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Vol. 2 of 2

HISTORIC STRUCTURE REPORT

ARCHITECTURAL DATA SECTION
(VOLUME II - SYSTEMS ANALYSIS)

DRAFT

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OLD STATE HOUSE
BOSTON NATIONAL HISTORICAL PARK

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National Park Service

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INTRODUCTION

This document contains Volume II of the two-volume Old State House Historic Structure Report (HSR). It updates and expands upon the information written in the original Old State House HSR, 1977, by the Society for the Preservation of New England Antiquities (SPNEA).

Sections of the original report have been reused and some modified to reflect the existing conditions in 1987 rather than ten years earlier. A number of sections have also been rearranged or rewritten to give more insight into the problems under discussion in the Conditions and Recommendations component.

New sections were included to equate the original report to the current standards of the Cultural Resources Management Guidelines (NPS-28) by adding or discussing in more depth a number of topics that the original report omitted, and to assess the impact on the structure due to any recommended treatment. Among the topics added are: (1) Code Analysis, (2) Energy Conservation Analysis, (3) Planning and Design Requirements, (4) Archeological Requirements, (5) Record Drawings, (6) Analysis of Impact of "Recommendations for Treatment" on the Structure, its contents, and the Historic Scene (Section 106 Compliance in accordance with 36 CFR 800), (7) Package Estimate Detail, and (8) Recommendations for Further Study. The "Structural Engineering Report," prepared by Goody, Clancy and Associates, Inc., and LeMessurier Consultants in 1987, is included in its entirety with related calculations and the report: "Measurements of Vibrations and Noise in the Old State House" by BBN Laboratories is also included (see Appendix A). These topics and others are required by NPS-28, and must be considered by managers and cultural resources professionals alike before any suggested undertakings are implemented on the structure.

It is not the intent of this report to invalidate all the contents of its predecessor, but to bring them more in line with the events that are about to impact the structure. However, the report will show that in fusing the thoughts of the authors into a single document, the NPS goals for the "Rehabilitation of the Old State House" can be successful.

Thanks to SPNEA authors Morgan Phillips and Sarah Chase for their writing of the original report which provided good background data for the updated information of this volume. Except for modifications and several new sections added to the report, most of Phillips' work ("Extant Conditions" of the original HSR) is contained in the sections called Historical Background of this volume; and Chase's work in Volume I, which is essentially the original 1977 HSR, less the section on "Extant Conditions." Commendations are also extended to Paul Vwinbaum, Boston National Historical Park, for writing the "Statement of Historical Significance," and to the typist, Teri Metzger, and editor, Mary

Ryan Volkert, for their contributions in assembling the documents in their final form. It is the team concept demonstrated in the preparation of these documents that makes for excellence in planning, design, and construction relative to the preservation of our cultural resources.

John B. Marsh

STATEMENT OF HISTORICAL SIGNIFICANCE

The Old State House (Second Boston Town House) was built in 1712-13 to house the governmental offices of the Province of Massachusetts Bay, the town of Boston, and Suffolk County. The structure is most significant because of its direct association with the American resistance to British colonial policies in the 1760s and 1770s.

The House of Representatives (General Court) for the Province of Massachusetts Bay met in the Representative's Hall on the second floor of the Old State House; there, representatives protested Parliamentary hegemony on issues of taxation and self-government. Patriot leaders elected to the House included Samuel Adams and James Otis.

Actions taken at the Old State House that furthered the patriot cause included Otis's call for a colonies-wide meeting to protest the Stamp Act (1765), and the House's issuance of the Circular Letter of 1768 addressed to the speakers of all the other colonial assemblies.

In the instance of the Circular Letter, Boston took the lead in the colonies in protesting parliamentary taxation and in asserting the principle that the British constitution guaranteed all subjects the right to be taxed only with their consent. The

House, contrary to the requirements of George III's ministers, subsequently voted against rescinding the Circular Letter. Passage of the Circular Letter and refusal to rescind it occurred in an atmosphere furthering violent hostility to the customs commissioners, who collected the disputed taxes levied by parliament. The violence, in turn, led to the stationing of British troops in Boston.

The Old State House was also the seat of royal authority. The provincial council, appointed by the governor acting for the king from nominees chosen by the House, met in the Council Chamber on the second floor. The council figured significantly in the aftermath of the Boston Massacre.

On March 6, 1770, the day following the massacre, Boston's selectmen met Lieutenant Governor Thomas Hutchinson in the Council Chamber to demand the removal of the troops that had occupied Boston since October 1768. In the negotiation that followed, the town, in the person of Samuel Adams, succeeded in having both regiments then stationed in Boston removed. The town rejected the council's compromise offer of removing only the regiment responsible for the shooting. The outcome was a clear victory for the patriot cause; the massacre itself escalated the conflict with Britain.

The east balcony of the Old State House is significant for its association with the Boston Massacre--from here, Lieutenant

Governor Hutchinson, immediately following the event, urged the milling crowd to disperse. It is also known for its ceremonial use--from the east balcony, the Declaration of Independence (July 18, 1776) and the proclamation ending the war with England (July 18, 1776) were first publicly read in Boston; and on October 24, 1789, from the east balcony, President George Washington reviewed a procession honoring him as the newly elected President.

The Old State House has additional significance as a governmental building. Called Boston's Second Town House, it was the site of town meetings between 1712 and 1743. This period saw the development of the Caucus (a political machine that acted as a countervailing force to the royal establishment) which facilitated the rise of an ideologically motivated opposition in the Revolutionary era. The representatives' room was also the first meeting place (and the only extant) for the state convention that in 1788 ratified the United States Constitution; upon ratification, the convention adjourned to the State House to publicly declare that the Constitution had been ratified.

The Old State House is the oldest extant building of Georgian design in the United States and it is an early instance (1881-82) of the preservation of a structure for historical reasons.

I. ADMINISTRATIVE DATA SECTION

The following data is based on NPS-28, Appendix F: Preparing a Historic Structure Report. Data is to be furnished by management and is usually written by the park superintendent. It must include all of the following:

A. PROJECT IDENTIFICATION:

Name: Old State House

Number: LCS Number 21037

Location: Boston National Historical Park, 206 Washington Street Boston, Massachusetts 02109

Period: 1713 to present

Significance: The Old State House is most significant (national significance) because of its direct association with the American resistance to British colonial policies in the 1760s and 1770s.

B. THE STRUCTURE'S ORDER OF SIGNIFICANCE AND PROPOSED LEVEL OF TREATMENT AS SHOWN ON THE LIST OF CLASSIFIED STRUCTURES (LCS):

The Old State House was listed on the National Register of Historic Places on October 15, 1966. It is on the List of Classified Structures, Category A, and legislation mandates that this structure "must be preserved."

C. PROPOSED ANTICIPATED DEVELOPMENT WORK (TREATMENT) BASED ON THE LCS AND THE DEVELOPMENT/STUDY PACKAGE PROPOSAL:

Park should complete this section.

D. PROPOSED USE OF THE STRUCTURE AND OPERATIONS AND MANAGEMENT REQUIREMENTS:

Park should complete this section.

E. OUTLINE OF COOPERATIVE AGREEMENTS OR OTHER DOCUMENTS:

Currently, there are cooperative agreements for the management of the Old State House between the National Park Service (NPS) (preservation managers) and the city of Boston (owners), and the NPS and the Bostonian Society (tenants). These agreements were signed in 1987. An approved General Management Plan for the Boston National Historical Park (August 1980) also exists.

II. GENERAL DESCRIPTION OF THE BUILDING AND SITE

The Old State House is in the heart of downtown Boston on a site indistinguishable from the urban landscape. This 1882 and 1909 (Colonial Revival) restoration of the original 1712-13 Georgian building stands two stories high. The building is enclosed by brick walls laid in English bond, and fenestrated by 12/12-light double-hung windows and 9-light ox-eyed wood windows. It houses an area of over 14,000 square feet divided among its first, second, attic and basement floors. A steeply pitched slate gable roof supported by wood trusses covers the structure and spans between its stepped gable end walls.

A three-tiered tower rises to a height of approximately 48 feet from the center of the roof above the building's central staircase. This structure is covered by a metal ogee shaped roof and is enclosed by wood sheathed walls fenestrated by tracery over 12/12-light double-hung and 9-light oculus windows. Like the framing that spans the floors and roof of the brick structure below, the tower's framing is constructed of heavy timber. Its load transfers down to the heavy timber roof (brick building) trusses, through the brick walls, and to the foundation.

Three entrances with pediments above them provide access to the building's interior. However, the main point of access is through the south elevation, or plaza area entrance, of this group. After entering the building, one passes through a vestibule and another doorway before entering the exhibit spaces. These exhibit spaces compose the museum for which the structure is currently used. There are finishes from 1882, 1909, and 1943 throughout the museum spaces, however, the 1882 finishes are most prevalent and representative of the building period.

Major building egress is via the north entrance doors where one steps down to a sidewalk on the site and back into the urban landscape. The immediate areas surrounding and below the building are entirely supported by the roof of the Massachusetts Bay Transit Authority's (MBTA) State Street subway station. This structure is the Old State House's foundation. To the north, east, west, and south of the building are major streets abutting the sidewalks at the building's perimeter. There is State Street North to the north, Devonshire Place to the east, Washington Street to the west, and State Street South to the south. All streets are asphalt paved, except for the brick paved State Street South which is closed to major vehicular traffic. This street now serves as a pedestrian plaza and connector between the NPS visitor center at 15 State Street and the Old State House.

Currently, the Old State House is in good condition, but in need of repairs. The solutions to needed repairs, and other problems of the building, are explained in the study that follows.

III. EXISTING BUILDING SYSTEMS

A. FOUNDATIONS AND SUBSTRUCTURES

1. Building Proper

a) Historical Background: As observed from the boiler room at the southwest corner, the original foundation of the building was probably of stone construction bearing on solid earth below grade. What remains of this foundation lies resting above the concrete encased steel beam of the current foundation.

The foundation of the building from 1902-04 to the present consists of beams, columns, tunnels, trusses and vaults as described in the Conditions and Recommendations section that follows. Evidence (Illustrations 1 through 3) indicates that the building was underpinned and shored and the soil excavated from beneath it in preparation for the new subway station; when the station was completed, the building rested on its roof.

These foundations were altered in 1907 [1] and again in 1976-77. The 1907 alterations relocated the boiler room of the Old State House from beneath the rotunda to its present location at the southwest corner of the building where it lies beneath the basement floor. In 1976-77, the subway station was renovated.

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[1] Washington Street Tunnel Drawings--Section 6, Boston Transit System, 1907

The renovations were a part of the MBTA's Contract No. SM-538: State Street Station Modernization of which several actions centered around the Old State House's foundation.

Sheet S-3 of the construction drawings shows that Columns S-13 and S-15, beneath the south wall of the building, were lowered and strengthened, respectively. Columns S-016-1/2, S-24, and S-26, and trusses ST-16-1/2 and ST-26, all supporting the floor of the building above, were removed and replaced with three 14-inch by 30-pound I-beams. These I-beams are supported by the tunnel wall and two back-to-back 12-inch channels connecting and stiffening Columns S-15 and S-16.

Field inspections and the drawings indicate that the alterations had little or no impact on the building's current deteriorating structural condition. However, a nonstructural concrete block partition wall, which was installed at the time of the alterations, is damaged. The damage to the wall is believed to have resulted from the settlement of the building's southwest corner which is supported by Column S-18 in the subway. For whatever reason, the building settled and Column S-18 appears to have shifted or moved and cracked the wall which surrounds it.

b) Conditions and Recommendations: The foundation system of the Old State House is basically the superstructure of the MBTA State and Washington Streets subway stations. This system, approximately 4,000 square feet, is composed of (1) concrete encased steel girders, beams, and columns, (2) a series of reinforced concrete arches or barrel vaults, and (3) the reinforced concrete East Boston Tunnel (see the Foundation Drawings).

Girders, beams, and columns support 1,540 square feet of the building beginning at the south wall of the East Boston Tunnel and extending to the exterior perimeter of the building's south and west walls. While the entire west wall is supported in this manner, the supports for the south wall end within 45 feet of the east wall.

The girders (I-beams) supporting the south and west walls are placed in pairs and sized from 18 inches by 55 pounds per linear foot (plf) to 24 inches by 80 plf. They rest on 12-inch square built-up columns (plates and channels) spaced 10 to 15 feet on center. The columns are 8-1/2 to 35 feet long due to the changing elevations of the floors. Beams (I-beams) spanning from the wall girders to support the floors are 8 inches by 15 pounds to 8 inches by 18 pounds in size, and the trusses, which also help support the floors, are approximately 5 feet deep. The beams and trusses are connected to and supported by the columns at one end, and at the other end by the wall girders or sections of the tunnel wall. The supporting columns are 12 inches square like the columns beneath the walls. All columns transfer the building loads to isolated steel and concrete footings which rest on sand and gravel over clay.

The main tunnel extends diagonally and northwesterly from the same point where the beams, girders, and columns terminate to support 1,240 square feet of the building (which consists of the building's floor and north wall). The members rest directly on the roof of the tunnel with the exception of several basement columns. The basement columns are cantilevered from corbeled piers at the edges of the tunnel in areas where the tunnel curves away from them.

Subway tunnels supporting the building are generally constructed of reinforced concrete. They were constructed using "shield tunneling," [2] a construction method of that time similar to "slip forming" of today. During construction, the steel shield is set in place atop a prebuilt concrete side wall. Concrete is poured over the shield and, when cured, forms a section of the roof and side walls of the tunnel. After curing is complete, the shield is advanced by jacks on the prebuilt wall to construct another section until the entire tunnel is completed. This tunnel also transfers its loads to sand and gravel on a clay base much like the system above.

A differently constructed section of the tunnel supports the remaining easterly 1,220 square foot section of the Old State House above. This section is composed of concrete arches or

[2] Boston Transit Commissions "Engineering Report," 1902-1904.

vaults reinforced with steel rods and supported on steel girders. This system runs transversely to the longitudinal or east/west axis of the building. Under the east wall mass, concrete encases a steel girder in a cross section that is 3 feet thick and 6 to 9 feet deep. The steel girder is supported at the ends on the side walls and at two intermediate points by steel columns. Part of the southerly wall of the building is extended down in concrete construction 3 feet thick. The northerly wall of the building rests entirely on the vaulted roof of the tunnel. Over the tunnel and lobby at this point, the floor of the room (Whitmore Hall) was raised approximately 19 inches and replaced with concrete and steel. Loads from the building in this area are also transferred to sand and gravel on the soils.

2. Boiler Room and Sidewalk Area

a) Historical Background: The current boiler room was constructed in 1907 to replace the earlier, or original, one that was located beneath the rotunda. Drawings suggest that the boiler room was relocated to allow for subway expansion. The earlier space was located near what is currently the passageway and stair area of the station where it would have blocked circulation space. It is conceivable that the earlier boiler room was of stone construction, much like the original foundations of the building.

What remains of this stone foundation has deteriorated mortar joints which have allowed the stone to settle. Consequently, the brick wall above this area has settled and cracked. Column S-18, which supports this section of the wall, appears to have shifted or moved as stated above. In addition, the boiler room's ceiling (composed of the concrete sidewalk and concrete encased steel beams of the sidewalk and building) is deteriorating from earlier moisture problems. The moisture has caused the steel to rust, expand, and spall the concrete from around it.

b) Conditions and Recommendations: To quote Morgan Phillips, "the boiler room is an integral part of the Washington Street subway construction." It covers 406 square feet of the subway station and is located just below the southwest corner of the Old State House's basement. Columns supporting the concrete encased steel beams and reinforced concrete slab of the boiler room are essentially the same as those supporting the walls and floors of the building above.

The boiler room floor supports a reinforced concrete wall that separates the boiler room from the rest of the subway. This wall and the walls of the Old State House support the surrounding reinforced concrete sidewalks and their concrete encased steel framing. The sidewalk, sidewalk framing, and the girders at this section of the Old State House form the ceiling of the boiler room.

