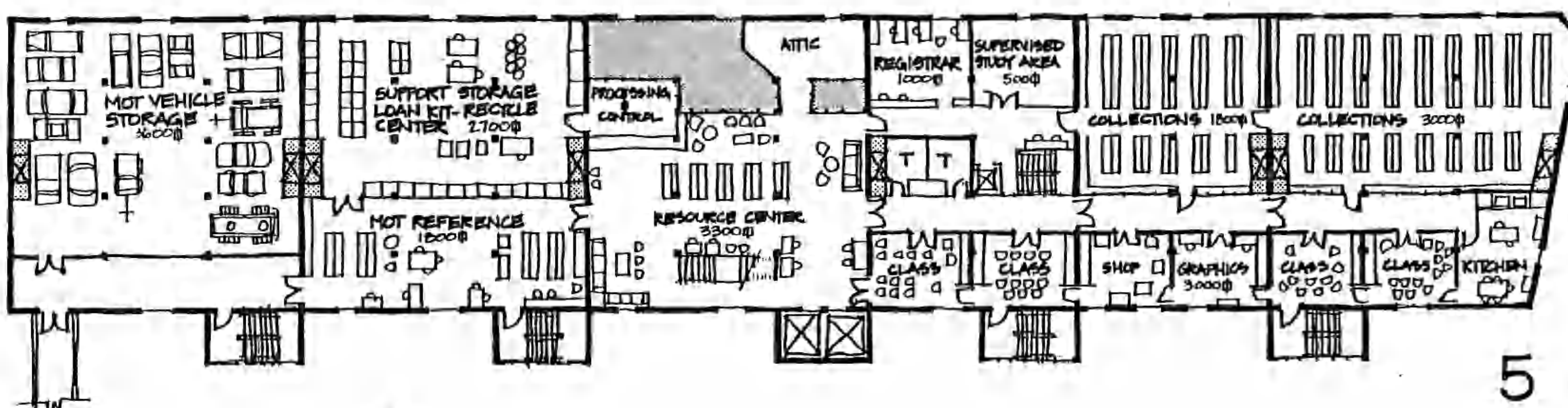
Objects exhibited, or used in programs on the third or fourth level will be subject to the same climate controls as in the Collections Storage area. Security from theft and vandalism will be accomplished through exhibit cases, special "closets" and intensive staffing.

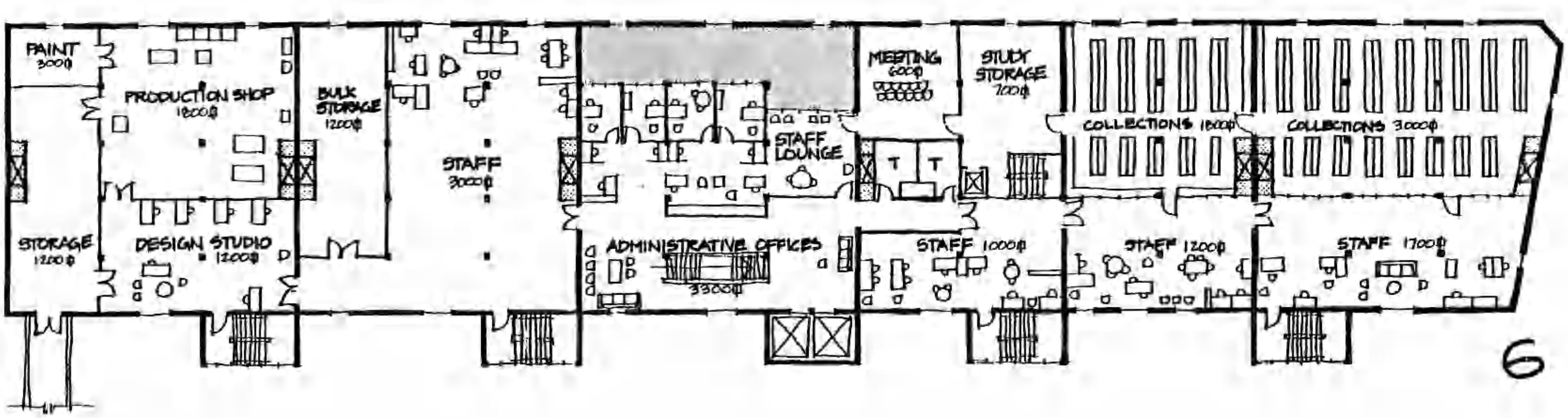
For security and control puposes, egress from the exhibit areas and access to the rest of the museums will occur back through the central circulation core and common museum lobbies. The public can also exit from here through the building lobby to the commercial shops and retail arcade on the first and second levels, or to the front apron area outside the building. Emergency egress from exhibit areas, as well as from other areas within the building, will be via four enclosed fire stairs dispersed along the building's length. These fire stairs will lead directly down to grade and to the outside.



PUBLIC CIRCULATION

The following floor plans represent the museums' program development for the non-exhibit and support areas at the fifth and sixth levels of the Wharf. All vertical circulation is located outside of the building shell, with passenger elevator service at the center bay serving the Resource Center at level five and administrative offices at the sixth level. The exterior freight elevator is located at the northern-most bay to serve directly the Museum of Transportation exhibit areas on levels three and four, and large vehicle and exhibit set and prop storage on levels five and six.



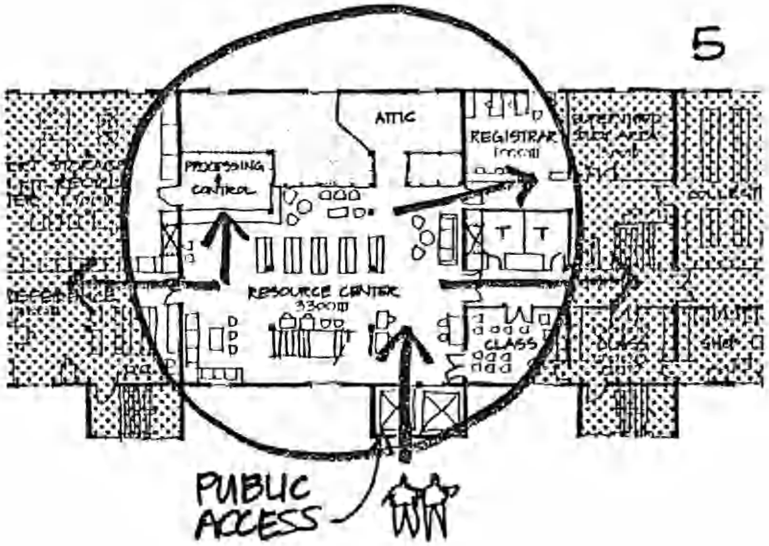


C. Resource Center

The Resource Center Reading and Circulation area is located within the central bay on the fifth floor. Public access will be provided to it by both elevator and stairs from the museum orientation area or building lobby. It is where objects, reference materials, background information, workshops and classes and staff related to specific subjects covered by the two museums are made available for public and staff use. An indexing system to these resources will be made available through the Children's Museums computer for use by either staff or the public.

Here, staff operating from a central circulation counter will provide visitors with basic information and control access to other physical and human resources. The public will be assisted in obtaining information using reference materials, working with the Registrar and collections, and, sold or loaned related books, audio/visual materials, kits and other new or recycled educational supplies.

Adjacent to the circulation counter will be the Resource Center processing area which will provide work space for checking circulating kits and cataloging books and periodicals.

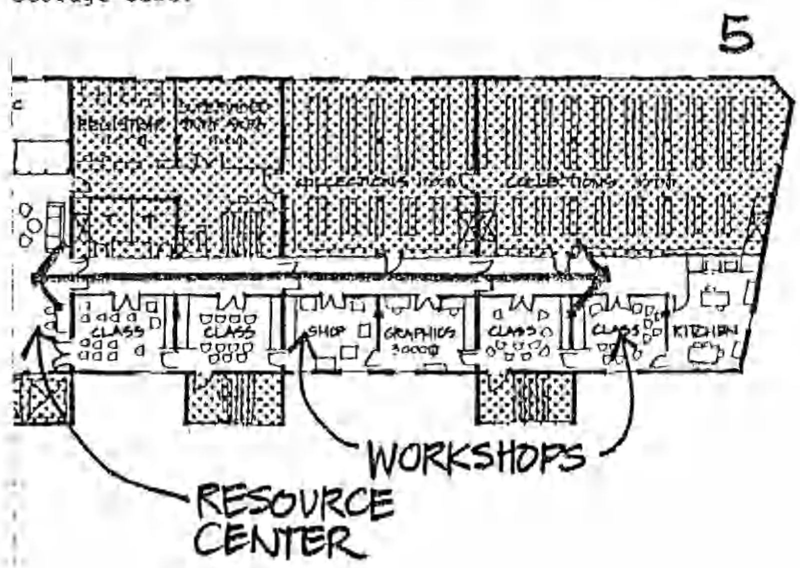


Visual supervision by staff will form the main control and security of the Resource Center during normal operating hours. During after hours usages of adjacent classes and workshop spaces by the public, the Resource Center will be made secure by a series of overhead metal screens similar to those used by stores in a shopping mall.

D. Classrooms/Workshops

Adjacent to the Resource Center Reading and Circulation area, in the southern zone on the fifth floor are the majority of the workshop/classroom spaces. Secure storage units for collections materials will be built within classrooms and workshops. Objects housed in this storage should be limited to only those necessary for conducting courses and would be returned to Collections Storage after their use.

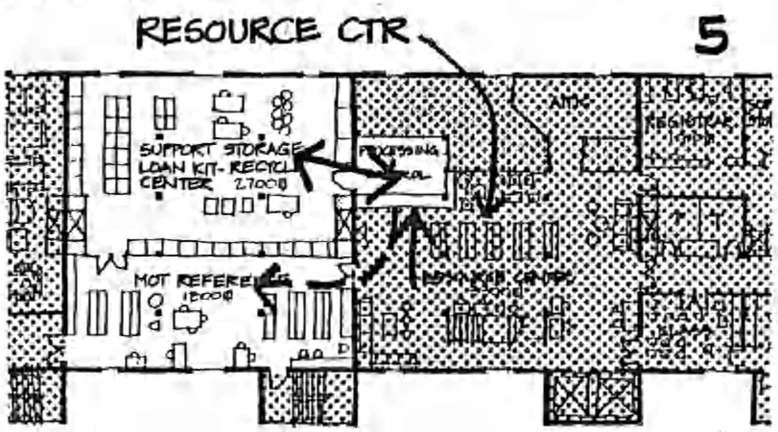
Public circulation from the Resource Center to the classrooms will allow the public to view the Collections Storage area. This visual "access" might be similar to display windows of a large department store. Various storage/display technique options could be used adjacent to these windows. One recommendation is to use the tray storage system along the glazed wall, but only one tray in depth. Thus, the public could view the objects from the outside while staff would have access to them from the Collections Storage side.