Between 1969 and 1977 when the structural engineering firm of LeMessurier Associates/SCI investigated the structural conditions at the Old State House, they made written findings. In 1976, these findings resulted in recommendations for reinforcements to structural components. The recommendations were carried out under the program of repairs directed by the architectural firm of Stahl-Bennett, Inc.

Below is a summary of the findings of the structural engineers, a description of the reinforcements that were carried out, and an outline of several suggested repairs that must still be explored.

> Foundations: The structural engineers had determined that the foundations were solid, because they consist almost entirely of steel and concrete subway construction. Most recently, the authors of this report observed evidence of possible structural movement of the foundations.

Currently, proposals for monitoring possible movement of the building and subway are underway to evaluate new thinking relative to their stability. Accordingly, several questions are being asked and weighed. For instance: (1) Has the subway structure settled and, if so, did it cause the cracks in the walls of the Old State House?, and (2) Is the subway still settling, and will it continue to damage the walls of the building and decrease its structural integrity? In addition, inquiries about the condition of Column S-18 must be satisfied and actions must be taken to resolve the problems in the deteriorating stone foundation, brick walls, and concrete sidewalks and beams at the southwest corner of the building (Illustrations 4 through 6). These problems and their funding requirements are addressed by the "Structural Engineering Study" that accompanies this report.

B. SUPERSTRUCTURE AND EXTERIOR CLOSURE

1. Masonry of Exterior Walls

a) Historical Background

(1) Original Brickwork:. About two-thirds of the brickwork of the exterior walls appears to date from the 18th century, much of it probably from 1712. Although some areas have been so heavily reworked as to make their age uncertain, other areas show three types of evidence that--taken together--strongly indicate an 18th-century date. These three characteristics are:

(a) Bricks typical of the period, laid in English bond.

(b) Early lime mortar still exposed to view in many areas, covered by repointing in others.

(c) Remnants of paint still on the bricks or mortar, sometimes present in a number of layers.

Areas having old paint layers on early looking bricks and mortar must predate by many years the stripping of the paint in 1909. They could not date from the 1882 restoration because it is most unlikely that Clough would have taken the trouble to duplicate perfectly the 18th-century bricks and mortar, only to then paint them all. This line of reasoning also rules out the brickwork's dating to the mid-19th century or to the Rogers period; it is almost unthinkable that such perfect 18th-century type masonry would have been created at any time between 1830 and 1881 and then painted over. The most logical conclusion is that the early looking brickwork with lime mortar and remnants of paint predates the first known painting of the brickwork in 1773 (see The Revolutionary Period, Volume I).

The following areas show these types of evidence of an early date:

(d) The north and south facades, excepting Chandler's 1909 basement story and brick water table; Chandler's patches directly beneath the first-floor windows on the western half of each facade; and Chandler's large patches above the subway area.

(e) The brickwork between the windows on the east facade. Admittedly, these bricks could date from 1773 when most or all of the east wall was rebuilt (see The Revolutionary Period, Volume I).

(f) Probably most of the second and third stories of the west facade. Paint is found on the brick here, and--under the recent cement repointing--lime mortar. It looks as though a small area of lime mortar may still be exposed in the small area over the third-story window.

(g) Possibly two vertical zones on the first story of the west facade, between the outer corners of the facade and the windows. Although completely repointed with recent cement mortar, these two zones appear to be of the early brick. The earlier views of the west facade show these as areas that might have escaped the constant series of alterations being just outside the area occupied by so many different doorways and shop windows. Later photographs from the periods of Clough and Chandler show them as obviously older brickwork sandwiched in between later masonry.

(2) Early Jack Arches: Most of the windows on the north and south facades have early jack arches of finely gauged brick voussoirs, with those on the first floor scored to imitate horizontal joints. Some of the arches have been partly or wholly replaced with later brick of various unidentified

dates. The early work can be distinguished by its orange-brown color, fine vertical mortar joints (made possible by very careful gauging of the shapes of the bricks), and matte-like rubbed surface. The early arches have been preserved best at the second-story level where the cornices have offered protection. Two fine examples do exist at first-floor level, over the first two windows to the west of the north doorway; these can be contrasted with the later type in the next window to the west.

None of the early type of arch has been identified on the more heavily rebuilt east and west elevations.

(3) Later Brickwork: Since there have been so many repairs, especially to the gable ends, it is hard to inventory and date all later patches of brickwork. However, the following areas have been identified:

(a) The belt course across the east facade between the first and second floors is of Victorian brick, probably Clough's work. It obviously postdates 1880 since a photograph taken that year (Illustration 40, Volume I) clearly shows no belt course in this location.

(b) The jack arches of the windows on the heavily rebuilt east and west elevations are not original work, as mentioned previously. Illustration 67 shows three windows on the east elevation whose jack arches were rebuilt in 1957 on steel angles. (The upper pair of the S-shaped tie rod anchors dates from 1975.) Later patches of brickwork also can be found as repair work in the original arches on the north and south elevations. All later arch brickwork is more reddish-purple in color then the original; it has wider vertical mortar joints and a shinier surface.

(c) Chandler's 1909 brickwork is found in many locations and is identifiable in several ways. The bricks are good reproductions of the building's early bricks, but more purplish. A good number of Chandler's header bricks have a yellowish glaze. Also, Chandler used light gray, fine textured mortar, which contrasts slightly with the older lime mortars. The following areas consist of Chandler's brickwork:

(d) All above grade walls of the basement, up to and including the water table.

(e) On the north and south facades, a large area around and above the subway entrances which were redesigned by Chandler; the area beneath the western windows of each facade (Chandler shortened these windows); and in two small strips beside Chandler's doorway on each facade.

(f) On the east facade, most of the first story (up to balcony level in the center), and a patch directly beneath each of the two second-story windows.

(g) On the west facade (recently repointed with Portland cement), most of the first story except for the two older patches just in from the corners.

Still later brickwork is seen in the third-story gable end wall of the east facade which George Sherwood almost entirely rebuilt in 1957. The newest brickwork of all is currently being introduced into the area of the redesigned subway entrances.

(4) Parapet Copings and Chimney Caps: All photographs from before the 1882 restoration until quite recent decades (well after the 1909 Chandler restoration) show brownstone coping stones on all parapets, with neatly halved joints where they meet end-to-end. These appear in as late a photograph as one at the Bostonian Society showing the east end and automobiles of 1949 or later.

George Sherwood's plans for repairs in 1957 (Illustrations 103 and 104, Volume I) call for replacing almost all of these stones with wood copings covered with lead coated copper (LCC). Indeed, this arrangement is found on the entire east parapet, except under the unicorn. Here, and under the south scroll of the west parapet, examples of the old brownstone copings remain with their neatly halved joints. On the west parapet, except for the one length of brownstone, the copings are brown tinted cement of uncertain, but rather recent date.

The light colored stone caps on both east and west chimneys (the east one covered over with cement) are almost surely the ones Sherwood specified to be reset in 1957 (see Illustrations 103 and 104). These appear to be the ones shown in photographs taken in the early 20th century, including some before 1903 when the subway was built. It is not clear how much farther back they date.

(5) Granite Steps and Doorway Piers: Chandler's 1908 drawings for the redesigned north and south doorways show the lowest three steps in each doorway as "Old" granite steps to be kept in place (Illustration 59, Volume I), while the top two are labeled "New." It is probable that the old steps survive from Isaiah Rogers' redesign of the doorways (Illustration 18, Volume I) since they seem to be the ones shown in all views after 1830.

It is also possible that some of the granite blocks Chandler used as pedestals under his columns on all three doorways (or as jamb pieces of the north and south doorways) are older material, perhaps moved from other locations. If older, the jambs must have been moved forward by Chandler since Rogers' plans and preChandler photographs show jambs set back from the granite pedestals (Illustrations 18 and 43, Volume I).

(6) Light Wells: The light wells around the west end of the building were built as part of Chandler's reworking of the foundations, as shown on his drawings (Illustration 58, Volume I).

b. Conditions and Recommendations

(1) Exterior Walls: Badly eroded mortar joints were found in a number of areas in 1976. The brick foundation at the sidewalk level had suffered from rain splashing back and needed selective repointing, especially toward the west end of the north and south walls (Illustration 7). Although these areas had been repointed since that time, selective repointing in several areas is still needed today on the east, north, and south walls.

The cement wash or watershed on the belt courses (particularly those at second floor level on the north and south walls) is deteriorated and should be repaired. The belt courses themselves need some repointing.

(2) Mortar Color, Texture, and Strength: A philosophical and practical problem arises in choosing the appropriate mortar color, texture, and strength for repointing, repair, or rebuilding. One could use only the soft white lime mortar that was original to the building, and which has survived in at least half of the wall area. Or, in the areas built by

Chandler such as the foundation and the areas directly beneath the first-floor windows, one might use a slightly stronger, grayer mortar (matching Chandler's) to preserve a visual indication of the Chandler work. The latter course seems preferable since a lime mortar today is not truly comparable to historic lime mortars. Historic limes were not as pure as today's limes and contained some natural cements or hydraulic qualities.[3] Consequently, a historic mix of 1:3 (1 part lime to 3 parts sand) is stronger (50-300 pounds per square inch (psi)) and more durable than a mix of today (50-200 psi) using the same proportions of sand and lime. The Chandler mortar color is light enough not to break up the design of the building, but dark enough to provide the inquisitive viewer with information as to the building's history and a sense that the building has changed over the years. It is also believed to be lean enough because it is compatible with the strength of the brick in the walls which show no damaging effects from the use. During the formulation of the new mortar, care should be taken to match the original color, strength, and texture of the Chandler mortar, which was probably slightly lighter than its present dirty and stained color. The mortar analysis indicates that this mortar is composed of 1 to 2 parts lime matched with 2 to 2-1/2 parts sand.[4] However, the strength of this mortar has not been tested, but since a lime mortar today with the same ingredients as the latter mortar is

[3] National Lime Association, Durability of Mortar and Masonry, Technical Notes, 1975.

[4] Paint and Mortar Study, Old State House--Boston National Historical Park, Andrea Gilmore, November 1987, Pages 114-119.

potentially weaker and less durable, a little portland cement may have to be added to the mix to achieve comparable results. A mix such as 1:3:12 should suffice since its strength may be as low as 300 psi.

As for the much more recent gray cement mortar on the west end and in the portions of the east parapet rebuilt by George Sherwood in 1957, there is no historic reason to preserve this color. Since the mortar is in good condition, however, practically suggests its color be repeated for all minor repointing in this area. (Small patches of white mortar in these areas would look strange.) The color can be changed when major repointing or rebuilding becomes necessary.

(3) Water Penetration Through the Brickwork: Water was seeping through the exterior wall at the northeast corner of the building at the second-story level, spoiling the plaster and new paint inside the Council Chamber. This condition undoubtedly was related to the poor condition of the brickwork (most deteriorated mortar) in this location where repointing was urgently needed. Water leaks were also caused by bad flashing at the east parapet wall, leaky windows, and leaky pipes in the walls. The condition was halted when repairs were made in the summer of 1986.

A second area of serious water penetration was at the foundation level in the western half of the building. The walls were also repointed to stop the leaks.

In the cellar, the plaster did not entirely cover the foundation walls and severe dampness and even dripping water was seen during wet weather. At present, no areas are evident where structural stability is threatened but the mortar is deteriorated in some places. If allowed to continue, water soaking of portions of the foundation will threaten the stability of the handhewn first-floor girders whose ends are bearing on the foundation walls at the water table level. Along the north wall, the plaster in places of the space set aside for conservation activities has failed due to the past wetness (Illustration 8). Capillary action once occurring through the northern brick foundation walls of the rotunda spoiled the plaster to a height of 6 feet. Illustration 9 shows this, as well as earlier standing water ("a"). Along the south wall, there was severe dampness in the masonry construction in and around the head of the boiler room stairs.

Given the fact that the building sits almost entirely over subways and other excavated space, the nature of the problem was not rising damp fed by subterranean water. Rather, the water appeared to have come from two sources: defective downspouts and drains, and rain water on the sidewalks. For example, directly outside the damp area at the head of the boiler room stairs the downspout was broken off. Even without that inflow, the drain pipe to which the downspout would have been connected did not drain during rains. Other drainpipes were broken as well (Illustration 10) and were contributing to the deterioration of the mortar. As for the sidewalk water, the sidewalks simply abut the building's brickwork and there was every reason why water should penetrate there. There was also standing water in the south gutter during wet weather (Illustration 11). Clearly the first remedial step was to reconnect and clean the entire drainage system. Afterwards, a brick terrace was installed over the sidewalk and street by the Boston Redevelopment Authority (BRA) in 1986. Water leaks are less noticeable since the above work was performed, however, after all of the work some of the soft mortar in these areas continues to be washed out. Consequently, a more durable mortar mix should be used here.

(4) Parapets: By virtue of their thinness and severe exposure on both sides and quality of brickwork, the parapet walls soak right through in prolonged wet weather. During rains, and even long afterward, the west parapet can be seen from the street to be thoroughly soaked, contrasting sharply with the portions of the wall below roof level. Sometimes efflorescence is seen on the parapet walls under drying conditions, and some brick have spalled. The west parapet (Illustration 12) has particularly severe efflorescence on its west face under certain weather conditions. Unfortunately, the moisture penetrates downward by capillarity far enough below roof

level to wet portions of the plaster and furring at both ends of the attic, and the wooden roof construction where it contacts the masonry. Moisture all around the ox-eye windows is causing them to deteriorate, and undoubtedly had much to do with the reason their sashes and casings had to be renewed in 1957. Although the woodwork near the roof is holding up remarkably well under these damp conditions, the wetting of wood and spoiling of plaster do tend to justify some corrective action.

One step that was taken in 1987 was to repair or replace some portions of the cap flashing where the newly laid roof abutted the parapet walls. Unlike the new LCC base flashing, the cap is of old lead and split in some places (Illustration 13). However, this defect does not account for the soaking through of the parapet walls, nor does the slightly imperfect but still good condition of some of the stone, cement, and LCC covered copings. Rather, the walls soak through because they are thin and saturated with water on both sides.

Some alternative solutions are mentioned below; there are undoubtedly others. None of those discussed here seem really safe or effective. Selection of the proper one will require much additional discussion.

One choice is to do nothing. The present condition has existed for a long time, and the tradition of periodically repairing the damage to the parapets could be continued.

Another alternative would be to apply a water repellent to both sides of the parapets. However, this should be done after other steps are taken to make the wall watertight, and then only on a test section first to assess its effect.

Note that moisture penetration of the porous walls in a salt-laden environment such as Boston is probably the most difficult and controversial problem to solve. But, in light of its effects on the structural stability and longevity of the parapet wall's fabric, measures must be taken to remedy the current problems.

First, all obvious cracks and deteriorated mortar joints should be repointed to seal the wall from possible water penetration. In doing so, the mortar used should be compatible with the deteriorating or porous brickwork so that it will not damage the already feathered edges. Should the mortar and brickwork not be compatible in all joints throughout the wall, the existing mortar should be raked down 2-1/2 times the joint's thickness and the walls repointed with a compatible mortar. Once the walls are repointed they should be thoroughly cleaned.

Secondly, the cleaning of the walls should be performed to remove all loose mortar, dirt, salts and other stains that blemish its appearance. Only a soft bristle brush and low water pressure are deemed necessary for this task. When washing has been completed, the walls should be left so until they are thoroughly dried.

Finally, when the walls have dried, an attempt should be made to stabilize their porous brick surfaces from water penetration. Common surface treatments using water repellent or waterproof coatings have been used to stop water infiltration in masonry walls, but no treatment has been proven totally successful and free from damaging consequences.

Studies show that clear water-repellent coatings such as silicone or silane have had little success in treating water infiltration in walls because, although they keep liquid water out, they allow water vapor to enter. Once the water is in the walls, the water-repellent coating prevents the water and dissolved salts from coming completely to the surface, and then the problems begin. Water and the pressures from salts trapped in the walls will cause damage under freeze-thaw and drying conditions. Such damage will result in cracking and spalling of the wall surfaces.