E. Reference Library and Loan Kit Storage

The north zone of the fifth floor houses the Educational Materials Storage area and the Reference Library. Access to these areas is also controlled from the circulation desk within the Resource Center. The Reference Library primarily contains the Museum of Transportation's collection of historic books, periodicals and catalogues. Access therefore would be controlled in the same manner as access to the Collections Storage area.

The Educational Materials storage and work area serves as a backup to the circulation desk Here, the public will be able to buy a variety of educational materials or check out a specific loan kit for use at sites away from the museums. However, kits ordered in quantity would be picked up at the first level service desk located near the loading dock. Returning kits would be received at this service desk and returned to the Resource Center work area, repaired, replenished and then placed back in storage for future loan.

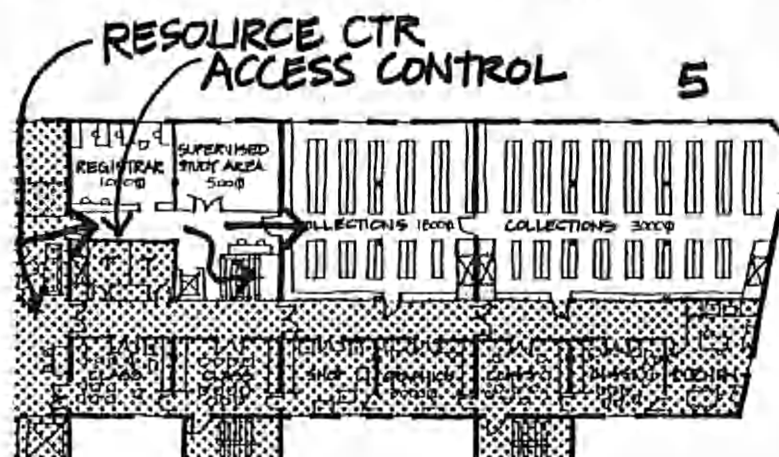


F. Collections Storage

Access to the Collections Storage area will be by referral from the circulation desk to the Registrar's Office located immediately off the Resource Center in the south zone. The Registrar's Office will serve as the direct entry to the small and medium size object storage spaces and will provide remote access control to the large object storage. Within the Registrar's Office a computer terminal will be available for accessing, cataloging, and inventory tasks. Temporary storage for objects and work counters for processing them will also be provided here.

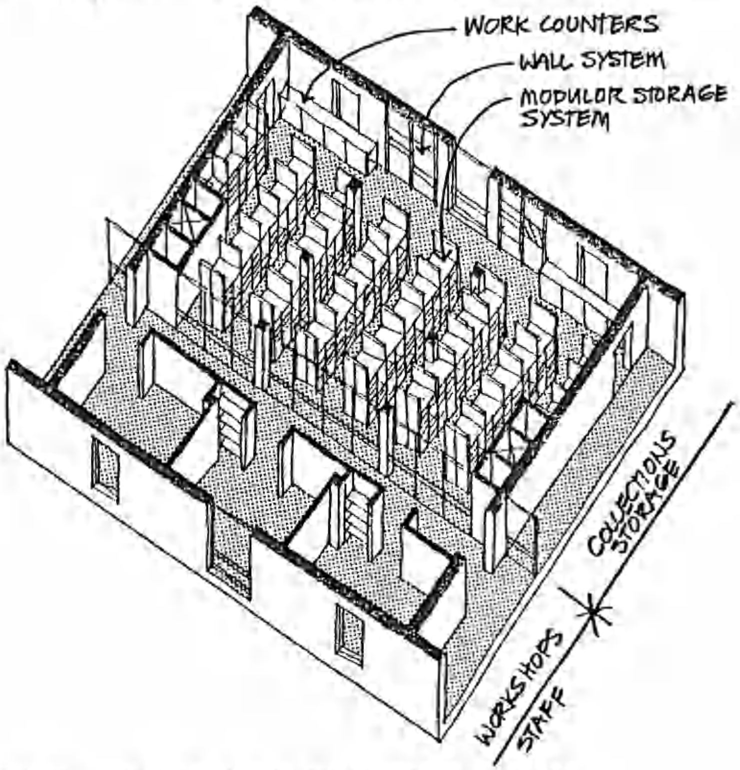
Adjacent to the Registrar's Office will be the Conservation Lab and a fumigation chamber for objects entering the Collections Storage spaces for the first time. The Conservation Lab requires both direct natural light and fluorescent and incandescent artificial lighting. Plumbing capable of filtering corrosive chemicals, portable work tables, locked supply and collections storage units, and a special solvent storage closet will also be provided. In addition, a self-contained fumigation chamber capable of handling a portable storage rack for objects is recommended. Gases used in the fumigation chamber will be exhausted through filters directly to the outside of the building.

The small and medium size object storage spaces will be in contiguous bays adjacent to the Registrar's Office. Access will be controlled for entering and exiting; The only other form of egress from Collections Storage will be via emergency exit doors to corridors leading directly to fire stairs towers. Vertical circulation within the Collections Storage spaces will be by internal stairs. A small dumbwaiter system is recommended for internal transportation of objects between the fifth and sixth floors. Otherwise, a second controlled entry point to Collections Storage must be provided on the sixth level from the passenger elevator, in addition to the entry point at the Registrar's Office on the fifth floor.



The large object storage spaces will be composed of open floor areas and large metal shelving adapted from industrial type storage systems. Access to each space will be from the Registrar. In addition, oversized openings for easy access will be provided in the large object storage area. Circulation passages, corridors and door openings for large objects will be based upon an 8'-0" high x 8'-0" wide x 20'-0" long portable pallet. An exterior freight elevator capable of handling the pallet size and a weight of eight tons will provide vertical circulation for these large objects.

Adjacent to the large object storage areas will be a Restoration Shop for repair and renovation of vehicles and other large objects. It will function as a general machine shop with access limited to selected staff. An alternative shop location which requires study in greater detail, is to develop the Restoration Shop as an exhibit where the public can see restoration work in progress. The latter would necessitate locating this function on one of the lower public exhibit floors.



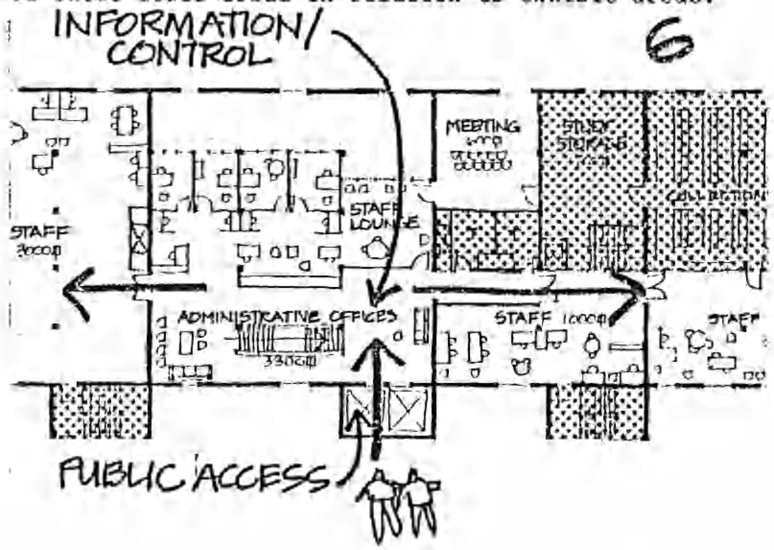
TYPICAL BAY CONTAINING COLLECTIONS STORAGE

G. Staff Areas

The main staff area is on the fifth and sixth floors and will be used for eduactional and exhibit program development. The issues related to staff use of the collections have not been finally resolved. For this study, the assumption is that objects used by staff would be housed within the staff work spaces. Therefore, ample secure storage, locations for carts, layout tables, and work stations would be provided within the staff areas. As part of program development, meeting and work spaces to accommodate groups involved on particular projects will also be provided here.

A separate staff work area will be provided near the large object storage. Since access to these collections would still be controlled from the Registrar's Office it would be controlled to this staff work space as well.

Satellite staff areas will be developed on the exhibit floors to provide visual supervision of the exhibit areas and to monitor the flow and activity of visitors. The security of objects on display here will depend in part upon the location and visibility of these staff areas in relation to exhibit areas.



C2. GENERAL BUILDING CONSTRUCTION

This subsection outlines the construction and restoration of the Wharf to a level developed in the earlier feasibility study of December, 1975, and since modified by this study. All building spaces will be developed to a given architectural, environmental, fire protection and security level. A following subsection (C4) will describe the additional measures that will be taken to increase these levels to meet the more stringent conservation criteria generated for spaces containing specific activities and functions related to the storage of museum collections.

A. Exterior Building Shell

1. Masonry Walls
To restore the normal retardation level of water penetration associated with the existing masonry walls, all exterior walls of the Wharf will be repointed and damaged brick replaced. The repointing will consist of the raking of all joints back to sound mortar and the tuck pointing of the joints with a mortar similar to that originally used.

Further research and actual site testing must be conducted to determine the exact means of cleaning exterior masonry wall surfaces. It is important that both the mechanical repair and cleaning of these masonry walls be accomplished without damage to the friscit or hard fired surface of the brick. Where the face of the brick is damaged, replacement will be necessary.

2. Masonry Wall Openings
All windows will be glazed with fixed sash and insulated glass. The first two floors will be glazed with clear insulated glass and the upper four floors housing the museums will be tinted solar gray which will screen out approximately 66% of the ultra-violet light.

Service doors and emergency egress doors will be solid panel metal with weather-stripping. Public entry doors to the building and to the museum exhibit spaces will be glazed and weather-stripped. To reduce dust and dirt carried in by the Museum visitors and staff, vestibules will be provided with open floor gratings at all public entrances and a floor scrubber with a forced air screen will be used at entry points to the exhibit spaces.