Waterproof coatings will not cause problems in the walls as long as water is not allowed to enter. However, under normal conditions it is almost impossible to keep the building totally dry. For example, the users and environmental control system would contribute to moisture in the walls. And in the case of the parapets, some moisture would enter the walls over time just from the surrounding atmospheric conditions. Should the water enter the walls and be trapped behind the impervious coating, it may seek the path of least resistance causing water damage, especially under freeze-thaw conditions.

In spite of the problems associated with the water repellent or waterproof surface coatings, a greater problem lies in the unprotected porous and deteriorating wall surfaces left exposed to the salt-laden environment. Consequently, a coating should be considered.

Evaluation of the two coatings indicates that, over time, the water repellent coating will be less damaging to the structure if all sources of water problems (deteriorated mortar joints, capstones, brick, etc.) are eliminated.

Again, no coating should be applied over all of the wall surfaces until its effects on the wall have been tested, studied and found suitable. The wall should also be dried out, cleaned of all salts, and consolidated (repointed, cracks patched, etc.) before a coating is applied.

A third approach involves the injection of a metallic chemical dampproof course into the walls at the roof line using silicones in the way some English restorationists have done. (It would be very difficult to insert an equivalent metallic through wall flashing.) This would not protect the parapets themselves, but only the interior woodwork and plaster at the roof line and below. It also might create a concentration of water in the brick just above the treated area, with attendant greater damage during freeze-thaw and wetting cycles.

(5) Cracks in Masonry Walls: The end walls (east and west) have moved outward. In 1975, the most recent in a long series of repairs to the gables was carried out following the recommendations of structural engineers. The parapet walls were tied to the roof trusses at two points on each end of the building using tie rods and S-anchors matching two existing ones on the east end. Counting the existing ones, this makes a total of two tie-back points at the west end of the building and four at the east. Two additional holes higher up on the west gable were drilled to receive rods but the rods were never installed. The fact that these rods were not installed is insignificant since attempts to stabilize an unreinforced masonry wall with the rods attached to the upper chords of the wood trusses seems inadequate.

A broader concern about tying back the gables relates to the fact that there is outward movement of larger portions of the end walls rather than just the parapet and attic areas. Vertical cracks at the east end of the north wall (Illustration 14) and at the west end of the south wall (Illustration 15) indicate outward movement of the east and west end walls. However, whether the movement has ceased or remains active is a matter to be addressed by the structural engineering section of this report. In both cases, an outward lean of these walls is visible. The cracks on the side walls rise through almost two full stories, widening as they approach the cornice. They then pass through the jack arches of the second-story windows at the end of each side wall (see Illustration 15).

There are also cracks in the plaster of the Council Chamber (Illustration 16) and Representative's Hall (Illustrations 17 and 18) that correspond exactly in location to the cracks in the exterior brickwork. Although these cracks existed prior to 1975, they clearly had extended and widened since the walls were painted in that year. In several places, the 1975 paint clearly shows the pattern of a dried layer that has been broken, rather than just a wet layer that has flowed into a preexisting crack. Illustration 18 shows the corner of the south and west walls (labeled "a" and "b") in the Representative's Hall; at "c," a piece of 1975 paint still spans the crack, though it has been torn and twisted since its application.

Glass telltales should be installed over these cracks (on both the exterior and interior wall surfaces) with a removable adhesive to ascertain the rate of movement over the next several years.

A number of shear cracks of various ages along the north and south walls will need repointing.

The structural engineering study will determine whether the cracks in the walls are of a structural or thermal nature. Recommendations for further repairs will be included in the structural engineering report.

(6) Jack Arches: Several of the jack arches above the windows show old repairs, and some were rebuilt by George Sherwood in 1957 (see The New Council Chamber and Later Work, Volume I). Several more arches now need at least partial rebuilding.

In some instances, they appear to have failed through erosion of their mortar. In several cases (above the windows at the east end of the north wall and the west end of the south wall, especially), the failure of the arches is attributable to the aforementioned spreading of the walls and the formation of vertical cracks upwards through the window bays. On the east end wall, both factors may be combined. Several of the wooden window casings are now noticeably stressed by the masonry above, being no longer supported by an arch.

Wherever the early orange-brown brick is found in arches that require rebuilding, the brick should be numbered carefully and reused in order. It would be a good idea to conceal rust-resistant stainless steel angles under each rebuilt arch (as George Sherwood did on three windows of the east end wall) to insure continued support in spite of any future spreading of the arch.

2. WOODEN STRUCTURAL FRAMING

a) Historical Background: Ever since its reconstruction after the fire of 1747--and perhaps even as first built in 1712--the Old State House has been framed internally in 10 structural planes, except for an 11th truss placed in the attic space to strengthen the roof. The roof trusses form the visible element of each of these planes, spanning 32 feet of the Council Chamber and Representative's Hall and (above the staircase) supporting the tower. These charred but still sturdy trusses of handhewn timbers have doubled upper chords, of which the lower chord is curved (Illustration 107, Volume I). They are very similar in this respect to those in King's Chapel which was built in almost the same year (1749) as the Old State House was reconstructed.

In plane with the 10 trusses are 10 north-south girders framing the floors of the second story. The joists run east-west and frame into these girders. The girders were originally supported on "ten pillars of the Doric order" (see The Revolutionary Period, Volume 1) rising through the first floor. This floor, like the one above it, is framed with north-south girders in the 10 planes and east-west floor joists. Posts or piers in the cellar support the first-floor girders at mid-span, being located directly below the posts rising through the first story. The planes align naturally with the areas of masonry between the windows on the north and south walls.

Through the years, those who have wished to change the plan or appearance of various spaces have felt free to change the location of posts or to eliminate them altogether. However, insofar as the story has been reconstructed, new posts have always been located in plane with the roof trusses and floor girders. In general, where a post has been omitted, some other provision has been made within the same structural plane to provide for support of the girders of the first and second floors.

As the building was rebuilt in 1748, the first floor was a merchants' exchange with columns down the center in the structural planes. [5] The first known alteration of this pattern was by Rogers in his 1830 remodeling. In his 1830 plan, as republished in the Rededication (Illustration 18, Volume I), Rogers has done away with the columns down the center of the eastern half of the first floor. (This area would become Topliff's News Room.) Instead, he called for two rows of five columns each. Thus, each second floor girder was now supported by two columns at about the third points, rather than by one column at mid-span. Each pair of columns is in one of the structural planes, except the easternmost pair which are well to

[5] WPA, p. 202, and section, "The Revolutionary Period."

the east of the last structural bay. These last two probably served only some secondary function; perhaps they terminated, as the other columns did, some sort of partition that looks like newspaper shelves in the plan. There is no indication of how Rogers might have rearranged supports in the cellar under this area. There is also, admittedly, no proof found yet that Rogers did in fact carry this plan out exactly.

As for the west half, the facsimile of the Rogers' plan shows a large meeting room (the City Government's Hall of the Common Council) on the second floor above the new post office on the first floor. Both are shown as large open spaces; no indication is given as to the way Rogers planned to support the floor of the meeting room. One guess (and it's only a guess) is that columns did exist in the post office, being of so little visual importance that they are not shown.

There is more evidence of Rogers' handling of the staircase. Just to the west of the staircase he shows a pair of columns supporting the second floor girders in each of the fourth and fifth structural planes (counting from the west). These must be the "pillars" described in this area in 1838 by Abel Bowen. [6] These are presumably replacements for two previous columns that had stood at mid-span. The floor girder in plane five, however, and that in plane six (along the east side of the stairs) had to have a section removed at mid-span in order to accommodate the

[6] WPA, p. 241.

circular stairs. This may be inferred from the fact that on opening up the area in 1882, Clough found the configuration shown in Illustration 45, Volume I, in which the two floor girders were cut to accommodate the stairs and their framing. He also found four iron tie rods supporting the four cut ends from the roof truss tie beams directly above. (The top ends of the rods are visible under the attic floor.) The rods pass down through the circular partitions around the staircase (rotunda) in the second story, as shown in Illustration 45.

That Clough thought this to be the original 18th-century arrangement is not so significant as the fact that he did find it. The entire arrangement almost certainly dates back to Rogers' installation of the central staircase, unless the tie rods are a later reinforcement. Rogers probably looked at his plan for the first floor and concluded that neither the curved partitions to the east of the stairs nor the two columns in plane five to the west of the stairs were adequate to support the girders. (The two columns are shown as being closer to the north and south walls than the innermost tie rods above, and thus would have limited effectiveness in supporting the sawn-off ends of the girders.) The curved partition also appears to come a little closer to the north and south walls than the similar partitions above (with their concealed tie rods). Although, the possibility is that Rogers merely thought the first-floor partitions were not rigid enough.

In any event, Rogers' work shows his recognition of the 10 north-south structural planes of the building. He continued to provide support in those planes wherever he removed (as he probably did) some or all of the 10 earlier columns down the building's east-west center line.

The poster, ca. 1850, advertising Charles A. Smith's clothing store (Illustration 32, Volume I) includes an interior view of that store in the west end where the post office had been. This shows that the original center line of columns had been replaced by two offset rows, as had been done in the eastern portion of the building. These new columns appear in the four structural planes in this part of the building. Thus, during this period, the original structural bays continued to control the placement of supports, at least in the west end.

Later, in 1881, Clough also worked within the original structural system. When he created Whitmore Hall in the east end of the first floor, he did away with the ca. 1830 double row of columns and reintroduced the old arrangement of columns at mid-span (see Illustration 19, a, b, c; and Conditions and Recommendations, Whitmore Hall). There is admittedly some question about the farthest plane to the east, where there is no column.

It is possible that Clough returned to a single row of columns in the west end as well. The only evidence yet found to support this is Chandler's 1908 drawings which show a row of "Old Cast

Iron Columns" in the basement of the west end in the structural planes at mid-span (Illustration 63, Volume I). Probably, these did not date back to the period of Charles A. Smith's clothing store. This store existed on the floor above this row of columns and had, as already described, two rows of columns which would have required two rows of columns or piers in the cellar. Our guess is that a third row down the center line of the basement would not have been necessary at that time. It seems more likely that Clough installed the central row of iron columns that Chandler found (and which still survive) in the course of restoring the story above to this same early structural arrangement.

In the staircase, Clough left in place the tie rods which he presumed to be Rogers', supporting the second floor girders from the roof trusses.

In 1909, Chandler created Robert Keayne Hall in the west end installing four new columns in the structural planes there at mid-span (Illustration 59, Volume I). Our guess is that they replace Clough columns in these same locations. They survive today.

b) Conditions and Recommendations: Between 1969 and 1975, the structural engineering firm of LeMessurier Associates/SCI now LeMessurier Consultants, Inc., investigated the structural conditions at the Old State House. In conjunction with the 1977 HSR, a further visit was made by a staff member of this firm (see Appendix B).

Consequently, this company's written findings and recommendations, up to 1975, prompted extensive reinforcements in the attic and staircase of the building under the program of repairs directed by the architectural firm of Stahl-Bennett, Inc.

Currently, visual inspection of the floor system through openings in the building's finishes indicates that the wooden structural framing is in good condition. The 10 vertical structural planes cited above form 11 structural bays at the attic, second, and first floors, but the roof which had an 11th truss added in 1976 has a total of 12 structural bays.

Except for the east half of the first floor, the bays of the first, second, and attic floors are generally composed of 12-inch by 12-inch wood girders, 3-1/2-inch by 5-inch and 4-inch by 6-inch floor joists, and 2-inch by 4-inch ceiling joists.

The girders are handhewn members whose ends are supported by the north and south brick masonry walls, and their centers supported on 4-inch by 4-inch wood columns encased in a molded wood trim. Each girder is spaced at 9 to 12 feet on center. The girders' connection to the walls is unknown.

Floor joists are at 18 to 20 inches on center, are supported by the girders, and connected to them by half mortise and tenon joints. The joists as stated above are generally sawn members measuring 3-1/2 to 4-inch by 5-inch cross sections, except at the end walls where they are essentially deeper (3 by 6s or 4 by 6s) to accommodate the longer spans. These joists and the girders together support a 1-inch subfloor and 1-inch finish floor, except in the Council Chamber where an additional finish floor was added.

Like the floor joists, ceiling joists are also of sawn members and rest at 18 to 20 inches on center. These members are suspended from and supported by the floor joists on 1-inch scabs. They in turn provide support for the plaster ceilings which are attached to wood and metal lath. Scabs and lath are nailed to the supporting members with cut or wire nails.

As noted above, the framing in the east end of the first floor differs from other framing throughout the building. This framing is of steel 8-inch by 8-pound (I-beam) joists and beams whose spans differ in dimension and direction from those of the wood joists and girders in other areas of the building. The beams are supported on 6-inch cast iron columns. The floor supported by this framing is raised 18 inches above its historic level and is composed of a 1-inch wood finish and subfloor over an 8-inch concrete slab.

Modified king post trusses in the attic support 1 inch thick board roof sheathing in addition to the slate roofing above. The bottom chords of these trusses also serve as girders of the attic floor framing. Currently, the trusses appear stable, but most have been repaired following the fires noted during the building's history, and more recent repairs following the investigations of 1975.

Phillips stated that this investigation included detailed calculations that proved the old roof trusses to be capable of supporting the roof and attic floor. He continued to say that the two middle trusses (also supporting both the cut second floor girders and the tower) were overstressed, and light trusses of steel (Illustration 109, Volume I) therefore were bolted to both sides of the old trusses in these two bays. These will assume an increasing share of the weight of the tower as the old trusses continue to weaken. They also include vertical tension rods that pick up the lower chords of the old trusses, from which hang the old tension rods supporting the second-story floor and partitions around the 1830 staircase (Illustration 45, Volume I). Two other old trusses had deep checks in their top chords and were reinforced with bolts as shown in Illustration 112, Volume I. A number of purlins at the west end of the roof were found to be sagging or weak, and also were reinforced. In one instance, this action completed an older, cut nailed, triangular reinforcement (Illustration 108, Volume I). This is the 11th truss referenced above.

The performance of all these repairs should be monitored over the coming years in case any further problems become apparent.

While the original wood truss members are constructed of eastern white pine and joined together by mortise and tenon joints, repairs or replacement members are constructed of white oak and joined to the original truss members with wire nails. Dimensions of the members are as follows:

- Upper top chord 9-1/2 inches by 8 inches.

- Lower top chord 8 inches by 6 inches.

- King post 11 inches by 8 inches.

- Diagonals 4 inches by 6 inches

- Bottom chord 10 inches by 11 inches.

As Phillips goes on to say that for the central staircase which was both moving and sagging, the engineers devised a method of reinforcing the soffit with plywood so as to connect the two stringers of the stairs in a rigid, structural way. This, along with other repairs to the surrounding second-floor framing (Illustration 110, 111, Volume I), has produced a stable and apparently satisfactory result. Its performance should continue to be observed over the years, and its long-term success under the heavy loads of public use. The structural engineers most recent recommendation is to test the staircase so that its actual load-carrying capacity can be certified.

The framing of the first and second floors was found adequate in 1975, (except in the staircase), and was not strengthened. It is this element that seems to require some reinforcement. The easternmost girder of the second floor structure is apparently unsupported across the entire 32-foot width of the building. In the section on Whitmore Hall, tentative evidence is presented to the effect that there had been a column or pair of columns here until at least 1882. If this is so, it would be historically appropriate to recreate this column (as argued in the section on Conditions and Recommendations, Whitmore Hall, the library and the directors office). Such a column would seem to be of utmost structural importance unless, on opening the ceiling during the coming renovation of this area, it is found that some other provision was made to take the weight of the second floor in this area. In either case, questions of the column and floors will be answered since the engineers will certify the actual floor loading-carrying capacity (like they are doing for the stairs).

As for the tower structure itself, the first stage was rebuilt almost entirely sometime after 1921 and it appears very stable. The upper stages are sheathed internally and are difficult to inspect. Therefore, a careful eye must be kept during repairs to the exterior woodwork of the tower for signs of rot or other structural weakness. However, no signs of potential failure have been observed by either the engineers or the authors of this report.

Dormers are simply framed with 4-inch by 4-inch members and enclosed in board sheathing. The cheeks of the dormers support slate shingles which are comparable to that of the roof. At this time, dormers are in good condition and structurally sound.

In past studies, the condition of the structural framing relative to today's code requirements for assembly areas was not analyzed. These conditions are evaluated in the structural engineering section of this report. The evaluation stresses the need for the framing to comply with today's code based on the building's current and future use. However, where compliance with code is not feasible because of conflicts with preservation policies and guidelines, alternative recommendations are made.

3. Tower

a) Historical Background: It was not possible to examine every element of the tower since some portions of the exterior are accessible only from staging, and some interior portions such as the ogee roof are entirely covered with interior finish boarding. Exterior paint color sequences were confused by weathering. Thus, an inventory of the dates of different elements can be done best when the tower is staged for exterior woodwork repairs. The partial disassembly of exterior woodwork elements for repair would permit not only their thorough study, but also examination of the internal parts of the structure. Areas not needing to be opened now for repairs can await full investigation until a later time.

There are some elements clearly datable to the following periods: 18th century (probably 1748); ca. 1830 (approximately the time of Rogers' remodeling); 1882 (Clough's restoration); post-1921 (after the 1921 fire); and 1975 (steel reinforcements by Stahl-Bennett). Aside from Stahl-Bennett's easily identified steelwork (Illustration 109, Volume I), those elements postdating the 1921 fire are those that show neither charring nor the smoke that appears on adjacent older elements. Photographs taken just after the fire (Illustration 75, Volume I) show that the tower was well blackened on the inside with smoke, even to the top. Heavy charring occurred at the level of the first stage (Illustration 88, C-C, Volume I). Much of the charring visible inside the first stage apparently relates to the 1921 fire, rather than the 1832 fire, because some elements secured with a late type of cut nail are charred, and the nails are charred as well. In some cases, these cut nailed elements protected the woodwork underneath them from charring.

(1) First Stage (Illustration 86, C-C, Volume I): It is likely that although the tower stood firm through the

1921 fire, the heavy rebuilding of the first stage occurred, as a result, shortly after that fire. No record has been found yet, however, to document precisely the apparently large amount of material that is circular sawn or machine planed, wire nailed, uncharred, and unsmoked. Certainly this material does not predate the 1921 fire. It includes the two corner posts on the north side of the tower, the upper portion of the southeast corner post, most of the braces and studs, and most of the inner layer of sheathing boards. Also included are the girts (horizontal beams in the outer walls halfway up the first stage) supporting the joists for the upper floor of the first stage. By contrast, the southwest corner post, and the lower portions of the southeast one, appear to be handhewn, are well charred, and were merely cased with wire nailed vertical planks while the other posts were replaced. They are probably ca. 1748, and in that case, could have been charred by an earlier fire as well.

The nails securing the exterior layer of matchboard to the inner layer of sheathing are of wire type, projecting through the uncharred inner layer. This shows clearly that the present matchboard of the first stage was applied after 1921. The fact that it does not have paint layers going back to the Clough colors confirms that it is not 1882 material taken off and reapplied after the 1921 fire.

The oculus windows, however, date from 1882 and were reapplied after the fire. (The oculus at the upper level on the south side was not inspected.) They have the Clough colors as their lowest layers: black sash and brown casing. The water table board at the north side of the tower, just above the dormer, also has the Clough brown. The quoins, seen from a distance, also look as if they have more paint than the sheathing.

Another survival of pre-1921 material has occurred where the ridge of the roof intersects the east and west faces of the first stage. Charred sheathing boards (west side only), studs, and other light framing members are seen. Most of these pre-1921 framing members are secured with cut nails, except where they adjoin post-1921 beams, and are wire nailed.

The most important exception to the general rule that the outer tower walls were rebuilt after 1921 is seen at the cornice level of the first stage. The topmost horizontal board of the inner layer of sheathing, on all four walls, is clearly very early. This suggests that at least a portion of the feature on the exterior of this horizontal board (the cornice) may date to 1748. This topmost sheathing board is charred, shows rough up-and-down saw marks, shows the char marks and nail holes where the previous studs had been, and most importantly, shows the inner ends of handmade nails (plus cut nails) that probably secure elements of the cornice. Early framing may exist immediately above this sheathing board, concealed by the ceiling of the first stage. Thus, there is a good probability that the cornice of the first stage incorporates 18th-century materials.

The floor (both boards and framing) that divides the first stage of the tower into two stories is entirely of post-1921 vintage, established by a lack of smoke as well as by the usual wire nails. It must have been installed at the same time as the girts, already mentioned, that support it.

The previous floor was about 6 inches higher. Remnants of its charred boarding and framing can be seen around the outside surface of the pre-1921 matchboard "silo" that enclosed the stairs. Also visible is a continuous cut where the rest of the boards fitted. This surface is much more severely charred below the level of the earlier floor than it is above.

Both the fire of 1832 and that of 1921 were concentrated in the attic. It seems probable that the charring of the tower's silo and stairs occurred mostly in the 1921 fire; the floor would have protected the areas above it.

Two doorways lead off the attic staircase to the first stage of the tower (on the north at the lower level, and on the south at the upper level). Surviving portions of the sheathing on the back side of the tower's silo and stairs sheathing indicate that these doorways had led into small partitioned spaces. The partitions that had enclosed the other sides of the spaces have been removed, but their traces remain as paint lines and other such evidence. At least at the upper level, it seems clear that these partitions were removed after the 1921 fire since the worst charring marks coincide fairly well with the locations of the missing partitions, which apparently were in place and limited the progress of the fire. At the upper level, the remaining sheathing boards are cut nailed. At the lower level they are wire nailed, and the evidence concerning charring is confusing.

(2) Second Stage (Illustration 86, B-B, Volume I): The four corner posts of the second stage of the tower extend down into the first stage of the tower and are supported by two 1748 roof trusses. These posts are handhewn and charred, and they appear early. Reinforcing planks have been applied with wire nails as casing, sometime after the 1921 fire. In the second stage itself, much of the framing is probably 18th century. This should be determined better when the exterior matchboard around the base of the second story is repaired.

As for the exterior finish woodwork, Clough's statement that he replaced most of the trim on the tower is borne out by the fact that, among a good sampling of the woodwork elements reachable without staging, none were found that appear to predate 1882. The earliest paint color scheme found so far is chocolate brown with black on the sash. This corresponds to the color values seen in the photographs taken just after the 1882 restoration. A type of cut nail with a round knob on the head secures some elements of the chocolate brown trim, such as the north pilaster on the east face. Other elements similarly dating back to the dark brown period (i.e., exterior window casing moldings--at least those sampled) are secured with wire nails and have no earlier nail holes. The pieces behind the moldings also show only holes for the wire nails. Since the paint layers are very nearly the same on the cut and wire nailed elements, it seems probable that both date to 1882. Certainly, they all predate the ca. 1910 Chandler period since Chandler used white, and no dark colors have been used since. All window casings, moldings, pilasters, and other items located so far which are thought to date to 1882 have machine plane marks, as would be expected for this late date.

The sashes in the second stage are definitely Clough's work of 1882. His assertion that he replaced them all, and the presence of black as the lowest exterior coat, make it clear that they are not earlier. The black also shows that they do not postdate ca. 1910, when an unbroken tradition of lighter sash colors began with Chandler's white. Evidence of the 1921 fire exists as newer muntins pieced in where the sashes were broken during the fire (Illustration 75, Volume I).

The cut nailed interior window casings and matchboard adjacent to the sashes have almost the same paint layers as the sashes, and almost certainly date from 1882. Below the sashes on all four interior walls is later, wire-nailed matchboard with very few paint layers. These look perhaps 50 years old and could be part of repairs done after the fire. Meanwhile, as will be described in the section on the tower stairs, the matchboard silo that forms the staircase is older than either of the two types mentioned here, and is clearly integral to the ca. 1830 staircase.

(3) Third Stage (Illustration 86, A-A, Volume I). At this level, those samples of exterior woodwork that were examined also appear to date from 1882. They have dark brown as the lowest coat, except for the black sashes. And the pilasters are secured by the same large cut nails with round knobs on their heads as were seen in a pilaster on the second stage. One pilaster was pulled loose and definitely has only the holes relating to these nails, as does the backing board behind it. These elements, like those on the second stage, are machine planed. The tongue-and-groove matchboard below the windows is cut nailed and looks Victorian. One of the knob headed cut nails was found in the framing of a window in the third stage where an interior matchboard was pried loose. This suggests that Clough did some framing work here.

The cornice looks older than 1882, but it could not be reached. A number of loose dentils from the cornice were found in the interior of the third stage, however, these have (like the other exterior woodwork inspected) the paint color sequence going back only to dark browns. These dentils retain badly rusted-out nails and show no signs of earlier nails. Older elements might be found in the cornice, should it be disassembled.

The balustrade needed disassembly and repair in 1976, at which time some early pieces may have been discovered. So far, none have been identified. The metal urns with their finials almost certainly postdate 1882, for example, since there are no finials seen in photographs of the Clough period (Illustration 41, Volume I). (The present finials appeared about 1903; earlier ones had existed at least as far back as 1751 (Illustration 4, Volume I).

The interior of the third stage has mostly turn of the century matchboard on the walls. Although this latter is wire nailed, it must date back at least to 1910 since one board is inscribed "F. McGrath, 6-16-1910." An older type of cut-nailed matchboard, probably relating in date to the stairs, is found beneath the windows of the north and east walls.

(4) Tower Stairs: The tower stairs are of Greek Revival design, and may well date to Rogers' remodeling. In any event, about ca. 1830s would be the period of these stairs. This date is reinforced by the character of the lath on the underside of the stairs, as seen from inside the lower story of the first stage of the tower. These lath are half sawn/half split, as is characteristic of the period in question. The nails securing the treads and risers to the outer silo of vertical matchboard are well developed cut nails lacking uniform heads--also characteristic of the Greek Revival period.

The original portion of the silo (from the third-story ceiling upward) consists of random width matchboard (secured with cut nails) having quite a few paint layers. The nails in this boarding look typical of the 1830s. In this area virtually the entire stair and silo construction (except for some patches in the matchboard, etc.) seems to be of a piece, having more paint layers than the 1880s matchboard and other trim elsewhere in the tower. Along with original treads, risers, and railings, the stairs have a tall interesting newel post in the upper levels.

Below an uneven horizontal seam at the third-story ceiling level, the early matchboard is not seen. Rather, the silo consists primarily of a narrower, uniform-width matchboard still secured with cut nails, but having fewer paint layers. (A still later wire-nailed strip covers most of the seam, and covers paints on both the earlier and later boarding.) This later matchboard is an integral part of the partition that divides the tower stairs from the large third-story room. The other side of this partition (facing south into the third-story room) is of plaster with fully sawn, circular sawn lath. It also features baseboards and other woodwork associated with Clough's remodeling of 1882 (see Interior Construction, Attic-Garret). Both the earlier and later types of matchboard show paint blistering, undoubtedly caused by the 1921 fire.

The question arises as to whether the attic's spiral staircase before Clough was at least partly exposed to view along the east, south, and west sides, where it is now enclosed by the silo. This would make sense in light of the decorative nature of the stairs. What is clear, however, is that at least for some time prior to perhaps 1900, the stairs definitely was exposed on the north, from what is now the landing at the top of the stairs from the second story. The east-west partition (with two doors) that now encloses the stairs, and the north-south partition that divides off a closet under the stairs (Illustration 20, g), are both made up of wire-nailed boarding, having uniform width and very few paint layers. This most recent matchboard butts awkwardly against the plaster soffit of the stairs and is an obvious addition.

One interesting but still undated feature of the stairs is a circular opening in the silo, directly in line with the lower oculus on the south elevation of the tower. This opening allows the oculus to indirectly light the enclosed stairs. The 8-lite window that fits the opening was found lying nearby in the tower.

b) Conditions and Recommendations: Currently, the tower's exterior is in good condition following repairs (tower restoration) it received in 1982. The repairs to the tower included the following:

(1) Repairing and regilding the copper roofs

(2) Restoration of metal urns.

(3) Restoration of wooden balustrades.

(4) Patching and refinishing woodwork.

(5) Reflashing urns and balustrades.

(6) Recaulking tower joints.

(7) Restoration of windows and frames.

(8) Repainting all of tower and its components.

Although the repairs were made and are assumed to have been properly performed, several problems have developed over the years. At this time, layers of paint are blistering, peeling, and flaking off the walls, and a number of the areas that received epoxy repairs are shedding epoxy fill. We conclude from visual inspection that as the tower's wood components and the epoxy fill both expand at different rates, the bond between the two was broken. Tiny voids between the wood and epoxy surfaces developed and became larger as water entered and went through freeze-thaw cycles. The epoxy then had no substance to hold it in place and later failed, leaving voids in the wood finish as before. For this reason, epoxy repairs should be limited in areas of high moisture.

Consequently, repairs should be made to stabilize any deteriorating areas of epoxy and wood, and repaint the entire tower afterward. Any missing components of the tower should be replaced with like materials. In particular, some areas are the missing modillions under the tower's ogee roof cornices, and some have failed or deteriorated caulking in the joints of the woodwork and glazing compound in a number of the window sashes.

4. Windows, Doors, and Other Exterior Woodwork

a. Historical Background

(1) Chandler Materials: A large portion of the woodwork of the exterior walls is Chandler's, as explained in the section Chandler Restoration, Volume I. This includes:

(a) All three doorways.

(b) The balcony on the east wall.

(c) All first- and second-story window sashes, and the sashes of the two central windows in the attic gable ends.

(2) Materials Predating Chandler: The casing of the center window in the east wall at the first-story level is Clough's. The mullioned window/door leading onto the balcony is of the Greek Revival period, first appearing in a view of 1837.

The really exciting discovery, however, is that some wooden early Georgian style features of the exterior walls are 18th-century materials. They therefore probably date to just after the 1747 fire, when all but the brickwork had to be renewed. These wooden elements include the segmental pediment, entire entablature, and Corinthian pilasters of the east elevation's balcony doorway treatment. These elements are assembled with handmade nails, as judged by several pulled from the Greek fret on the soffit of the entablature, and from the neck molding directly beneath the capital of the north column (Illustration 21). In the latter case, the molding covers a seam between the column and capital, attesting to the date of these two elements as well as its own.

All of these early features are covered by an enormous number of paint layers, which--although confused by weathering--one count put at 57 layers. They include, near the bottom, a buff paint containing very find sand. Later on in the sequence can be seen dark browns of the 1880s, followed by a later distinctive salmon color.

Thus, in spite of everything that has happened to the building over two and a half centuries, one of the most prominent and well-known features (backdrop for the reading of the Declaration of Independence in 1776) survives in good condition.

(3) Materials Post Dating Chandler. As for recent woodwork, the four ox-eye windows (sashes and casings) in the gable ends are the work of George Sherwood, who specified their renewal in 1957. They have very few paint layers, and are obviously from that time.

George Sherwood specified the replacement of only the finial at the outer south corner of Chandler's east balcony as part of his work. However, both the finials at the outer corners are probably Sherwood's; they do not match exactly those against the brick wall (Illustration 22) which date from 1909 and have fewer paint layers.

b. Conditions and Recommendations

(1) Windows: There are over 80 windows in the Old State House. Their conditions range from good to bad as reflected by their ages and the degree of weathering they were subjected to over the years.

A number of the windows need extensive work, due to the highly weathered finishes of some and the deteriorated components of others (Illustration 23). Caulking around some windows has deteriorated. Although the weathered window finishes are a concern, this condition can be upgraded if the finishes are stripped down to a solid coat of paint (or at worst to the wood substrate) and refinished. Stripping or removing paint from the windows should be done with organic solvents or heat in well ventilated areas. Because of the intensity of the work and the fire risk associated with it should the paint be removed by heat, the entire window should be removed from its opening in the structure during refinishing tasks.