3. Roof
During the replacement of the existing roofing and flashing, roof deck insulation will be installed over existing tongue and grooved sheathing at the roof level. Additional insulation as well as ventilation may be required over the sixth floor Collections Storage areas.

B. Interior Spaces of the Building

1. Masonry Walls and Timber Construction
The interior masonry wall and timber construction will probably be sandblasted similarly to those areas previously cleaned on the first floor. However, chemical cleaning processes are also being considered (a final determination of the cleaning methods used will be made during later design studies).

With the exception of the Collections Storage spaces, a vapor barrier on the inner face of exterior walls will not be provided initially. After building occupancy, the museums will install a furred gypsum board wall with a vapor barrier in the remaining spaces, bay-by-bay, as money allows. When the exterior walls of a particular bay have been fitted with a vapor barrier, the interior masonry walls can then be sealed with a masonry silicone treatment.

2. Floors
Finished flooring surfaces will be determined by the program activities occuring in different spaces. The main public spaces will be carpeted; the vestibules and lobby will be brick, quarry tile or a rubber flooring similar to that used in heavy traffic areas such as airports and subway stations. Staff spaces and collections areas will have either carpet or cushioned sheet vinyl.

C. Building Systems

General

From the standpoint of the security, fire detection and mechanical systems, the building is divided into three vertical zones. These zones resulted from a final building plan where activities requiring similar conservation criteria were grouped into easily definable zones. These zones, being completely isolated from one another, actually form three separate buildings. The two end zones have higher performance and conservation standards than the center zone which contains lobby and circulation functions. Total systems automation functions will be independent of these zones for monitoring and control.

1. Security

When the museums and commercial tenants are closed to the public, all vulnerable exterior openings of the building will be protected by intrusion alarm devices that will be monitored by computer and controlled from a central security office. After-hour building access will occur here through a single entry point controlled by a watchman and supplemented or entirely controlled by an automatic card reading device. Within the building, there will be singular paths of entry to the individual museums and commercial spaces also controlled by automatic card reader access points. These provide separation for the museums from the remainder of public building spaces. Areas of high sensitivity (i.e. Collections Storage), within the museums will be protected by card readers and backed up by area protection devices.

During normal building operation, doors used by the public will be deactivated; the balance of the automatic card reading doors will continue to be monitored. Controlled access to less sensitive spaces will be maintained by either a mechanical card reader or a high security key lock. Doors that may require future installation of automatic reading devices will be provided with special frames and stubbed conduit.

2. Fire Protection and Detection

The fire protection and detection system for the building will consist of an alarmed sprinkler system, smoke detectors in the air handling units, ionization detectors throughout the building, and manual alarm pull stations. A completely new sprinkler system will be installed throughout the building; however, in Collections Storage spaces the sprinkler heads will be removed and replaced by a Halon gas system.

For fire protection and emergency egress purposes, the building will be subdivided into the same three vertical zones as outlined earlier. A fire-rated wall separation will occur between zones. In the event of an alarm, the museums will conduct complete building evacuation via emergency egress stairs located along the apron side of the building.

Various operational modes for mechanical equipment, including those for emergency conditions, will be described in the following section. Included in the equipment design will be an automatic smoke exhaust system for the building bays occupied by the public. This will provide additional egress time for public evacuation and reduce the extent of smoke damage to the collections.

3. Mechanical Equipment

The overall mechanical system design is a combination of central building plant facilities and decentralized air handling units within each building bay. In order to achieve economies in initial and ongoing operational costs, a central plant was selected to provide chilled water and heat to the air handling units in each individual bay. In addition, chilled water and heat for the commercial spaces would be metered.

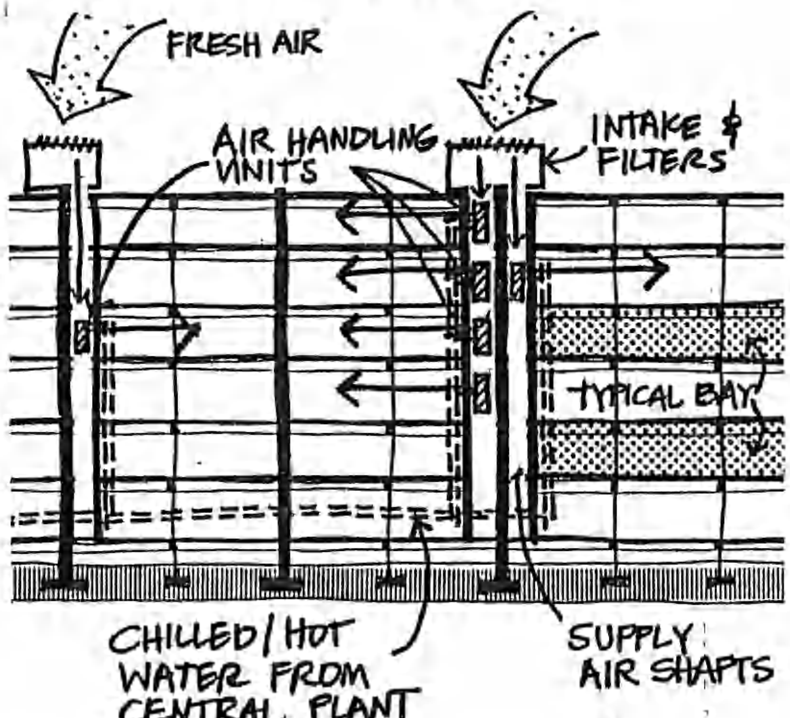
The outer end zone of the building will be served by twenty-four hour operation of the mechanical equipment to maintain the established environmental criteria. In the center zone the maintenance of the environment is more difficult to achieve because of constant air changes occuring at the lobby levels.

Objects housed here should be selected based upon their ability to adapt to more rapidly changing conditions. In addition, the air handling equipment serving the center zone will be designed to allow for night setback operation to conserve energy.

For both end zones of the building, individual air handling units will be installed to maintain the air standards required by the conservation criteria of that particular bay. This arrangement allows for (1) a variation of uses between bays, (2) greater economies in energy consumption, (3) the easy adaptation of a bay from one set of standards to another. (4) phasing of equipment installation and (5) operational mode changes due to emergencies.

The main fresh intake units of the building occur at the roof level; they serve vertical supply air ducts which run down through the building. Each intake unit consists of a metallic prefilter to remove the saline and dust particles, and an activated carbon filter to remove sulfur dioxide, nitrogen oxide, ozone and odors. A sulfur dioxide monitor downstream of these filters will close the intake if predetermined parameters are exceeded. Hopefully, at the time of installation, a smoke detecting monitor will be available to automatically close the intakes in case of fire in adjacent structures.

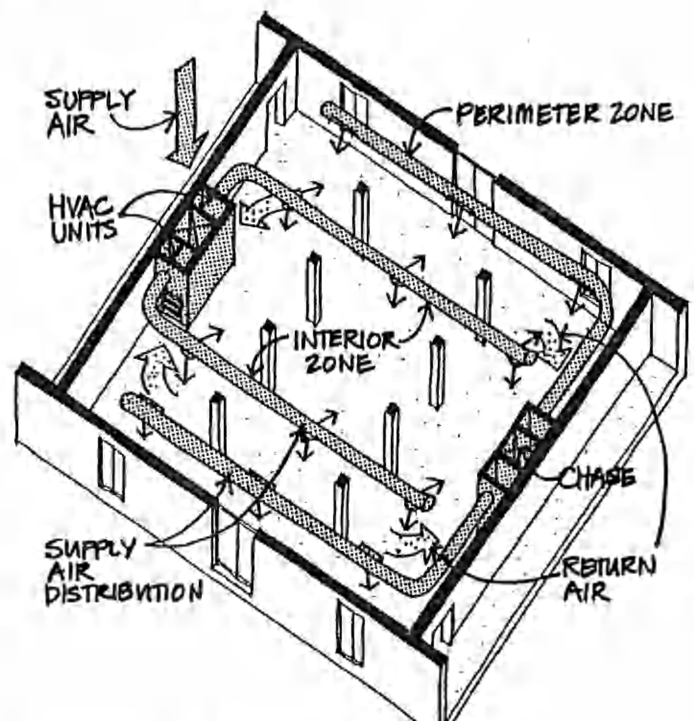
Vertical supply air shafts in pairs adjacent to interior masonry walls provide freshly treated air to the air handling units within each bay. These vertical shafts will also provide chase space for distribution of most building services including electrical, security and control wiring, main risers for the sprinkler, domestic water and waste service, and service lines to the air handling units.



BUILDING ENVIRONMENTAL CONTROL SYSTEM

The air handling units at each bay will be zoned to serve either perimeter or internal spaces of a particular bay. In bays with few partitions (i.e. exhibit bays) supply air will be ducted to the perimeter of the bay; internal supply and return air will need no ducting to the equipment. When extensive partitioning is required (i.e. collections, workshops, offices, etc.), supply air to both the perimeter and internal zones will be ducted.

In the Collections Storage spaces fresh air supply and return air to the units will be mixed, filtered, humidified and tempered to the established summer range of 76° Fdb, 50 - 55% RH with 2° F and 5% RH variation, and winter range of 68° - 70° Fdb, 40 - 45% RH with the same variation. Each unit will have its own temperature and humidity control which will be monitored and/or controlled by the central building automation system.



BAY ENVIRONMENTAL CONTROL SYSTEM

In the case of fire, one of two different operational modes will occur in the mechanical equipment system; The mode will depend upon whether the space is treated with a fire-suppression system of water or gas. The Collections Storage areas, including tray and special small objects storage will be protected with the Halon gas system. For the gas system to be effective, the space must be sealed to a point where the desired level of Halon can be maintained for thirty minutes. Therefore, when either the smoke detectat the HVAC equipment or or space ionization detector is activated, fresh air supply to these air handling units will be closed so that only the recirculating side of the units is maintained. Doors leading to adjoining collection spaces will be closed and the affected Collection Storage space will be sealed.

The balance of all museums' spaces will be protected by a sprinkler system and by a smoke control system. On a particular floor, every two adjoining bays will be serviced by a smoke shaft extending through the roof. When fire is detected in a bay, the air handling units will shut down for that bay and the louver to the smoke shaft will open. Air being supplied from the adjacent bay will create a positive pressure and thus exhaust the smoke through the opened smoke shaft. By careful placement of the smoke shaft within the bay, the concentration of smoke can be controlled and routed away from the public circulation path for emergency exiting.