Repairs requiring the replacement of window components is another task that requires the removal of the entire window. Major repairs should be made by replacing or splicing (use of dutchmen) the deteriorated window components with like materials, rather than epoxy or wood fillers. The use of the latter should be limited to minor repairs to the windows since epoxy repairs are not expected to hold up on large surfaces in the outdoor environment under continuous wetting and drying of the wood.

When the windows are refinished, they should be primed and repainted white. Although browns and creams show up next to the wood substrate on several of the earlier windows that remain, white was used most extensively as the original color on other windows throughout the building. The white is representative of the 1909 Chandler restoration, rather than ca. 1882 or an earlier period when the browns and creams were used.

The refinished windows should be given a weathertight installation in the walls. Sashes should be weatherstripped and openings between the window frames and the walls should be recaulked to reduce air infiltration. Weatherstripping such as rolled vinyl strips, metal strips, or plastic spring strips may be fastened to the rails of the sashes to provide an airtight fit between two sashes as well as between the sashes and their frames. An oil-based caulking should be used between the frames and the walls.

An extra step that can be taken to weatherstrip or improve the thermal efficiency of the windows at the Old State House is to install storm windows. However, the visual impact of storm windows on the historic scene of the building must be considered. A typical exterior storm window will alter or distort the pattern of the muntins in the window sash by refracting light from the extra layer of glass. Similarly, the interior storm window will distort the pattern of the muntins, but to a lesser degree. Although either application will distort the historical appearance of the sash to some extent, the latter is preferable since it will impact the sash's appearance less. However, if installed, the interior storm windows must be operable and provide a seal to the interior spaces while allowing some ventilation around the historic window sashes to avoid deterioration of the wood windows should moisture become trapped and condensed between the layers of glazing.

Another problem associated with the windows is that of airborne noises transmitted through them to the interior space of the building. This condition is most noticeable in the Council Chamber during lectures or presentations. While the addition of interior storm windows and window weatherstripping are expected to lower the noise levels in the spaces, it will in no way solve the noise problem since the windows must be opened for ventilation. An environmental control system that would permit the windows to be closed at all times is not expected to be installed.

(2) Doors: The three exterior doors of the building are in good condition and have recently been repainted. Yet, with the paint's placement over a substrate of deteriorating layers of old paint, it is not expected to last very long. Therefore, like the windows, the doors should be refinished. Loose layers of paint should be stripped down to a solid paint layer or to the wood substrate and sanded to a smooth finish. Paint stripping should be done with a heat gun or organic solvents, after the doors are removed from the building.

Once stripped, any deteriorated door components should be replaced in kind or repaired with wood dutchmen, epoxy, or a wood filler, depending on the extent of its deterioration. The wood repairs should be followed by priming and repainting of the doors. A good exterior primer should be used along with a good exterior paint. The paint color should be dark green to match the dark green historic paint on the doors of 1882. The doors should be weatherstripped and the openings between their frames and the walls must be recaulked, like those of the windows.

Interior doors are also in good condition. However, the paint finishes they will receive would be the same paint used on other woodwork in the rooms where they are located. The section on Interior Construction should be consulted for the appropriate colors.

(3) Other Exterior Woodwork: Pediments above and the engaged columns flanking the three first-floor doors (entrances), second-floor balcony window, and the balcony compose the other exterior woodwork, along with the roof cornices which are discussed in the roof section below.

The pediments and columns are in good condition except for open joints of the moldings and the loose or deteriorating moldings themselves. In addition, the heavy build up of paint on all the woodwork is severely cracked. Consequently, this woodwork should be refinished following a controlled stripping process.

To begin with, several samples of the paint should be removed down to the wood substrate on all woodwork and saved for analysis and future reference. The remaining paint should be stripped or removed down to a solid or stable layer of paint or the wood substrate using a nonflammable, water washable, organic solvent or a heat gun as used for the windows and doors. Deteriorated sections of fabric should be repaired later. After stripping is complete and all repairs are made, the columns and pediments should be sanded down, treated with a wood preservative, primed, and repainted with a good exterior paint. They should be painted to match the entrance color scheme of 1882.

The balcony is in poor condition, and should be repaired and refinished if the public is to use it in the future. In their current conditions, the flooring and roofing should be removed and the structural components inspected and strengthened if needed. The roofing should be replaced. The balustrades and all of its components (urns, rails, balusters, etc.) should be taken apart, repaired, and rebuilt. All wood of the balcony should be treated with a preservative, primed, and painted in the same colors as the windows throughout the building.

C. ROOFS

1. <u>Slate</u>

a) Historical Background: In 1882, Clough removed a mansard roof and built the present roof (Illustration 24) which employs the 1748 roof trusses and accurately reproduces the contour of the roof that existed during the Revolution. The dormers also date from the 1882 restoration, but the slate on their cheeks (not a historically correct treatment) indicates they are somewhat freely imitative of those that existed on the roof 200 years ago. The window casings of the dormers show a paint sequence going back to the dark browns of the Clough restoration, while the sashes have the accompanying 1882 black as the earliest layer.

The roof boards are interesting. On the lower two-thirds of the roof, where Clough removed the mansard roof and built the present one, most of the boarding is typical of the 1880s. One of these boards, seen through a hole in the attic plaster (on the south slope, in the fifth roof bay from the west end), is signed "E.(?)H. Porter, July 11th 1882" (Illustration 20, f). On the upper one-third of the roof, which had been above the mansard roof, some much older roof boarding survives interspersed with Clough repair work. These boards (seen from within the garret above the third-floor ceiling) are wider, roughly sawn with an up-and-down saw, and more heavily charred by fires. Although no wrought nails have been found protruding through these early looking boards, the boards still might date to 1748. The nails could have been pulled, or the boards could be the lower of an original double layer, so that no slate or shingle nails would have protruded through them. (There is at present only one layer of boards.) Then again, handmade nails may yet be discovered.

Some of the present roof slates date from the repairs of 1975, but most are those applied in 1936 and rehung in 1975.

b) Conditions and Recommendations

(1) Roof Description: A steeply pitched (1:1), 5,000-square-foot gable roof covers the Old State House. This roof slopes to the north and south, and drains into gutters and downspouts over decorative wood cornices. It is bordered at the east and west ends by brick parapet walls which receive the roof's flashing. Smaller gable roofs (plus or minus 25 square feet each) are located on the 10 dormers and the pediments at the walls.

Overall, the roof is in fair condition, but lacks true integrity due to minor flaws in several components such as the roof covering, cornices, gutters and downspouts, flashing, and the roof hatch. Due to its condition and the lack of insulation, the roof as an energy conserving component of the building envelope is also questionable. Since it is necessary that the roof perform well as a part of the building envelope, its problems with probable solutions are outlined and discussed below.

(2) Roof Covering: The roof framing is covered with a blue-gray slate roofing supported by 5- to 10-inch board sheathing. This covering is in generally good condition except for the few cracked, broken, or missing slate scattered about the roof surface (see Existing Condition Drawings). Although there is no visible evidence of roof leaks at this time, there is the potential for future leaks to develop in these damaged areas.

Furthermore, the damaged areas are an eyesore. For those reasons, the damaged slate should be replaced with slate of the same color and texture. The existing slate roofing is a combination of the newly installed replacement slate of 1975 and the older (1936) slate relaid during the time of the 1975 work.

(3) Cornices: Roof cornices have molded fascias with square modillions below the soffits and returned against a molded frieze. Unlike the roof covering, the wood of these cornices is in poor condition due to water penetration from the overflow of an improperly sloped gutter system and periodically plugged downspouts. Visual inspection shows that areas of the cornice's fascia, soffit, and modillions are deteriorating. In addition, the heavy build up of paint covering the wood surfaces of the cornice is blistered, cracked, or peeled. While the deteriorating wood generally results from the water of the overflowing gutters, the deteriorating paint results from the water of the gutters as well as aging, weathering, and poor surface preparation.

Since the conditions of the paint and wood are likely to get worse, the source of their problems must be eliminated or at least dealt with. Gutter repairs and adjustments must first be made followed by cornice repairs and repainting. Heavily deteriorated cornice woodwork should be replaced with like materials while lightly deteriorated cornice woodwork should have the deteriorated sections removed, and only the smallest hollowed sections consolidated with epoxy or similar wood fillers. All areas should be sanded to a smooth finish and, afterward, properly primed and painted with a durable exterior paint and primer.

(4) Gutters and Downspouts: The 6-inch semi-circular LCC gutters and 3-inch by 5-inch rectangular downspouts mentioned above are not draining properly. The gutters are improperly sloped and the downspouts are occasionally plugged causing water to stand in the gutters and flow over the sides of the building rather than flow into the city's storm drains. Although the NPS's maintenance staff periodically cleans the gutters and downspouts, maintenance actions are no substitute for the proper operation of this system. Consequently, when the cornices are repaired and repainted the gutters should be cleaned of debris, and adjusted to the proper pitch. Any broken gutter seams or hangars should be repaired. The entire system should be maintained in this fashion throughout its lifetime.

(5) Roof Flashing: An LCC roof flashing is installed along the base of the towers, above the cornice (drip flashing), and at the base of the parapet walls. Most of the flashings are in good condition except for that at the parapet walls.

Before the repairs in May 1986, flashing at the east parapet walls contributed to water leaks in the building. Joints in the flashing at the west parapet wall had also opened up. The joint sealer of this flashing had failed and allowed water to enter at points along the flashing. The cap and base flashing were unable to restrict the horizontal flow of water on the roof because they are not high enough. While modern building practice requires cap flashing to extend downward a minimum of 4 inches over the base flashing, and the base flashing to a minimum of 4 inches upward along the wall, the existing cap and base flashings are only 2-1/2 and 2 inches in length, respectively. Despite the fact that the arrangement may be a historic detail, the cap and base flashings function poorly. Under the circumstances, they should be replaced with new LCC flashing during the roof repairs. The dimensions and details of the new flashing should conform to the dimensions of the flashing used in modern building practice.

Joints of the flashing should be sealed with a durable joint sealer. After repairs are made, the flashing should be maintained for the life of the roof system.

(6) Roof Hatch: The roof hatch is in good condition following repairs made by the maintenance staff of the Boston National Historical Park in March 1987. However, the hatch should be inspected periodically to assure that it is watertight.

(7) Insulation: There is no insulation in the attic space at this time, and the roofing materials alone are

insufficient in helping to control building temperature. If we are to create a more energy-efficient building, the attic ceiling below the roof should be insulated. A batt insulation should be installed during the roof repairs.

2. Metal Roofs

a) Historical Background: The metal roofs and wood cornices of the tower have sections of framing and exterior trim which survived from the 18th century. However, most of the tower roofs are accurate reproductions dating from 1882. Later repairs to the tower roof (first stage) were made in 1921, and the most recent to the tower roofs and cornices in 1982.

Other metal roofs of the entrance pediments are from 1882, except for the metal roof on the east balconies segmental pediment. This roof and all the cornices of the building are believed to date from the 18th century. They are believed to have survived from 1748.

b) Conditions and Recommendations

(1) Roof Description: There are eight small metal roofs at the building. Three roofs cover the three stages of the tower, a fourth roof covers the deck of the balcony, and four other roofs cover the pediments over the north, south, and west elevation entrances and balcony window of the east

elevation. At the top of and covering the third stage of the tower is an ogee shaped dome roof with a 1:2 slope and a centrally located weather vane at the crest of the ogee curve. The roofs at the second and first stages of the tower are simply skirt roofs extending from the floors at these levels. All of the roofs appear sturdy and help to define the tower in the Boston skyline.

(2) Roof Coverings: The roof coverings are constructed of a gilded copper which is currently in good condition, except for some nicks and dents and possibly a broken seam in the section covering the tower's third stage. Although the tower roof could not be assessed and inspected, evidence and observations of water entering the structure have led to this conclusion since the roof was only repaired 5 years ago (1982). On several occasions during rainy weather, water was observed wetting the ceiling and flowing into the ceiling fire detector at the tower's third stage. The exact path of water flow from the tower roof must be identified and repairs made for water cessation when staging is placed around the tower during the planned building renovation.

Another roof worthy of a detailed inspection and repairs is that covering the deck of the balcony (Illustration 25 and 26). This roof shows no evidence of current leaks, however, its seams are buckled and appear loose in several areas. Conditions of the roof below the posts of the balcony railings are also questionable. When the balcony is dismantled for restoration, the roof over its deck should be restored at the same time. The roof covering should be removed and all framing inspected and repaired if needed.

At this time, roofs over the pediments of the entrances and balcony appear to be weathertight but should be inspected for leaks when the entrances are renovated. These typical copper roofs are aged and covered with patina, nevertheless they are in good condition.

(3) Cornices: The wood cornices of the metal roofs are in fair condition but some need work to restore them to a condition that will protect their structures and finishes from the weather, and enhance visual integrity at the same time.

Tower cornices were refinished several years ago but currently show some effects of weathering. The paint is deteriorating in several areas, along with areas of the most recent repairs which appear to be failing. Several modillions appear to be deteriorating.

When staging is placed around the tower for the upcoming roof repairs, the cornices should also be repaired and repainted. A sample modillion should be removed and used as a model to replicate replacements for any modillions currently deteriorating or missing. Before painting of the cornice begins, those areas needing repairs should be examined closely to see what went wrong with the 1982 repairs. Any obvious discrepancy in the choice of materials or methods used to make the former repairs should not be repeated.

Experience has forced designers not to use synthetic fillers to repair wood where the wood is placed in moist areas and is subject to constant dimensional changes (wetting and drying). In such an environment, repairs of this type will certainly fail if not kept covered with a durable paint finish. Therefore, any badly deteriorated pieces of wood in the tower cornices should be replaced with like materials, rather than filled with an epoxy or equivalent wood filler. Epoxy should be used sparingly and only on small voids in the wood due to the water expected in these areas.

(4) Gutters: There are no gutters on the eight metal roofs, however, the metal edges of these roofs should be straightened out in areas where they are bent (Illustration 27). Typical areas where the edges are bent are the tower and balcony roofs.

(5) Flashing: The copper flashings of the pediment roofs are in good condition, but should be recaulked. Areas of the current caulking are beginning to fail.

D. INTERIOR CONSTRUCTION

1. Council Chamber

a) Historical Background: Most of the Council Chamber is Perry, Shaw, and Hepburn's work of 1943 (Illustration 94-102, Volume I). No features postdating that year have been found. Mrs. Cabot, who came to the Bostonian Society in 1957, said the floor there is the one called "new" in the 1943 drawings.

Older features surviving in the room include the upper moldings of the cornice, which appear in the 1943 plans as "existing work to remain." These have more paint layers than the rest of the cornice and match Clough's 1882 work in the Representative's Hall. They must have been part of Clough's complex design, of which all but the topmost elements were replaced by Perry, Shaw, and Hepburn with the present, simpler moldings.

Since the 1943 plans call for only selective replastering of wall areas, one can infer that some areas of 1882 wall and ceiling plaster survive as well.

The brickwork of the fireplaces--faced with Perry, Shaw, and Hepburn's 1943 marble--was shown as "existing old work" in the 1943 drawings (Illustration 100), and it in fact does appear in earlier photographs showing the Clough restoration.

The doors and door casings all date back to 1882 but were reworked by Perry, Shaw, and Hepburn. Their drawings call for rebuilding the center doors according to a simpler design (with fewer stiles and panels); they also specify the application of new moldings to the panels on both sides of all the doors to replace Clough's rather unusual molding design (Illustration 95 and 99, Volume I), mentioned already in the discussions of other rooms. Also, the side doors of the Council Chamber were rehung, as specified, so as to swing into the small anterooms. The 1882 design of the doors can be seen in pre-Perry photographs (Illustrations 49 through 52, Volume I). The old parts of the doors have many earlier paint layers than the 1943 modifications and paint lines show clearly where the push plates had been, as seen in older views. The hinges are shown in older views and paint lines indicate their previous locations on the side doors. The brass box locks (like the hinges and like locks in the Representative's Hall) are Clough's rather good copies of colonial hardware.