4. <u>Building Automation and Metering</u>

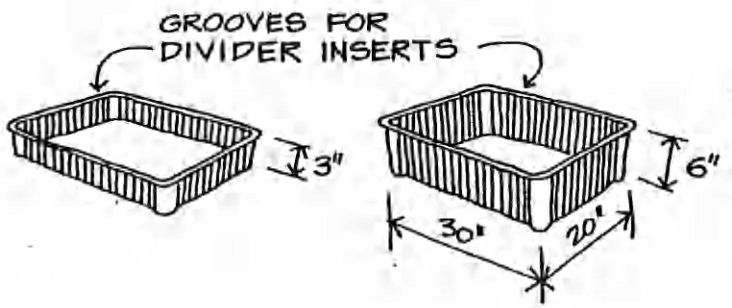
Before a final scheme can be developed for the building automation and metering systems, additional study will be necessary. At this point, an integrated system for security, environmental monitoring and control, monitoring fire detectors and metering is contemplated. This system would be based upon the use of the present Children's Museum computer facility with additional component units supplied by the same manufacturer.

The actual performance characteristics of the final system will depend on conclusions to several key issues. Various levels of environmental equipment monitoring and control capability need to be studied to determine whether a simple monitoring system would be adequate versus a more expensive automatic control system. The total number of microprocessors must be determined by the service demands for them. Finally, with the exception of the commercial spaces, metering of energy use could be replaced with a flat assumption rate of museum energy use for each bay.

A. Small Object Storage System

1. Tray Storage
Use of the existing plastic tray container (3" deep) will be expanded upon and a new deeper tray of about six inches will be used by the Museum of Transportation. The basic overall tray plan dimensions will remain the same; however, careful study of the weight of certain artifacts (i.e. biological and geological specimens, etc.) may produce yet a third tray size of a reduced area.

Since new molds have to be fabricated for the production of additional tray units, vertical grooves in tray side walls can be made to receive dividers on approximately 6-inch centers. This provides for up to 15 subdivisions to each tray for storage of smaller individual objects. These divider strips could be made out of sheet ABS plastic, acrylic, or masonite.



Small objects needing greater protection than provided by the tray and general storage space environment, will be protected by either a clear acrylic cover to the storage tray or by containerizing the individual object and storing it within the tray. Tray covers will be molded to engage the upturned tray edge, thereby, requiring the tray to be removed from the stack before removing the cover. Containerization of individual objects, such as illustrated by the North American Indians Necklace, will be done on an object-by-object basis.

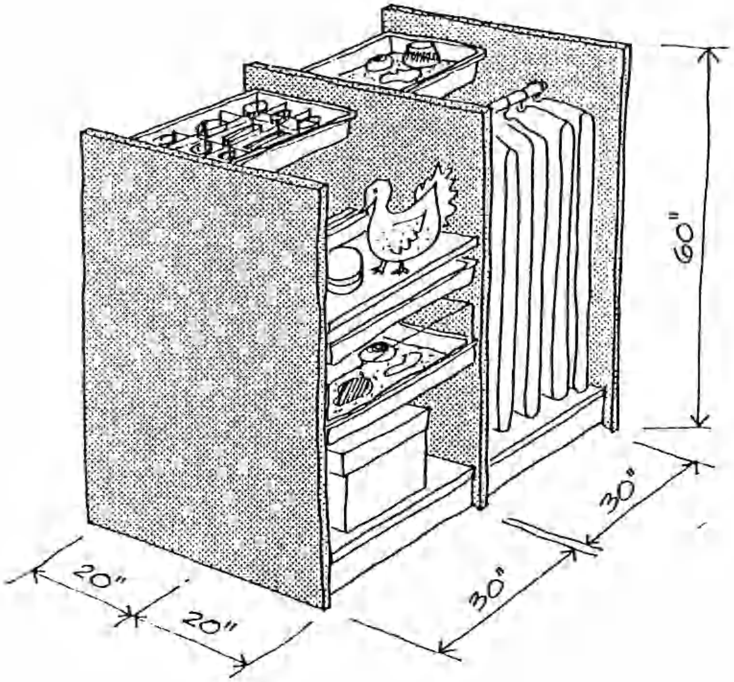
2. Hanging Storage
Within the same modular storage system, components consisting of single or multiple hanging rods will be installed to hang clothing on padded wood hangers, or draping fabrics and weavings. The fabrics themselves will then be covered with a see-through vinyl covering to protect against handling and dust. The multiple rods will be facing out and supported on a draw pull frame to allow total access to the entire unit and, thus, eliminate the problem of damaging the fabric when removing or replacing the object. Hanging rods must be non-ferrous, smooth in contour, and non-oxidizing; therefore, woods and plastics are most appropriate.

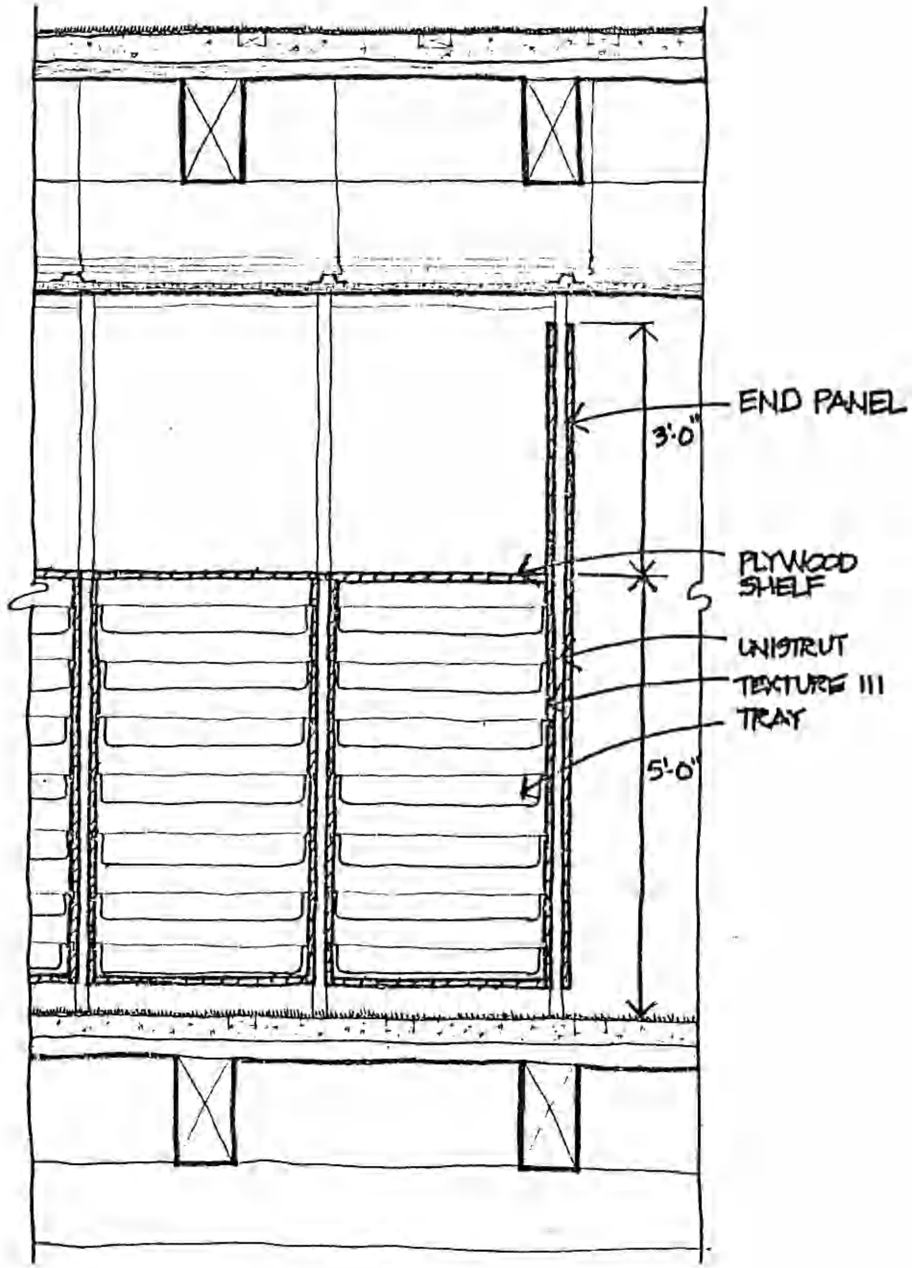
3. Shelving Storage
Depending upon the type, size and quantity of objects, shelving with varying depths and section configurations will be provided within the modular storage frame.

Twelve-inch shelving will be used for reference materials (including books, tapes, slides, etc.) and objects that have a high center of gravity and, therefore, are prone to toppling. The shelves containing this type of object would also have a small lip or restraining edge bar so that when the object is removed, it will have to be lifted versus being slid off the shelf.

4. Modular Storage Framing System
The proposed framing system is a modification of the present Children's Museum collections storage system. Made up of readily available raw materials (Unistrut channels and fastening hardware and scored plywood panels), this system can be easily fabricated and assembled with few simple tools and a minimum amount of training. The modifications are based upon information described earlier in Section B, possible Building Code regulations and the desire to increase the visual awareness of the collections to the public.

Following the recommended changes in tray orientation, which will need further testing by the museums for reliability, the 20" dimension becomes the tray depth, producing a basic module size which will be 20" deep and 30" wide. Storage modules will be designed to house tray storage components to a maximum height of five feet; the balance of the vertical distance to the ceiling will be used for shelf storage for medium size objects. The wood panel frame (texture 1-11 plywood with flame-retardant treatment) will be fastened to a metal channel (Unistrut) support system similar to the existing TCM system. The





channel spacing will be based on a 30" tray module; an alternative increased module size of 60" might also be tested in the future. The latter will reduce the amount of structural framing and provide for larger plan area for the storage of medium objects above the five foot height.