The door heads (Illustration 99, Volume I), as shown by paint layers, and the 1943 drawings, are Perry, Shaw, and Hepburn's. One important older item in the Council Chamber is the mullioned doorway with a transom, sidelights, and two French doors (Illustration 94, Volume I) leading onto the balcony. This is shown as existing work in Perry, Shaw, and Hepburn's drawings and appears (as near as one can tell) in all interior and exterior photographs of the building. The paint layers on the mullions and on the muntins of the door appear to correspond and to go back much farther than even Clough's work. The best guess is that the entire doorway dates to about the time of Rogers. The muntin profile is stylistically somewhere between Federal and Greek Revival. It was from these French doors that Clough said he got his model for the sashes he installed elsewhere in 1882; he believed that the doors were 18th century.

The other sashes, though not so old, nevertheless have more paint layers than the 1943 woodwork, and they appear in photographs taken immediately after the 1921 fire (Illustration 74, Volume I). They are clearly the work of Chandler, who installed new sashes throughout the first and second stories (see The Chandler Restoration, Volume I). A late Victorian photograph of the Council Chamber (Illustration 49, Volume I) shows Clough's 1882 sashes which had narrower and partially concave muntin profiles.

b) Conditions and Recommendations: Currently, the Council Chamber is in a state of disrepair. Its plaster walls and ceilings are cracked in a number of areas, and there is a 4-square-foot area of deteriorated plaster at the northeast corner of the east wall. Paint on the cracked walls and ceilings is also blistering, cracking, or peeling away.

The plaster and paint problems are a consequence of the ambient temperatures and humidity levels of the space, and possibly some floor movement attributed to the footfall of visitors which tends to vibrate the partitions resting on the floor. Unlike the cracked walls and deteriorated paint which result from the excessively high humidity levels at low temperatures, the deteriorated plaster of the east wall was caused by the leaking roof flashing and the leaking piping which has since been repaired.

Beneath the plaster wall, a portion of the paneled wood wainscot was also damaged by the leaking and had to be removed. In addition, a 20-square-foot section of flooring was removed, and in the process damaged, when trying to gain access to the wall behind to shut off the leak at the piping. Other areas of the floors are heavily worn by foot traffic.

In an effort to restore the room finishes, cracks must be repaired and holes patched in the plaster walls and ceiling, and then repaint them. Floors and all other woodwork must be refinished. Paint colors for the walls and ceilings could be selected from the paint analysis, or painted any light color since the brightness of this exhibit space should be a major concern. Floors should be stained as before.

The paint and mortar analysis show that this room's finishes were heavily altered in 1943, although there are pieces of earlier fabric remaining. However, since the later finishes are most dominant, we should at least retain the general character of the

1943 space. The space is as it looks today, less the current paint scheme and marbleized baseboards. Plaster walls and the woodwork were at that time painted light brown (Munsell 7.5 YR 7/2) and (Munsell 7.5 YR 6/2), respectively. The ceiling was painted with a white calcimine paint. [7]

2. Representative's Hall

a) Historical Background: This room appears the same today as it did in a later Victorian photograph that shows the east wall of Clough's 1882 restoration (Illustration 47, Volume I). The floor is of fairly narrow, cut-nailed, softwood boards. This same type of flooring appears in the second-floor anterooms around the staircase, also little changed since Clough.

The Chamber's side doors (to the two anterooms) are missing, having been removed and stored in 1976. The center doors are unchanged, as shown in the oldest photograph of them (Illustration 47, Volume I). They, like those in the Council Chamber, exhibit a remarkably correct looking reproduction brass box lock (remarkable, at least, for 1882).

The sashes are not part of Clough's restoration since documents prove that Chandler replaced all the sashes of the first and second stories in 1909 (see The Chandler Restoration, Volume I). Two facts confirm this. The present sashes have fewer paint

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[7] Ibid, p. 19.

layers than the 1882 woodwork, and a late Victorian interior photograph (Illustration 47) clearly shows sash of a narrower and partly concave muntin profile. These previous sashes were undoubtedly those that Clough, as he reported, modeled on the sash in the mullioned doorway to the balcony. The present sashes appear in the photograph taken directly after the 1921 fire (Illustration 73, Volume I).

The north fireplace has been blocked to accommodate the flue of the boiler. The 1907 plans for the construction of the Washington Street subway line include plans for the present boiler room. They show that the previous boiler under the staircase (offset to the south) and the planned boiler room (at the east end of the building) both used the same flue on the east end wall (Illustration 56, Volume I). This is probably the present flue that runs up through the north fireplace. As explained in the chapter on the history of the heating system, the boiler room offset under the rotunda probably dates to ca. 1903; it was preceded by Clough's circular boiler room of 1882 directly under the rotunda. It is uncertain what flue this 1882 boiler room would have used. Thus, it is not perfectly clear when the fireplace in the Representative's Hall was closed.

b) Conditions and Recommendations: This room, like the Council Chamber, has cracks in the walls and ceilings. These cracks, however, are minor and repairs to them would be limited. Paint on the walls and ceiling is also blistering, cracking, and peeling, such that there is a need to repaint the room with the appropriate colors. The paint study of this report states that yellow plaster walls (Munsell 2.5 Y 85/2), white woodwork (Munsell 5Y 9/1), and a white calcimine ceiling are the original paint scheme for this area [8], however, white or any light color could prove to be most suitable because of the space's use for exhibits. Although the original paint scheme covered the 1882 construction, there is flexibility in selecting the new paint scheme. Our mission is not to restore the space to its 1882 appearance but to adapt what remains of that appearance to the current use.

The floor of this space is worn from heavy foot traffic and needs to be refinished. The color of the stain for the refinished floor should match that of the existing stain. All of the existing floor stain should first be removed, the floor sanded, and then new coats of stain applied.

3. Robert Keayne Hall

a) Historical Background: Keayne Hall's woodwork and cornices correspond perfectly to Chandler's 1908 designs for the creation of this memorial room, and show no significant later alterations. The sashes are those that Chandler installed when he shortened the window openings (see The Chandler Restoration, Volume I). Studied with a hand lens, paint samples from these

[8] Ibid, p. 28.

sashes have about the same sequence as found on the rest of the woodwork.

The only older elements we have found in Keayne Hall are the doors to the staircase (Illustration 70, Volume I), which--with molding profiles typical of Clough's work--must date from 1882. One of Chandler's 1908 drawings (Illustration 59, Volume I) notes that these doors are to receive new "architraves" (i.e., the bolection moldings there today).

The floor is almost certainly Chandler material. Its boards are much wider (more colonial in appearance) than those of the 1882 flooring seen on much of the second story. Too, it shows no signs of having been altered, which would have been the case if it coexisted with the very different spatial arrangement that preceded Chandler. Thus, it does not appear to predate Chandler's creation of this room.

As for being more recent than Chandler's work, this seems unlikely. It is more worn than the 1943 floor in the Council Chamber, Mrs. Cabot never heard any stories suggesting that it was more recent than about the Chandler era, and it appears in a photograph marked with the date 1922 as well as photographs from ca. 1940.

b) Conditions and Recommendations: Finishes of Keayne Hall are in good condition with minor cracks in the plaster of the walls and ceilings. These cracks should be repaired and the room repainted. Keayne Hall, whose existing construction remains typical to its appearance in 1909, had a paint scheme at that time consisting of pale green (Munsell 5GY 8/1) plaster walls, cream woodwork (Munsell 10Y 9/1), and a white calcimine painted ceiling. [9] Although it is not necessary to return the room to its historical paint colors, the historic construction must be retained. An alternative to the historic paint scheme is to use white or any other light color as in other exhibit areas of the building. Finish flooring of the room should be refinished. Refinishing should extend to doors and windows alike.

Aside from the work to be done on its finishes, the rooms exterior entry is of particular interest because its width and location at the higher end of the site makes great potential use for handicap access to the building. The entry, with the help of the Bostonian Society staff, is currently used for this purpose, however, when the building undergoes renovation a more efficient and compatible means must be devised so that the entry is better equipped to allow handicap persons to enter the building under their own power. Portable or removable ramps or lifts on the steps are a consideration at this time, but their design should not permanently impact the building. This door to Keayne Hall should not be altered, nor should the steps or floors. Every

[9] Ibid, p. 16.

effort must be made to preserve the entry and adjacent building components.

4. Central Staircase, Hall

a) Historical Background: The entire staircase and hall (Illustration 46, Volume I), including doors and floors, is Clough's restoration work of 1882. The stairs to the third floor also date from 1882. Supporting evidence for these judgments is as follows:

(1) The documents make it clear that Clough built the staircase and hall (see The First Restoration, Volume I).

(2) With the possible exception of the two outside entrances, Chandler did not alter the staircase and hall in 1909. It appears in its present form in pre-1909 photographs, and the staircase and hall appears in Chandler's drawings (Illustration 59, Volume I) as "Old Circular Stairs."

(3) There is no physical evidence of any significant alteration in the staircase and hall.

(4) The staircase and hall and most of the its trim are highly characteristic of Clough's rather free and heavy-

handed Colonial Revival style, including the unusual door panel moldings he used elsewhere.

The doorways that led from the staircase into the north and south entrance vestibules (Illustration 19, dd), however, contain material from several different periods. The pilasters (Illustration 28, aa) that flank the existing door casings (and a related length of soffit) have many more earlier coats of paint than do the casings, and are undoubtedly the work of Clough (1882). The casings themselves (Illustration 28, bb) butt up against the pilasters and the soffit, and have about the same paint layers (mostly whites) as the paneling in the vestibules which is definitely Chandler's. The casings are, thus, almost certainly Chandler's addition to Clough's doorways. Chandler's drawings are rather ambiguous concerning this work, but two physical facts support this assumption. The first is that the pilasters within the staircase do not stop at the casings; their surfaces (and paint layers) turn 90 degrees to run through the wall (Illustration 28, c), turning again onto the vestibule wall to form pilasters there. The second fact is that the architrave molding on the pilasters (located just above the pilaster cap, at the same height as the topmost molding of the cornice) has a slightly different profile than that molding. If both features had been installed at the same time, this mismatch logically would not have occurred. Apparently, these doorways did not have doors as built in 1882; when doors were desired in 1909, it was necessary to add casings for them. These were double doors and they are now stored in the basement, having been replaced by the present ones in 1976.

b) Conditions and Recommendations: Since the stair strengthening of 1976, only the slightest amount of movement remains in this structure. However, the current questions lie in the adequacy of the stairs to serve as a "means of egress" in the Old State House. Under current building and life safety code requirements for assembly occupancies, the stairs are inadequate for the following reasons:

(1) Stairs do not meet the requirements for circular stairs prescribed by code. Its dimensions are inadequate.

(2) Stairs are the only means of vertical egress from the second floor of the building.

(3) Stairs do not meet the loading conditions (100 pounds per square foot (psf)) prescribed by code for assembly occupancies.

These and any other inadequacies of the stairs can only be waved by the Building Official from the city of Boston, with possible restrictions on the use of the stairs and the building spaces they serve. For example, the number of persons on the stairs at any given time may be decreased along with a decrease in the number of persons on the second floor at any given time (occupancy load). The engineering section of this report discusses the structural loading of the stairs in detail.

As for the finishes of the staircase and hall, these are in good condition following the renovation of the area in 1987. At that time, walls and ceilings were patched and painted along with the doors and trim. Although the area is currently clean, it will again be repainted and plaster cracks possibly repatched when the building is renovated in 1989. Whether it is repainted with the existing paint scheme or the paint scheme of 1909 is a matter that can later be resolved. The paint scheme of 1909 consisted of tan walls (Munsell 2.5Y 8.5/2), white woodwork (Munsell 5Y 9/1), and a white calcimine ceiling. [10] These colors were recorded during the paint study.

A number of elements, such as the floors and stair railings, were left untouched. These must be refinished and several missing balusters of the stair balustrades must be duplicated from the existing ones and replaced.

5. Vestibules

a) Historical Background: All three vestibules (north, south, and west) are Chandler's designs, as shown by his 1908 drawings. The only exceptions are, as described in the

[10] Ibid, p. 25.

previous section, the north and south vestibules' doorways to the staircase (Illustration 19, dd) which feature Clough's 1882 pilasters on either side of Chandler's 1909 door casings. Earlier materials may survive behind Chandler's paneling. The ticket booth in the south vestibule was installed in 1976. A portion of Chandler's paneling removed at that time was stored on the third floor.

b) Conditions and Recommendations: Like other areas of the building, the vestibules must be refinished. Walls, ceilings, doors and trim must be refinished with the appropriate color scheme after proper preparations are made. The space was historically finished with tan plaster walls (Munsell 2.5Y 8/2), white woodwork (Munsell 5Y 9/1), and a white calcimine ceiling [11]. Floors and steps must also be refinished and possibly protected with a loosely attached mat of some sort, since heavy foot traffic is concentrated in these areas on a daily basis. Protection such as this would extend the life of the floor and floor finish. This wood floor should be stained like other floors of the building.

6. Second-Floor Anterooms

a) Historical Background: These four rooms, off the central staircase, are essentially unchanged from 1882--attested to by such woodwork details as the characteristic Clough

[11] Ibid, p. 12.

molding profile seen on their door panels. Portions of three of the rooms (northwest, southwest, and northeast) appear in pre-1909 photographs. The closets high on the walls of the northwest, southwest, and southeast rooms date from the 1880s work; on the plaster in the latter room is the outline of a previous plumbing tank and the inscription "James Sullivan, plumber, April 1882" (Illustration 29, a).

The floors are of the relatively narrow, cut-nailed, softwood boards seen in the Representative's Hall, which is also an unaltered Clough room.

The baseboard on the east and most of the north walls of the northwest room (Illustration 29, b) is later, for some unknown reason, and possibly connected with the fire.

The sashes are those installed throughout the first and second stories by Chandler.

Two small interior windows were removed in 1976, one on the west wall of the southeast anteroom which lit the closet, and one on the east wall of the southwest anteroom which lit the bathroom. Both of their outlines are still visible (Illustration 29: c, d).

b) Conditions and Recommendations: Finishes of these rooms are in good condition, with the exception of small cracks and several small plaster holes from which plaster samples were taken for the plaster study. The paint on the walls and ceilings is deteriorating, along with the floor stain which is heavily worn off from the concentrated foot traffic around the exhibits.

These rooms must be refinished like other rooms of the building. However, there is an interest in adapting one of these spaces to something other than an exhibit area. Should one of the spaces be adaptively used, care must be taken to limit the impact on historic fabric.

The historic paint scheme of these rooms consisted of yellow walls (Munsell 10YR 8/4), white woodwork (Munsell 10YR 9/1), and white calcimine ceilings. [12]

7. Whitmore Hall, Library, Secretary's Office

a) Historical Background: If one were to remove the north-south partition (Illustration 19, g) that separates Whitmore Hall from the library and secretary's office, one would have the single space designed by Clough in 1882. This is supported by the following evidence.

The doors leading to the staircase feature Clough's unusual panel molding on both sides (Illustration 19, e). Their paint layers (on the Whitmore Hall side) go back through various off-whites to

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[12] Ibid, p. 22.

one or two bright whites. The three columns in Whitmore Hall (Illustration 19: a, b, c) likewise have Clough's characteristic panel molding and the bright whites as the lowest coats. Too, they are made up with cut nails typical of 1882. The casing of the mullioned window in the center of the east wall of the building (Illustration 19, f), located in the library, also has these whites on its interior finish boards and must be Clough's. Its first appearance in exterior photographs occurs just after the 1882 restoration (Illustration 49, Volume I).

The other interior window casings are much older, having many more layers of paint, and they easily could date from Rogers' work. All were shortened at the time the subway was built in 1903, and all were fitted with Chandler's sashes in the 1909 restoration.