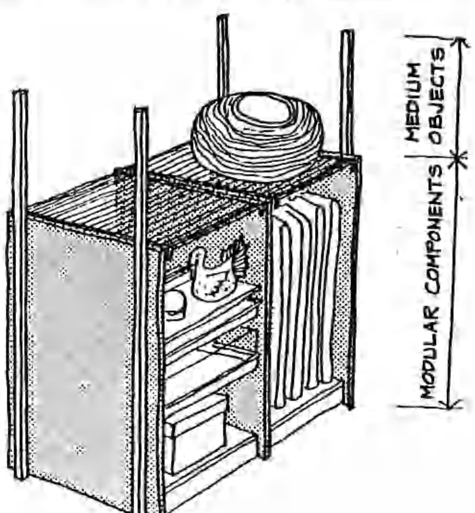
The modular storage system will be single width when occuring against building walls and double width (back-to-back) when free-standing in space. A 3" kick board base will be incorporated in the system to prevent object storage on the floor and also to reduce potential damage to objects from kicking or cleaning equipment. The metal frame and wood panels will be painted for maintenance and visual purposes.

A system of ledger strips to support tray, hanging, and shelf components will be installed using the grooving spacing of the Texture 1-11 panel. Strip materials such as plexiglas, metal, or teflon coated wood will be tested at a later date for ease in sliding the trays. Also, a restraining stop will be tested in the ledger strips to signal the person removing a tray unit to lift it to prevent its falling or tipping.

B. Medium Objects and Special Storage

By limiting the height of tray storage to five feet and possibly increasing the storage modular unit to a four by five foot area when back-to-back, lightweight medium size objects that are easily handled can be stored in the 60 cubic foot module space at the top of the module storage system. Depending upon the object size, dividers may be fabricated to subdivide the shelf storage area into more individual storage spaces and, thus, eliminate the problem of removing an object to reach another. This would also reduce the overcrowding of the objects. Access to these objects stored over the tray storage system would be by a step stool.

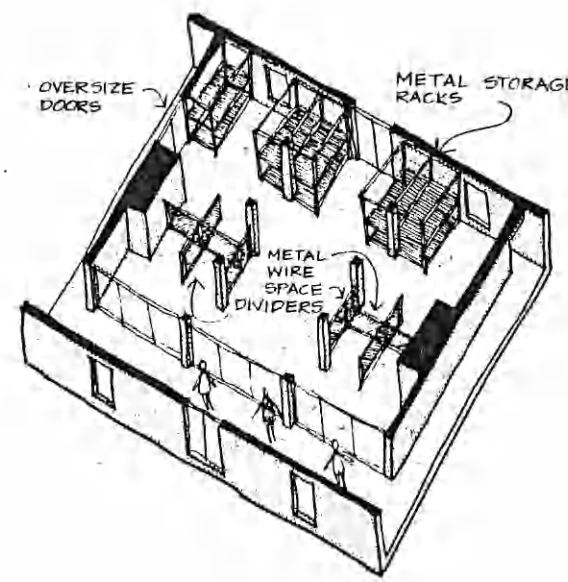
Special storage components not adaptable to the modular storage system because of the unique requirements of certain objects will be located at perimeter walls of the Collections Storage space.



C. Large Object Storage

Unlike the small object storage components, large objects can be treated as individual units distributed within different building storage bays. Therefore, only a few components have been determined at this point in time.

To separate and reduce damage of large objects, portable, free-standing wire mesh partitions will be used to subdivide storage bays into individual subcompartments. These partitions will be arranged to insure adequate aisle width for retrieval and movement of a particular object without disturbing others.



LARGE OBJECT HOUSING

For large, lightweight objects a demountable pipe frame storage system with treated plywood frames or shelves will be constructed to provide a second tier of storage at five feet above the floor level.

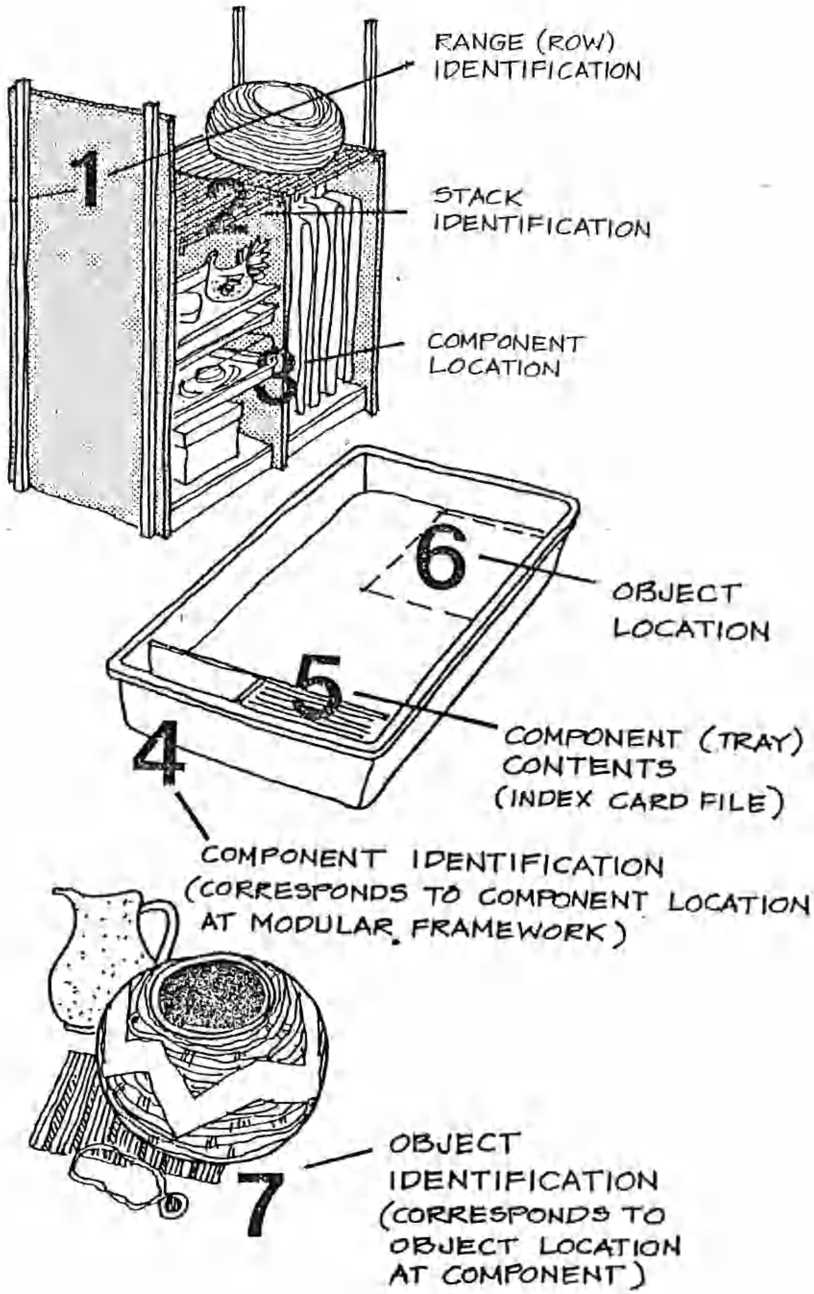
Storage locations for vehicles and objects that are themselves portable will be defined by boundaries painted on the floors. All wall and column surfaces in these storage areas will be fitted with bumper strips placed at appropriate heights to protect both the objects and room surfaces. Drop cloths will be used to protect the objects from dust.

D. Indexing For Artifact Storage

The Collections Catalogue can be stored in the computer; access to this information will be via a terminal at the Registrar's Office. The physical process of locating, using and controling the collections objects will be controlled by this catalogue. Each object will be coded with such information as to who has authority to use it, how it is to be handled, and whether it can be removed from Collections Storage.

As Collections Storage will be subdivided, by culture or category, each row of the modular storage system will be identified as housing a particular class of objects. Within each row, individual trays or shelves will be labeled indicating the objects that they house or the storage location of a related object if it is housed separately in special storage. When a particular tray of objects has been removed, a duplicate label indicating the user and location of the tray will be placed on the side panel of the modular storage system.

A label within a subdivided tray or on a shelf or hanging unit, will be used to identify a particular object, its current use and locate its position for return.



C4. DESCRIPTION OF COLLECTIONS HOUSING SPACES

This portion of the report reviews the additional interior finish work required for meeting conservation criteria that are in excess to the finished shell space as described in Section C2. This description will include the scope of work for architectural, mechanical, fire protection/detection and security systems.

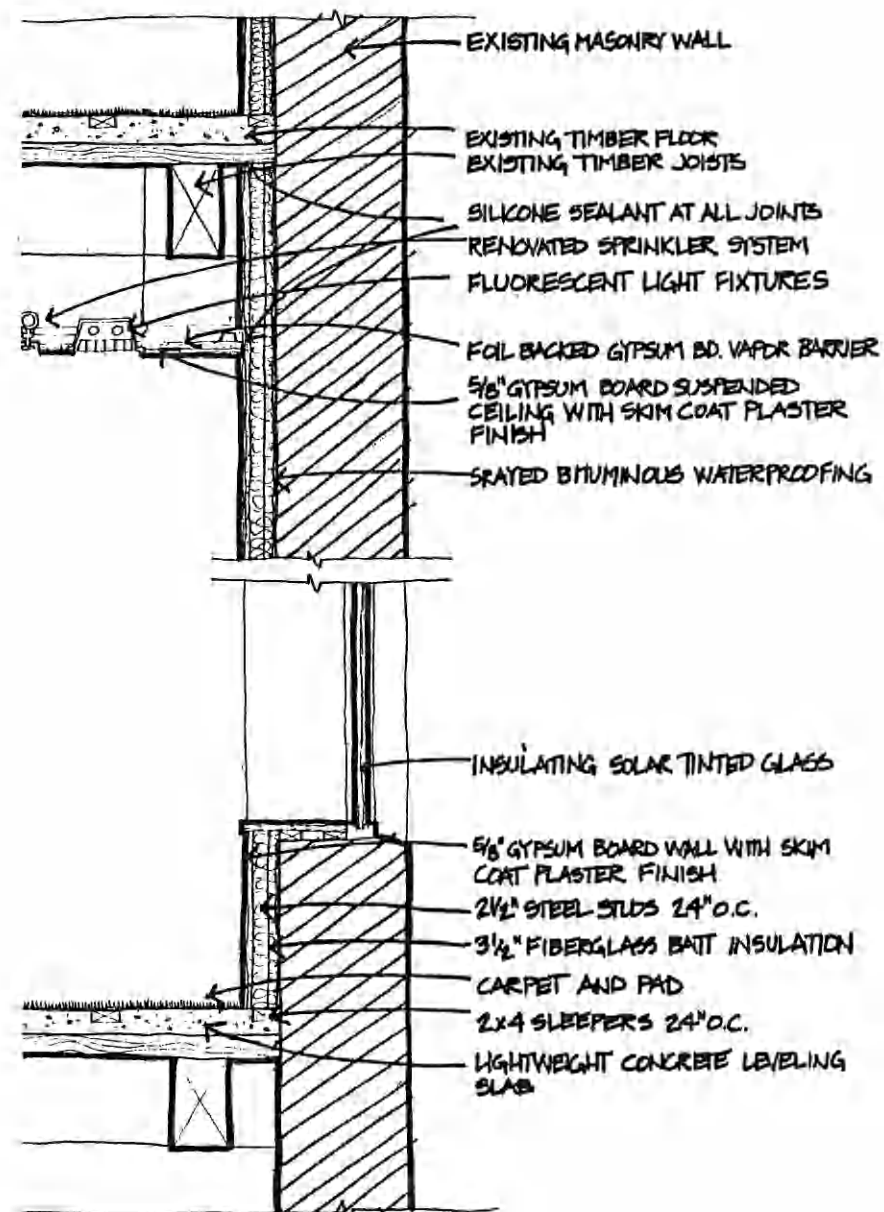
A. Architectural

The specific spaces that house the small and medium object collections will have to be separated both physically and environmentally from the existing building structure and adjoining non-collection museum spaces. All existing exterior walls that form part of the Collections Storage area perimeter will be covered with a new furred out plaster coated gypsum board wall system which includes insulation. A new suspended ceiling will be installed over collection spaces. Both the furred walls and ceilings will be thoroughly sealed to eliminate problems resulting from air infiltration and water vapor penetration to these Collections Storage spaces. Newly constructed walls that are adjacent to public corridors and requiring glazing will be of either a wood or metal storefront window systems. Laminated wire glass will be used with silicone sealed glazing joints. New solid walls will be plaster coated gypsum board on metal studs; they will be insulated if they form a separation between Collections Storage and non-collection areas.

In a particular collection space, the layout of the modular storage system will consist of free-standing rows in a back-to-back storage arrangement; the single depth will be employed at walls and/or along portions of the glazed viewing wall. The typical bay module width will be about four feet and the aisle a minimum of three and a half feet. Final aisle widths will depend upon the physical constraints imposed by existing column and wall locations within different collections storage spaces.

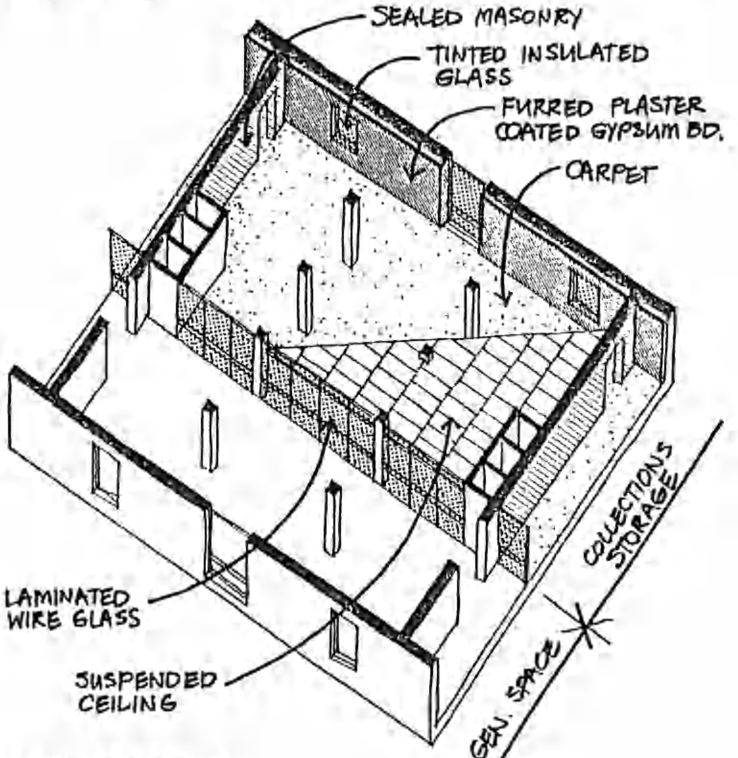
If needed for increased security between collection categories, separation of collections stacks within a collection space can be acomplished by inserting a wire mesh screen between the back-to-back storage units and providing sliding wire mesh doors at particular row ends.

Special storage units will occur along the perimeter walls of the collection spaces where maximum access and spatial flexibility occur. Structural support for these units will depend upon the storage hardware used; it can be from the floor, wall or ceiling.



The finished flooring surface will be carpet with an underlayment pad. Rolling items such as storage carts, chairs, etc. will need casters appropriate for use on carpeting.

Counter high work stations will be provided for temporary work within the collection spaces. These work stations will be used to sort through, replace and/or examine objects within a particular tray. Transferring objects from trays to carrying units will also occur at these work counters. Additional holding or layout shelves will be provided beside doors within the collection space and the door to the Registrar's Office in order to support a tray while the door is being opened.



INTERIOR FINISHES

The same space renovation criteria outlined for the small and medium objects will apply for large objects with the basic differences occuring in floor finish, door openings and interior partitioning.

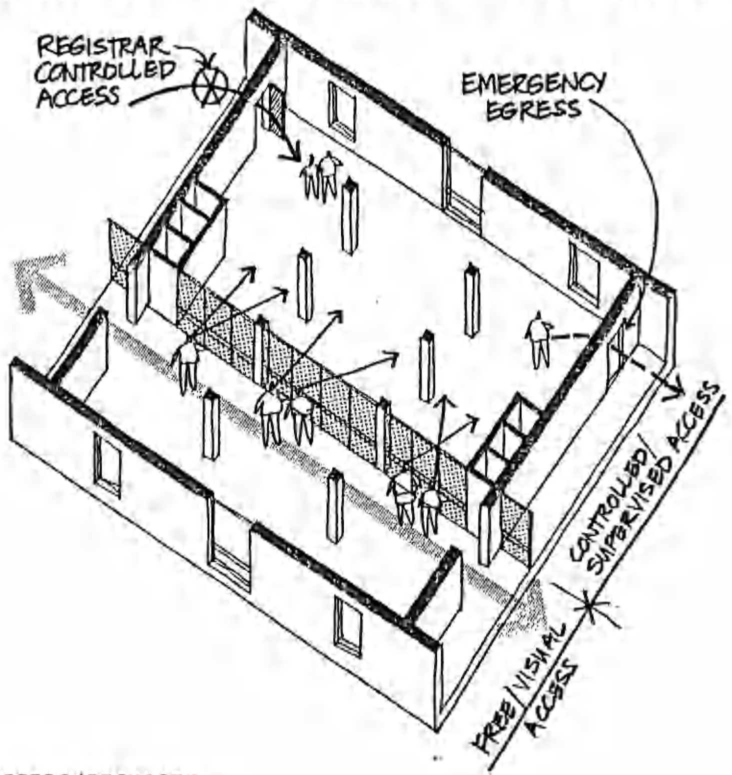
The finished floor will be painted concrete; wood sleepers will be poured integrally with the leveling slab to allow attachment of the pipe rail storage system. Doors will be oversized (8'-0" x 8'-0") to accommodate the passage of vehicles.

3. Building Systems

The accompanying plan drawing shows shared use of a typical building bay in which two functions exist - Collections Storage space and workshop space - but also require different levels of access and security, environmental control, and fire protection/detection. This arrangement provides for housing collections in harmony with other uses in the building and demonstrates the flexibility of the proposed support services for the building.

1. Access and Security

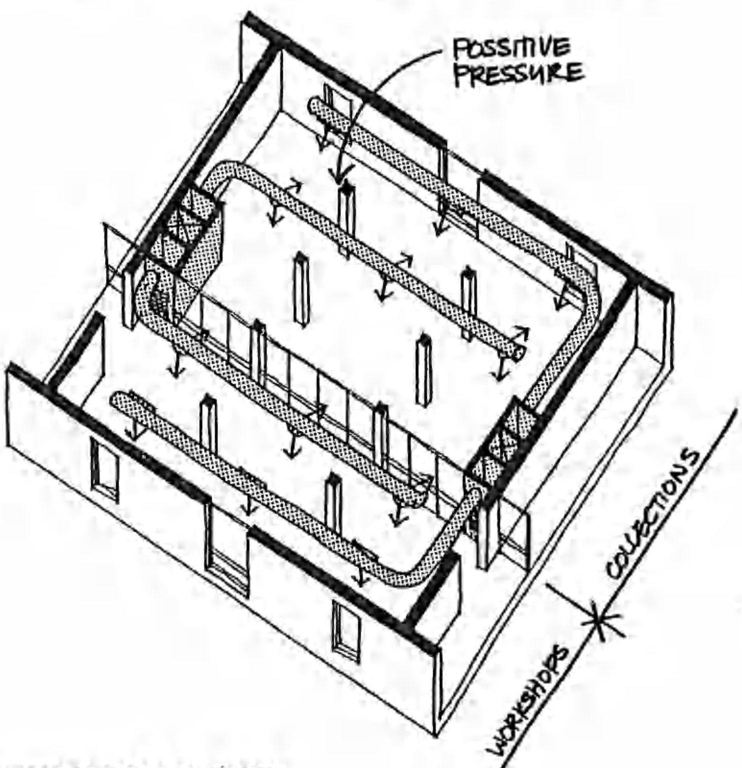
Access to collections will be controlled by a card reader unit located at a single entry point off the registrar's office. This card reader will record the



ACCESS/SECURITY

frequency of use and who uses the collections. A motion detection device will be located within the space to provide additional protection when the museum is closed. Secondary egress required for emergency exiting purposes will also be alarmed and monitored. Further separation of the internal collection space, if needed, can be provided by a wire mesh enclosure with a high security locking device.