The plaster cornices seen around the entire set of rooms, and over the three columns, are so stylistically integral with the Clough woodwork beneath them that they can be safely judged to date from 1882. At the two points where the ends of the later north-south matchboard butt up against these cornices (Illustration 19, hh), the cornices and the plaster wall surface directly below run cleanly behind the matchboard work; along the matchboard there is at least one layer of paint.

Some of the built-in bookcases in the offices could be as old as the remodelings of 1894. There are also two rows of freestanding bookcases that divide the freestanding office from the library. Sandwiched between these is a most interesting partition (Illustration 19, i). It consists of hinged glass windows above chair-rail level, with a wall below. The chair rail is of plaster on the side of the secretary's office, and of matchboard on the library side. This windowed partition is almost certainly Clough material. The south (library) side of this partition appears, with almost certain clarity, in general exterior photographs taken shortly after the 1882 restoration. In these, one just barely can see through the central window of the east facade. The clearest view, more so in some printings than in others, is that published in the first volume of the Proceedings of the Bostonian Society and in the Rededication. (In relating the partition to the window in these views, one must remember that in 1903 the window was shortened.)

Earlier exterior photographs (Illustration 40, Volume I) show a very wide doorway where the window is now, such that the partition could not have existed prior to 1882.

As for physical evidence, the partition is somewhat inaccessible because of the bookcases, but at least in the secretary's office one can see convincing indications that the partition dates from 1882. Its finish moldings are secured with cut nails similar to those used in the columns in Whitmore Hall. The window casings on the secretary's side match the casings of Clough's doors to the staircase, and their earliest paints appear to be the bright whites of 1882. Furthermore, the plaster cornice and wall surface on the east wall of the secretary's office turn west onto his partition (Illustration 19, j); no finish plaster passes behind the east end of the partition. The Clough cornice continues west along the north side of the partition and then returns (Illustration 19, k) along the south side. As yet, no evidence has been seen that suggests the partition did anything but end where the cornice returns--just to the east of where the bookcases end now. However, much more evidence will be opened to view when the bookcases are removed, as is the present plan. If indeed the partition simply ended, it must have left both the library and secretary's office open on the west, forming one room with what is now Whitmore Hall.

The 1882 partition was extended further west at a later date by a short matchboard partition with sliding door (Illustration 19, l). (The door matchboard may be later.) This partition abuts the previously described north-south matchboard partition that runs between the north and south walls of the matchboard, abutting 1882 plaster cornices. (The west side of this latter partition was covered with plywood by Mrs. Cabot sometime after 1947.) The evidence is confusing as to whether there is a difference in date between the north-south partition of matchboard and the short east-west section. However, they are both early enough to have cut nails. As already mentioned, they are later than Clough's 1882 cornices which pass under them carrying (at least at the ends of the north-south partition) one or more coats of paint. In the section The First Restoration, Volume 1, documentary proof is given that by 1894 there were three rooms in this area: an "outer apartment" (now Whitmore Hall) used for an exhibit of the topographical history of Boston; and "two inner rooms opening from the topographical room." This indicates that the matchboard partitions existed then and that there was a doorway from the or secretary's matchboard into Whitmore Hall. A photograph in the Bostonian Society's Proceedings for 1942 shows the north-south partition (along the east side of Whitmore Hall).

In addition to the installation of these matchboard partitions, two major changes have occurred in this Clough-designed space. In 1903, the floor was elevated 19 inches above its original position to accommodate the new subway station. Beneath the wood floorboards, there is now a masonry floor structure that is probably the "fireproof floor" installed at that time, as described in the chapter The First Restoration. The area of concrete flooring near the doors to the staircase, bearing the bronze label of the "W.A. Murtfeldt Company, Artificial Stone Walks, 31 Mill Street, Boston," also may be part of this 1903 installation. The windows were shortened at that time, too. Only the floor area directly adjacent to the doors from the staircase remained at its earlier level. In this area, one of Clough's square columns (Illustration 19, a) was left at its full length and in its correct proportions. The other two columns in Whitmore Hall (Illustration 19: b, c) were cut off at the bottoms to fit the raised floor, such that their proportions are now a little awkward. Where the wire-nailed baseboards of one shortened column were removed for inspection, early paint layers on the stiles and panels of the column were found to pass down below the present baseboard location (Illustration 30).

The floor itself is edge nailed and hard to date, but probably was installed in 1903.

Another important change that might have occurred ca. 1903 was the removal of the easternmost of the columns running east-west down the center of the room. This column would have stood in what is now the library. It would have supported the north-south floor girder of the easternmost structural plane (see Wooden Structural Framing). This would have placed it about 9 feet 7 inches east of the north-south matchboard partition (Illustration 19, m). The column probably would have been topped by an entablature that spanned the room matchboard and intersected the room's cornice directly over the mullioned window on the east wall (Illustration 19, f).

Clearly, a column stood in this location in the 18th century. Documentary sources include it when they speak of 10 columns supporting the second floor. These were replaced ca. 1830 with double rows of columns, which in turn were replaced by Clough with a single row ca. 1882. The main question is, therefore, whether or not Clough reinstalled a column and entablature in this particular location. Physical evidence suggests that he did. Some of this can be seen on the west wall of the library. This wall is the north-south, matchboard partition that runs along the east side of the easternmost surviving column. The cornice above the column was fitted with matchboard at the point where it appears to have continued further east (Illustration 19, n). From the evidence now visible, it is not clear whether or not this was done in conjunction with the installation of the matchboard partition. This will become much clearer when the bookcases are removed, as is the plan.

As a second piece of evidence, matchboard plaster cornice over the mullioned window (Illustration 19, f) where the column's entablature would have ended has a profile slightly different from that around the rest of the room (it has a very strange bed molding). This area could be a patch made when the intersecting cornice over the missing column was removed.

Paint evidence has not been found on the ceiling or cornices to substantiate this patching theory. However, this might be accounted for by replastering at that time, or by use of calcimine paints which are frequently washed off. In the Bostonian Society's Annual Proceedings for 1937, it is reported that the walls of the exhibit rooms have been "painted" and the ceilings "whitened"--a likely reference to a distemper or calcimine. In 1944, the proceedings relate the need for "painting and calcimining" the whole interior of the building, further confirming that calcimine was used in the building, which could confuse paint evidence on ceilings (see The Chandler Restoration, Volume I).

There is no obvious patch in the floor where a column was removed, but the floor may postdate the column's removal. At the time of the forthcoming remodeling, a hole or two should be dug in the ceiling to look for an east-west patch line in the ceiling plaster (corresponding to the missing cornice) and signs of a column.

b) Conditions and Recommendations: Although most of the first floor is in good condition, the eastern half merits special attention because of plans to make changes, and because of the less than perfect conditions of the existing construction. The current plan for this space is to remove the north-south, matchboard partition (Illustration 19, g) that divides Whitmore Hall from the two east end offices, and the east-west matchboard partition that divides the library and secretary's office. This would turn the three rooms into one, to be used for an exhibit of the history of the Old State House.

The plan to remove the north-south partition is commendable, in that it will restore the room to its original size as remodeled in 1882 by Clough (with the exception of the raised floor of 1903). However, the east-west partition should be retained. This open-ended partition, now hidden by bookcases, runs west from the east end wall and intersects the north-south partition (Illustration 19, i), while separating the two offices. It consists of windows on the upper half and matchboard below, and is almost surely Clough's work of 1882. (This can be positively confirmed when the bookcases are removed and holes are made in the ceiling for the new lighting fixtures.) This partition would not block light, probably not interfere with displays, and even might serve as a useful divider. More importantly, its retention will help illustrate the type of changes that compromise the building's architectural history--the very subject of the exhibit to be installed there. Moreover, if the building is interpreted to 1882, compliance would restrict the removal of any building fabric from that or an earlier period. The removal of this partition will impact the historic integrity of the space. Therefore, management should seek another alternative (NPS-28, Management and Operations, Chapter 5, page 4).

A further recommendation regarding Whitmore Hall concerns a column that probably existed in 1882. In the section Wooden Structural Framing, the building's 10 north-south structural planes are described. Each consists of a roof truss above and columns below, supporting floor girders. The section also discusses various rearrangements of columns through the years. In the portion about Whitmore Hall, it is noted that the current supports in this area for the floor of the Council Chamber are columns dating back to Clough's restoration of 1882. It also is pointed out that there is no column (Illustration 19, m) where the easternmost girder of the second floor presumably exists, although there probably was one here in Clough's time. It seems likely that the north-south floor girder is not properly supported, now that there is no column beneath it. This situation has not caused noticeable problems to date; perhaps the Council Chamber has been little used for large assemblies in recent decades. During the forthcoming remodeling, a hole in the ceiling plaster should be made, large enough to fully assess the structural situation here. In all probability, one or more columns will be found necessary to carry the second-floor load down to the heavy steel beams below.

In addition to having structural value, a column with entablature matching the rest of Clough's colonnade in Whitmore Hall would be welcome both aesthetically and historically. This is especially true of the colonnade if Whitmore Hall is enlarged to include the library and secretary's office. All that needs to be done to be sure of historical correctness is to check for more positive evidence of Clough's missing column and cornice. This can be done by making some holes in the plaster just prior to the coming renovation.

Finish construction of these spaces is not in the best condition. There are cracks and holes in the plaster ceilings and walls, missing trim from the missing column, missing sections of ceiling cornices, and deteriorating finishes on the floors and other woodwork. Consequently, the walls and ceilings must be repaired, the missing cornices and column trim replaced, and the entire room renovated to reflect the proposed uses. Finishes should be reflected in the room's proposed use, despite historic colors which consisted of yellow walls (Munsell 2.5Y 8/4), white woodwork (Munsell 5Y 9/1), and a white calcimine ceiling for the entire area.[13] Like in other exhibit spaces throughout the building, any light paint can suffice for this purpose. Floors should be stripped of old stain, sanded and refinished with the appropriate colored stain.

8. Attic, Garret

a) Historical Background: The present woodwork and plasterwork of the attic almost all stem from two periods. Most date from the restoration of 1882 when Clough removed the mansard roof and the many small attic offices. The rest of the woodwork and plastering (except for a few items) is repair work done after the 1921 fire (Illustrations 71 and 72, Volume I and Illustration 20).

(1) 1882 Materials: Clough's work is typical of the 1880s. All nails are of a later cut type. Lath is circular sawn on four sides. Finish boards are machine-planed. The style of detailing is mostly early Colonial Revival--chamfered post and door casings, slightly incorrect cyma-astragal

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[13] Ibid, p. 6.

moldings, and so forth. The paint layers on this work consist of a series of whites.

Included among the Clough materials are the interior trim of the dormers, the dormer sashes, most of the baseboard, a good proportion of the plaster on the east and west walls and on the south side above the level of the knee wall, the wooden soffits of the rafter casings on the south side, the casings of the king posts, and the curved partition around the tower stairs (Illustration 20, a).

As for the floor, not all areas have been dated since there are a good many seams that could represent patches. Some 1921 or later patches are evident, especially along the edges. However, the majority of the floor seems to be Clough work, having fairly narrow circular sawn boards with late cut nails.

(2) 1921 Materials: The 1921 work is easily identified by the use of wire nails, metal lath, a baseboard molding not exactly matching Clough's, and the presence of very few paint layers. It was simply replacement material for Clough work that had burned, or for Clough's wood lath where it was considered a fire hazard. The majority of the newer work is found on the north side of the attic where the fire was concentrated, but also is found on the south side. Here, much of Clough's wooden lath was replaced on the knee wall along the eaves, and on some areas of the sloped ceiling. Clough baseboard

was taken off and reapplied during this work since it now overlays the metal lath and shows evidence of reuse, such as paint layers that pass behind the present miters.

This period also saw alteration of the rafter casings along the north side (Illustration 72). Clough's wooden soffits must have been badly charred, as they were not replaced; the new plaster on the sides of the casings simply was turned under to form a soffit.

The ceiling plaster is of 1921 vintage toward the north, with some 1882 plaster surviving toward the south. The flat part of the ceiling is framed mostly with wire-nailed 1921 joists toward the north, and mostly with cut-nailed 1882 joists toward the south.

(3) Materials Predating 1882: Earlier materials include the roof trusses of 1748 (see Wooden Structural Framing) and some early looking, up-and-down-sawn purlins in the roof area near the ridge. Some of the roof boards in this area also look as if they date from the 18th century (see Roofs). The king posts have been cut down where they pass down through Clough's 1882 casings in the attic (Illustration 20, b). On surfaces that were not cut down, the king posts show earlier lath marks. Plaster predating Clough's (underlying his lath) can be seen directly on the brickwork of some portions of the west end wall, and could probably be found on the east also. These

indications are typical of various bits of evidence relating to earlier room arrangements in the attic. Since it is so fragmented, no attempt has been made to sort out this evidence.

The interior casings of the central windows in each end wall of the attic (Illustration 20, cc), though at least partially were constructed with cut nails, still appreciably predate 1882, as attested by earlier paint layers.

The two doors to the tower stairs (Illustration 20, dd) are much earlier than 1882, having more paint layers and being of Federal design and construction. Parts of each casing on the side toward the stairs also have more paint layers than the outer finish boards that match the rest of Clough's work. It is uncertain whether these doors were in this location prior to 1882, or were reused from some other place.

(4) Materials Postdating 1921: The sashes of the two central windows on the east and west ends match Chandler's sash elsewhere on the building, and have only paint layers later than Clough's 1882 dormer sashes. Evidently, Chandler treated each end wall as a whole when changing the sashes in 1910.

George Sherwood's 1957 ox-eye window casings and sashes (Illustration 20, e) are easily inspected from inside the attic (see Masonry of Exterior Walls).

Missing Partitions. Documents from 1882 onward clearly refer to three or more spaces in the attic used for different purposes. No physical evidence has been found of substantial partitions that would have cut up the now undivided attic space. Rather, it seems that the partitions were very light dividers. No real partitions show up in the 1921 fire photographs.

b) Conditions and Recommendations: Currently, the attic is in poor condition. It is unheated, it has poor electrical service which is not up to code, and its wall and ceiling finishes which were removed during the structural repairs of 1975 are lying about the floors. The condition of the attic at this time constitutes a fire hazard, especially with the added hazard of its use as storage space.

Due to the need to make the attic a safe and functioning space, it should be renovated after it is first cleaned up. Renovation to the attic should include the following:

(1) Installation of new wiring and lighting services that are in compliance with code.

(2) Installation of heating services which will help control the temperature during the heating season.

(3) Installation of insulation in the ceiling and walls.

(4) Installation of an attic fan to help cool and ventilate the space during the cooling season.

(5) Repair of wall and ceiling plaster and reinstallation of wood trim.

(6) Repainting of walls and ceilings and refinishing of floors. If the attic remains a storage area it is not necessary to consider refinishing it with light or historic colors. Colors suitable for collection storage should be used.

(7) Install fire detection and suppression systems.

When the renovations are complete the room should undergo a stringent maintenance program.

Another consideration for the attic is its relationship to the adjacent building spaces. For example, if the attic remains a storage space, code requires that it be separated from the rest of the structure by at least a 1-hour fire rating. In addition, code requires that some type of automatic sprinkler system be installed. Although code requirements will impact the buildings historic fabric, these are considered essential to protect life, property, and the general welfare of the public.

9. Basement

a) Historical Background: The east end of the basement contains the 1903 subway station.

In the west end of the basement, early foundation walls are visible in some areas and covered over in other areas by recent wall surfacing materials. The various types of masonry seen in different parts of these walls are hard to date.

Some of the wooden elements are more easily dated. These include the handhewn, and apparently 1748-vintage, girders of the first-floor construction, running north to south. These show old whitewash in some areas where portions of the later casings have been removed. The casings have soffits consisting of machine-planed matchboard, and are constructed with late cut nails. They look as if they date to the period of Clough (1882).

Also, probably dating to Clough's restoration, are the iron columns (Illustration 63, Volume I) supporting the much older floor girders. These are discussed in the section on Wooden Structural Framing. At the extreme west end of the cellar is a newer column supporting the granite floor of the west vestibule.