2. Environmental Control
During normal museum usage, the typical building bay climate control will be provided by air handling units (four per large bay) running continuously to maintain the specified space conditions with normal fresh air introduction. During the unoccupied cycle (night) the fresh air intake will revert to a minimum position (not completely closed), thus providing a slight positive pressure in the building to offset air leakage through the walls and infiltration



ENVIRONMENTAL CONTROL

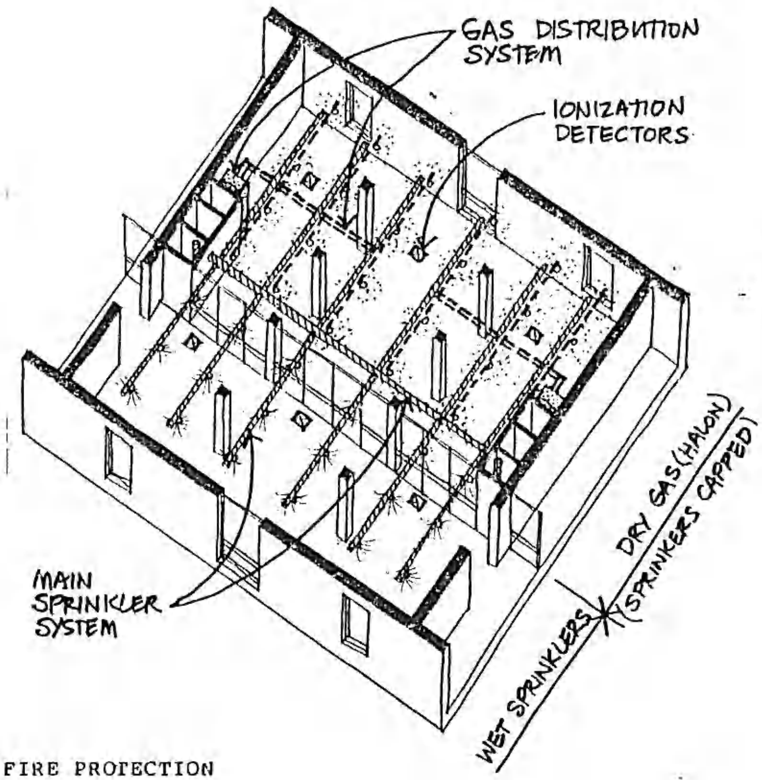
through windows and doors. Conditioning of space (temperature/humidity) will be monitored and the climate control system automatically adjusted to maintain these specified conditions.

Malfunctions of the air treatment plant or presence of smoke in ambient air (due to fire in adjacent buildings) will cause automatic shut down of the fresh air intakes for the duration of the emergency. During such times, the climate control system will operate with 100% recirculated air.

The supply and return air to the air handling units for the two uses (workshops and collections) will be isolated from one another. This will maintain the integrity of environmental conditions for Collections Storage and allow the air handling units to operate separately from one another.

3. Fire Detection and Protection
In non-collection areas, the fire emergency alarm will be initiated by manual pull stations, a smoke detector in the air handling system, space ionization detection devices, or an activated sprinkler head. A general building evacuation signal, consisting of sound, flashing lights and/or voice alarm, will commence and an alarm signal will be sent to the fire department. The sprinkler system will suppress a fire occuring in these spaces, the large object collection storage areas, and general storage areas. The climate control system including the air handling units serving the public portion of the bay will shut down; its outside air and return air dampers will be closed. For occupied spaces, the smoke shaft damper to the bay will then open to allow the exhausting of the smoke.

In the small and special object collections spaces, ionization detectors will initiate the fire emergency alarm system and will activate the Halon fire suppression system. The climate control system serving the collection area will shut down its outside air and return air dampers will also be closed. After the emergency, smoke evacuation will be accomplished by using the fumigation purging system.



FIRE PROTECTION

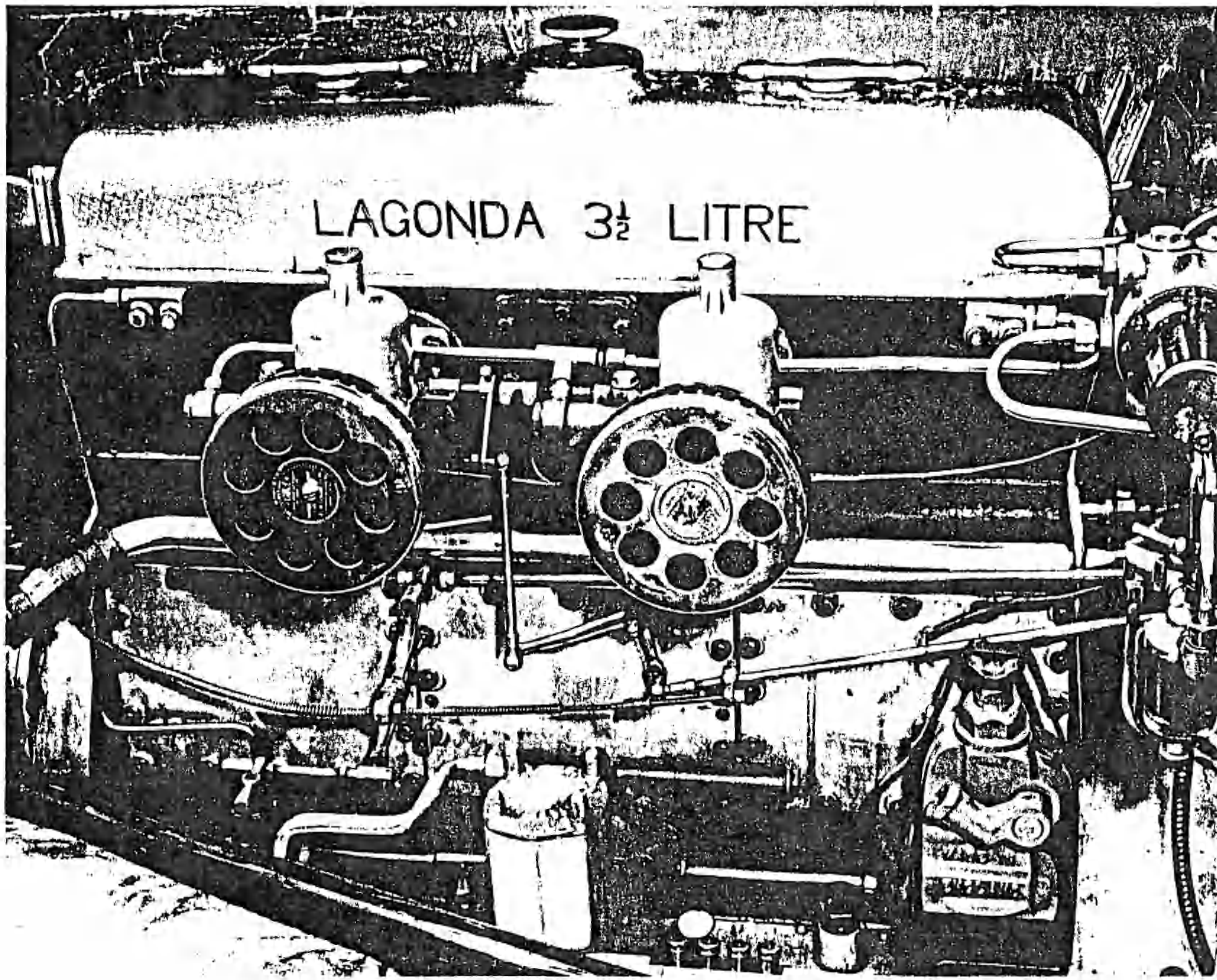
4. Fumigation

To reduce handling of the collections and conservation related work, the small object storage areas will be designed to function as fumigation chambers. The air handling units will have a remote mechanism to close the fresh air intake and allow only recycling of the air during the fumigation process, the air exhaust fan system will exhaust the fumigate and the fresh air damper will be opened to return the air handling units to their normal mode of operation.

5. Lighting

Artificial lighting will consist of fluorescent fixtures, suspended or recessed mounted. With the suspended model, the fluorescent tubes will be individually sleeved with an ultra-violet light filter. The recessed fixture would have a prismatic lens which will filter out the ultra-violet light.

Cost Summary for Study-Related Construction and Furnishings


LAGONDA 3½ LITRE

D. Cost Summary for Study-Related Construction and Furnishings

The following cost estimates have been developed based upon the study analysis and recommendations in Section B and the application of the program development to the Wharf in Section C. These costs are divided into three parts: 1) special architectural treatment to specific conservation-related support spaces (i.e. Registrar's Office, Conservation Lab, and Restoration Shop); 2) the Collections Storage housing components; and 3) building systems including security, fire detection/protection, mechanical equipment, building automation and acclimatization.

Where noted, these cost totals include overhead and profit mark-up for the general contractor and/or escalation for a two year period at a nine percent annual rate. Where costs have been determined for the total building (including retail), a percentage reduction has been made to reflect actual museum-related costs. Estimates for the architectural and building systems are based upon the present building scheme and published costing manuals. The Collections Storage components estimates are based upon costs of materials and labor supplied by the museums, published catalogue costs, and estimates from outside subcontractors and suppliers.

Construction and Furnishings Cost Summary

Conservation Support Spaces	$ 61,400
Collections Storage Housing	$ 316,400
Building Systems	$2,076,800
TOTAL COST	$2,454,600

D.1 CONSERVATION SUPPORT SPACES

The following costs represent the interior finishing and equipping costs necessary to fit out these areas from building shell space. Therefore, they do not include general building development costs of restoration, cleaning, glazing, vertical circulation system, HVAC, electrical, etc.

A. Registrar's Office		$21,400
Floor	1,000	
Walls (existing)	1,625	
Partitions	1,000	
Ceiling	1,500	
Lighting	1,500	
Dumbwaiter	9,000	
Subtotal	15,625	
Mark-up (1.37)	5,775	
Total	$21,400	

B. Conservation Lab		$21,300
Floor	1,800	
Walls	1,500	
Ceiling	750	
Lighting	1,500	
Cabinetry/Equipment	10,000	
Subtotal	16,250	
Mark-up	6,050	
Total	$21,300	

C. Restoration Workshop		$15,900
Floor	1,100	
Walls	1,800	
Ceiling	900	
Lighting	1,800	
Cabinetry/Equipment	6,000	
Subtotal	11,600	
Mark-up	4,300	
Total	$15,900	

D. UV Filters for Collection Storage Lighting		$ 2,800
2,800 linear foot @ 1.00/l.f.	2,800	

E. CONSERVATION SUB TOTAL	$61,400

D.2 COLLECTION STORAGE HOUSING

The cost estimates described below are based upon the individual storage demands for both museums and therefore are itemized in two parts. A factor for escalation over the next two years at nine percent/year has been carried. Both design fees and general contractors' mark-ups have been excluded since the museums will probably develop the storage system "in-house".

The development of the cost estimates for the individual museums is based upon three major collections storage housing types: 1) housing requirements for Collections Storage; 2) housing requirements for transporting objects; and 3) housing requirements for satellite storage in exhibit or public spaces.

For the Children's Museum, quantities of storage units required were determined by an inventory of objects presently in tray storage and the estimation of other objects by square foot areas or volumes. For the Museum of Transportation, estimates for housing units were developed from projected square foot areas determined by the Museum's staff.

TOTAL COLLECTION STORAGE HOUSING COST SUMMARY

Collection Storage Housing	215,658
Transportation Housing	5,660
Satellite Housing	45,000
Subtotal	266,318
Escalation	50,082
COST SUB TOTAL	$316,400

A. COLLECTIONS STORAGE HOUSING $215,658

1. The Children's Museum $150,448

a. Modular Housing System $129,848
(30"w x 24"d x 60"h single-face stacks)

1. Trays (14 trays/double-face stack) $ 96,523
   - 385 double-face stacks @ $65 $25,025
   - 4,318 trays @ $11 47,498
   - shallow tray mold @ $3,000 3,000
   - tray accessories
     - 1,000 bubble covers @ $8 8,000
     - 1,000 flat covers @ $4 4,000
     - 2 cover molds @ $1,500 3,000
     - 2,000 divider sets @ $3 5,000
   - Note: other module system components (such as hanging rods, etc.) are covered under tray cost.
2. Shelves (6 shelves/double-face stack) $ 20,325
   - 155 double-face stacks @ $65 $10,075
   - 1,027 shelves @ $8 8,216
   - shelf accessories dividers @ $2/shelf 2,034
3. Indexing Accessories 3,000
4. Individual Artifact Container (Allowance) 10,000

b. Housing for Medium Objects (allowance) $ 4,000

Options

- Open steel shelving
  (72"w x 36"d x 72"h, 3 shelves/unit)
  unit @ $200
- Cubicles
  - Undercounter (36"w x 30"d x 30"h)
    - Open units @ $150
    - Unit w/door @ $200
  - Full Height (36"w x 30"d x 96"h, three 36"w x 30"d x 31"h cubicles)
    - Open unit @ $350
    - Unit w/door @ $420
- Stacking Cubicles
  (Plastic containers, 44"w x 44"d x 29"h)
  Unit @ $155
- Undercounter pull-out cart/bins
  (Millwork counter with pull-out bin on casters below, 42"w x 32"d x 33"h)
  Unit @ $250

c. Housing for Large Objects (allowance) $ 3,600

Options

- Steel rack/shelf units
  (96"w x 48"d x 96"h, two shelves/unit)
  Unit @ $300
- Woven wire partitions
  (3'-0"w x 7'-0"h)
  Unit @ $50
  Door unit @ $125

d. Housing for Special Objects(allowance) $ 13,000

Options

- Five drawer flat file unit
  26"w x 20"d @ $215
  50"w x 38"d @ $335

- Vertical file unit
  2 drawer letter @ $75
  2 drawer legal @ $110

- Tube storage (rolled maps, drawings)
  (9 tubes/unit)
  4-3/8" dia.
  30" long @ $75
  48" long @ $105

- Photographic slide cabinets
  (27-1/2"w x 15"d x 7-1/2"h, 2 drawers/unit, 3,600 capacity)
  Unit @ $60

- Vertical panel units (framed posters, paintings, etc.; panel sliding on overhead channel track)
  Unit @ $300

- Vertical Hanging Unit (tapestries, rugs, etc.; 48" max. w. hanging bar on overhead channel track)
  Unit @ $150

- Wall system components
  96" metal slotted standard @ $4
  26"w x 96"h tack surface panel @ $25
  hanging rod @ $20
  clip strip @ $20
  shelf @ $10
  picture molding strip @ $20
  36"w x 72"h grid panel @ $80

2. Museum of Transportation		$ 65,210
a. Modular Housing System		$ 30,945
1. Trays (7 trays/single-face stack)		$ 23,120
• 80 double-face stacks @ $65	$ 5,200	
• 1120 trays @ $11	12,320	
• deep tray mold @ $3000	3,000	
• tray accessories		
200 bubble covers @ $8	1,600	
100 flat covers @ $4	400	
200 divider sets @ $3	600	
• Note: other module system components (such as hanging rods, etc.) are covered under tray cost.		
2. Shelves (3 shelves/single-face stack)		$ 3,325
• 25 double-face stacks @ $65	$ 1,625	
• 150 shelves @ $8	1,200	
• shelf accessories dividers @ $2	500	
3. Indexing Accessories		$ 500
4. Individual Artifact Container Allowance		$ 4,000
b. Housing for Medium Objects		$ 4,000
Options - see The Children's Museum Item 1b		
c. Housing for Machine Parts		$ 9,000
1. Trays (5 trays/stack)		$ 6,030
• 30 double-face stacks @ $65	$1,950	
• 300 trays @ $11	3,300	
• tray accessories		
60 bubble covers @ $8	480	
30 flat covers @ $4	120	
60 divider sets @ $3	180	
2. Shelves (2 shelves/stack)		$ 1,270
• 10 double-face stacks @ $65	650	
• 40 shelves @ $8	320	
• shelf accessories @ $3	300	
3. Indexing Accessories		$ 200
4. Individual Artifact Container Allowance		$ 1,500

d. Housing for Large Objects (not including vehicles) — $ 8,000

Allowance determined from projected area requirements of 2000 SF

Options - See The Children's Museum Item 1c

e. Library Housing — $ 8,265

Quantities determined from projected area requirements (2000 SF) and bound volume requirements (10,000 volumes)

1. Shelving for bound volumes and periodicals: — $3,300
   Steel library shelving, 36"w x 12"d (max.) x 90"h, 7 shelves/single-face unit
   15 double-face units @ $220

2. Cabinets for photographic slides: — $ 240
   Metal cabinet
   8 drawers @ $30/drawer

3. Vertical file units for documents and photographs: — $ 285
   Metal cabinet, two-drawer letter
   3 units @ $95

4. Vertical panel units for framed posters, photographs, etc.: — $3,000
   48"w (max.) x 84"h panel sliding on overhead channel track
   10 units @ $300

5. Flat file units for unframed posters, photographs, maps: — $1,440
   50"w x 38"d, 5 drawers
   4 units @ $335

f. Special Housing Requirements — $ 5,000

Options - see The Children's Museum Item 1d

B. TRANSPORT HOUSING (TCM and MOT) — $ 5,660

1. Carts - accepting trays from the module system; closed units with demonstration surface; locked doors — $ 3,600
   8 carts @ $300 (TCM) — $ 2,400
   4 carts @ $300 (MOT) — $ 1,200

2. Allowance for transport of large objects (TCM and MOT) — $ 2,060
   Options:
   a. Handtruck @ $55
   b. Box truck @ $180
   c. Dolly with attached handle @ $80
   d. Truck with ends @ $175
   e. Enclosed box truck with locking door @ $420
   $420

C. SATELLITE COLLECTION HOUSING (TCM and MOT) — $ 45,000

Collections "Mini" Closets:
(TCM) 20 units @ $750 — $15,000
(MOT) 40 units @ $750 — $30,000

D.3 BUILDING SYSTEMS

The following cost summary is compiled from the analysis of the individual building systems described in Section B. In developing this cost estimate, it was necessary to include the entire building, especially where equipment serves the building and not individual floors or bays. Therefore, an adjusted figure, reflecting the percentage of museum-related costs for the particular item, was used. (It also includes appropriate mark-ups for the General Contractor and for a two-year escalation period.) The building automation price is based upon an automation system using Digital Equipment hardware and the Children's Museum computer.

The total cost for these building systems at the wharf is $2,076,800.

BUILDING SYSTEMS COST SUMMARY

Report Section		Total Building Cost	Amount for Museums' Requirements	Cost Plus Mark Up
B4	Security: Devices/Door Frames	$ 46,300	$ 39,000	$ 53,400
	Electrical Service/Hardware	36,270	30,500	41,800
B5	Fire Protection: Detection	93,800	61,900	84,800
	Sprinkler System	168,500	141,600	194,000
	Halon 1301 System	63,800	63,800	87,400
B6.2	Environmental Control:			
B6.5	HVAC System	875,000	776,000	1,063,400
B6.1	Air Purification	17,000	17,000	23,300
B6.4	Smoke Control	52,400	52,400	71,800
B6.6	Building Automation (1)	221,800	146,600	200,800
B7	Acclimatization: Fumigation	19,200	19,200	26,300
	Coll/Purging System	10,500	10,500	14,400
	Delint/Dehum.	19,400	19,400	26,600
Subtotal		$1,623,970	$1,377,900	$1,888,000
Mark Up (2)		600,900	509,100	
Subtotal		$2,224,870	$1,888,000	$1,888,000
Architectural and Engineering Fees		222,400		188,000
TOTAL		$2,447,270		$2,076,800

Notes:

1. Based on automation system built around the Children's Museum computer.

2. Includes General Contractor's mark up of 10% overhead and 5% profit and escalation of 9%/year for two years, which results in a multiplier of 1.37.

Cambridge Seven Associates, Inc. 1050 Massachusetts Avenue, Cambridge, Mass. 02138 (617) 492-7000
830 Third Avenue, New York, New York 10022 Tel. (212) 752-1194

TRANSMITTAL

date 22 September 1978

job The Children's Museum

to Phyllis O'Connell

- [x] **enclosed**
- [ ] **under separate cover**
- [x] **by mail**
- [ ] **by messenger**
- [ ] **sent per your request**
- [ ] **sent for your information**
- [ ] **approved**
- [ ] **returned for correction and resubmittal**
- [ ] **approved as noted**

Renovation Survey for the Security Collection
Storage and Climate Control Systems for the
Congress Street
Wharf

by John STebbins/sd