This column, and the I-beams above it, were installed by Chandler (see his 1908 drawings, Illustrations 63 and 65, Volume I).

The partitions throughout most of the west end of the cellar consist of several types of turn-of-the-century matchboard, covered with more recent asbestos material as fireproofing. If this fireproofing is ever removed, the areas of matchboard could be dated more precisely. These partitions appear in 1907 drawings for the construction of the Washington Street subway line (Illustration 55, Volume I). The boarding is of utilitarian character, and probably could be sacrificed if the conservation facility being proposed for the cellar should so require.

The rotunda in the basement gives every appearance of being integral to the construction in 1882 of the first-floor section of the central staircase (rotunda) and its present sections by Clough. The rotunda consists of plastered, curved brick walls; the segmentally arched door openings with early Colonial Revival plaster moldings look like the work of the 1880s. Several of the doors to the west rooms have Clough's identifiable panel moldings. On the east side, the wall surface and door openings have been altered to conform with the plan of the subway station, probably in 1903.

The ascription of a date of 1882 to the rotunda (except for the alterations on the east) also can be achieved by a process of elimination. Since the Rogers plan of 1830 and Abel Bowen's description of this remodeling indicate only a half-rotunda on the first floor, there was almost certainly no full rotunda there until the present one--Clough's. Therefore, there would have been no need for a full rotunda of supporting walls in the cellar. By the same methodology, the rotunda could not postdate Clough because these curved cellar partitions were necessary to support his documented first-floor rotunda.

The two present toilet rooms in the cellar, opening off the rotunda, both appear as toilet rooms in the 1907 subway plans (Illustration 55, Volume I). In his restoration plans of 1908 (Illustration 58, Volume I), Chandler calls for a partition and steps to be removed from the south toilet room, and for the sealing up of a door that had led to the east. A clear indication of this erstwhile door is visible in the toilet room.

b) Conditions and Recommendations: The basement rooms appear a little shabby, partially because of water damage to plaster (already described) and partially because they are used mostly for storage. So much change has taken place here already that these spaces could be treated rather freely if new uses are contemplated for these rooms. However, when altering this space, extreme precautions must be taken due to the presence of asbestos on the wall finishes and ceiling beams (Appendix F). Occupational Health and Safety Administration (OSHA) Asbestos Regulations (29 CFR 1910.1001) and the local Environmental Protection Agency (EPA) office should be consulted for guidance for controlling asbestos containing materials in the Old State House basement. The city of Boston's Real Property Division should also be contacted at this time. The city has set up channels of communications for asbestos abatement in city owned buildings.

Most likely, the basement will change in use after the building program is formulated. Therefore, it will not retain nor return to a historic use or appearance. As a result, it is not necessary to consider reviving the historic paint scheme which consisted of yellow plaster walls (Munsell 2.5Y 8/4), white woodwork (Munsell 5Y 9/1) and a white calcimine ceiling.[14] A color scheme suited to the proposed use of the basement should be used.

E. MECHANICAL

1. <u>Heating and Alternative Environmental Control Systems</u>

a) Historical Background

(1) Boiler: The present boiler was installed about 1973 and is of no historical importance. The present boiler room location, under the southwest corner of the building, dates to 1908; the 1907 plans for constructing the Washington

[14] Ibid, p. 3.

Street subway line (Illustration 54, Volume I) include plans for this new boiler room. The previous boiler room, shown as existing in the 1907 plans (Illustrations 55 and 56, Volume I), was under the rotunda, offset toward the south. As shown in the plans, both boiler rooms used the same flue in the west end wall of the building; this is probably the present flue, running through the blocked-up north fireplace in the Representative's Hall.

According to the documentary record, a still earlier circular boiler room was built by Clough in 1882 directly under the rotunda (see The First Restoration, Volume I). The location of this earlier room would have conflicted with the construction of the East Boston Tunnel in 1903; the boiler room thus was moved southward, out from directly under the rotunda (Illustration 55, Volume I).

(2) Early Radiators: Several photographs of the Council Chamber that predate ca. 1910 show decorative Victorian radiators consisting of many small vertical pipes in three rows. They once were probably used throughout the building, however, none exist now in any first- or second-floor rooms. Examples of the radiators do survive in the attic (two on each end wall, disconnected). They bear a patent date of 1877. Perhaps they were reused from the lower rooms when the steam heating system was extended to the third story in 1909 (see The Chandler Restoration, Volume I). These were present in the attic

in 1921 when the post-fire photographs were taken (Illustration 71, Volume I). Another attic feature appearing both in the 1921 photographs and today is a set of noteworthy Victorian-style radiators, each consisting of a single row of large vertical cylinders joined by horizontal finned cylinders at the top and bottom. Their patent information is hard to read but could be deciphered. These stood in some of the dormer alcoves, as shown in a 1921 picture. Although the attic radiators are now disconnected, another similar looking radiator is still connected in the basement at the top of the boiler room stairs.

Another type of early looking radiator is still used to heat much of the cellar. These radiators consist of long lengths of pipe suspended horizontally along the ceiling or against walls from special fixtures.

The present radiators on the first and second floors appear in photographs after about 1910, such as the 1921 fire photographs (Illustrations 50 and 74, Volume I). Those in the Council Chamber were cased by Perry, Shaw and Hepburn in 1943, in paneling that matched their other work in this room. Two radiators on the north and south walls were moved from between windows into the window seat area. The radiator in the first-floor rotunda was cased at some time after being photographed by Arthur Haskell in 1933. The radiator in the northwest second floor anteroom (the Commission Room) has been moved into the window alcove since the 1921 fire photograph of this room. The cased window seat radiators in Keayne Hall are Chandler revisions of 1909 (see The Chandler Restoration, Volume 1).

(3) Extant Plumbing Fixtures: The oldest of the extant plumbing fixtures (the two sinks and toilet in the south cellar bathroom) look as if they could be as much as 50 years old. Their type is still very common, however, and of no special interest. All of the other plumbing fixtures are more recent. The equipment installed when plumber James Sullivan signed his name and the date 1882 in the plumbing tank closet in the southwest second floor anteroom has since been removed.

b) Conditions and Recommendations--1977: Heating/ Air Conditioning. A mechanical engineer examined the building for the purpose of assessing the present heating system and possible future ones. His report is included as Appendix C, and the results of his inspection are summarized further and discussed here.

At present, the building is heated by a two-pipe steam system fed by a gas fired boiler. The question is whether to upgrade the present two-pipe steam system, or to remove it and install a modern environmental control system offering air conditioning and year-round humidity control.

(1) Upgrading of the Present System: Clearly, at least some upgrading of the present system is necessary. The

Whitmore Hall/library area is always too hot in the winter, while the rest of the building is chilly and the attic completely unheated. The present system, if retained, should be fitted with better controls such as individual radiator thermostats of the mechanical type to replace the present radiator valves. The attic contains two types of nonworking but historic radiators, probably dating back to the 1882 Clough restoration. These should be reconnected if it is thought desirable to smooth out the very wide annual temperature swings in this area, which is now used for storage of paintings and artifacts. (Even if these radiators are not reconnected, they should be retained in their original location whenever possible.) An attic fan or window air conditioners in two or three of the dormers would cool the attic in the summer. Insulation over the flat part of the attic ceiling would help, too, although it might produce dangerous levels of snow accumulation on the roof.

The several types of old style radiators in the cellar are working, and also should be retained. The ca. 1909 radiators on the first and second floors--though less interesting than the Victorian radiators in the cellar and attic--are part of the history of the building. At least samples of them should be kept in storage, regardless of future changes to the heating system.

(2) Full Environmental Control: A full environmental control system is probably possible and could be designed along several lines, depending upon the exact

heating/cooling loads involved. The biggest problem would be to arrange for heat rejection for the air-conditioning system. Ideally, an arrangement could be worked out to tap into the chilled water supply of a neighboring office building, although the administrative problems of getting a chilled water line across one or more streets require more study. If this is not possible, heat rejection equipment located within the building will be necessary. The attic seems to be the only location for this, unless a variance somehow could be obtained to put heat rejection equipment in the basement, using street level air for cooling. A rather unattractive method of getting air into the attic-located equipment probably would be unavoidable, such as the replacement of some of the dormer windows (or possibly dormer cheeks or tower base) with louvers. Weight loads and vibration levels of the chilling equipment to be installed also would have to be assessed, with respect to the bearing capability of the attic floor (i.e., roof trusses).

Two types of heating/cooling equipment are possible. A ducted air system would have the advantage of better humidity control, but would require fairly large ducts running to all spaces. A system based on fan-coil units would need only small pipes for chilled water but would not, in itself, offer much opportunity for humidity control.

Perhaps some combination of the two types of systems would fit the building best. Diffusers could be installed around the perimeters of the ceilings of the second-story rooms, adjacent to the exterior walls of the building. Air ducts along the sides of the attic would connect these with heating/cooling/humidifying/ dehumidifying units housed in the attic. These units would obtain heat via a hot-water line from the basement, and would cool air by rejecting heat through louvers in the dormers.

Getting conditioned air from an attic-housed unit to the first floor is more of a problem. One could sacrifice some spaces on the exhibit floor for large ducts from attic to cellar, where air distribution equipment could be located. Alternatively, one might locate a chilling unit in the attic, with refrigerant lines to a fan-coil type of unit in the basement, either the existing boiler (or a replacement) or through a new connection to Edison Steam. Conditioned air from this unit could be distributed by duct work into floor registers in Keayne Hall. Getting ducts up from the basement unit into Whitmore Hall and the offices would require permission to infringe on the subway station, which immediately underlines the floors of the east end of the building. Alternatively, individual fan-coil units might be installed in the Whitmore Hall area.

If air conditioning and year-round humidity control are installed, the windows probably would have to be upgraded with some type of double glazing. Ultraviolet light-absorbing plexiglass could be affixed inconspicuously to the interiors of the windows. This would both help control air leakage and condensation, and protect exhibits from ultraviolet light.

If windows are blocked, some intake of outside air may be needed for ventilation. This should not be done at the street level because of automobile exhaust fumes. Perhaps the air that enters as visitors continually open the north and south doors would be sufficient for the whole building.

The west end of the basement has been proposed as a likely spot for a conservation facility. Ventilation would have to be improved for this to occur; opening the windows in the light wells only draws in heavily polluted air. Another problem that would have to be overcome is the high humidity levels caused by water penetration of the basement walls (see Masonry of Exterior Walls, Conditions).

(3) Which Course to Follow: The decision as to whether to upgrade the present steam system or convert to a full environmental control system must be made based on understanding the effects of the environment and the systems on the building and collections, and on professional judgement. A curator of collections would feel that a full environmental system in the Old State House is worthwhile. Clearly, the collections now are being subjected to severe annual temperature and humidity cycles (especially those in the attic), and to pollutants entering through open windows in the summer. Paintings over radiators are

drastically overheated and dirtied. Every professional standard of museum climatology is being ignored.

On the other hand, persons primarily interested in buildings would elect to leave the building and the present heating system intact, and provide for their continued preservation. Therefore, any proposed introduction of a new environmental control system is first resisted until its installation is proven sensitive and unintrusive to the building fabric and historic scene.

There is still the subjective question as to which equipment intrudes the least. If one sees 1909 radiators and steam pipes as objectionable, the present system is certainly intrusive--Whitmore Hall and the library contain almost a maze of pipes. But if one believes that the modern equipment and ductwork required for complete environmental control infringes too greatly upon historic spaces, then the "maze" may seem preferable.

With the problems of choosing the right environmental control system and the need to preserve the building and its collections, there is clearly a balance that must be sought. The balance is sought in the discussion that follows.

c) Conditions and Recommendations--Further Study (1987)

(1) Heating and Analysis of Alternative Environmental Control Systems: In his discussions on "Environmental Controls," Mr. Phillips argues, briefly, on the pros and cons relative to updating or replacing the existing heating system. However, his argument should be more extensive and specific relative to impact on the structure and collections resulting from the existing and/or alternative systems. The cost of all systems should also be addressed. If we are to make an intelligent decision on "which course to follow" in selecting an environmental control system for the building, questions of cost and total impact must be answered.

All who have lived in, worked in, or visited any building know of the impact on their comfort attributed to the environmental control system. Likewise, if we are museum conservators, we are aware of the impact these systems have on the collections.

In the upcoming discussions, model systems generating the "course to follow" in selecting a compatible system are analyzed and evaluated in terms of: 1) impact on the structure and its collections, 2) impact on the occupants, and 3) installation cost. However, before beginning these discussions, we shall first examine the qualities in a system desired for human comfort and the preservation of the building and its collections. These discussions are as follows.

(2) Human, Building and Collection Requirements: With an envelope of brick walls and double-hung wood sash windows, all under a slate roof, the structure, like any other, needs environmental controls for the comfort of its occupants and the preservation of its finishes and collections. Preliminary analysis indicates that with the makeup and size of the envelope enclosing the Old State House, it has a design heating load of 740,000 British Thermal Units per hour (BTUH). Should the building be provided with mechanical cooling, its cooling load calls for 27.5 tons of air conditioning.

Aside from the heating and cooling loads, the American Society for Heating, Refrigeration, and Air Conditioning Engineers 90-75 (ASHRAE 90-75) recommends temperatures of 72 degrees Fahrenheit and a relative humidity of 30 percent maximum during the heating season, and a temperature of 78 degrees Fahrenheit and relative humidities from 30 to 60 percent during the cooling season. These temperatures and humidities are effective when combined with sufficiently ventilated and distributed air within spaces.

To preserve the building and its collections (paintings, etc.), similar conditions of climate or environmental control are desired. These conditions must be constantly maintained year-around. Included is the control of the amount and type of light falling on the interiors, and infestations of insects and mildew. These, however, will be discussed in an upcoming study.

Studies show that too much or too little moisture in the air relative to temperature can cause serious damage to a building and its collections. In addition, damage can be caused by rapid fluctuations in the relative humidity. Consequently, experts recommend that the indoor climate be controlled to maintain a relative humidity of 40 to 60 percent and temperatures of 60 to 75 degrees Fahrenheit. The Bostonian Society is requesting similar environmental conditions for the protection of their collections, and human comfort.

It is conceivable that full air conditioning is required if we are to maintain the desired temperature and humidity levels in the structure. However, in the absence of air conditioning, other methods of climate control may be employed by curators or other occupants to achieve comparative results. These methods require occupants to manipulate existing building components and portable environmental equipment (windows, doors, fans, humidifiers/dehumidifiers, etc.), as needed, to help correlate the indoor and outdoor weather conditions. When these methods are correctly used, they can help control temperature, relative humidity, and air distribution. However, during inclement weather, the opened doors and windows may have to be closed.

(3) Current Environmental Conditions: At present, the building is equipped with a heating system only. The system, as described earlier, is a two-pipe steam heating system. It is composed of a gas-fired sectional cast iron low pressure

steam boiler in the sub-basement, and cast iron sectional radiators in the conditioned spaces. Steam heat is supplied to the spaces and returned to the boiler by way of 1- and 3-inch steel pipes.

Currently, the system is not operating efficiently as evidenced during field inspections, as well as discussions with members of the Bostonian Society's staff who occupy the building year-round. Occupants complain that, when the system is in operation, some areas are overheated while other areas are not heated sufficiently. This results in their discomfort from one area of the structure to the next. After investigating the system's performance during a later field trip, I now share the same opinion.

Moreover, when the Society's 1984, 1985, and 1986 hygrothermographs were examined, they corroborated our experiences. The hygrothermograph's readings in the basement and attic show that the two areas are at extreme differences in temperature and humidity. This may be due to the fact that the basement is heated and closest to the heating source while the attic is unheated (not connected to the source) and farthest away.

In the basement during the heating season, readings of indoor temperatures from 65 to 85 degrees are coupled with relative humidities from 20 to 40 percent over a 24-hour period.

Corresponding to these are outdoor temperatures ranging from 21 to 64 degrees Fahrenheit and relative humidities from 25 to 70 percent.

During the cooling seasons, basement temperatures range from 60 to 78 degrees, with relative humidities from 35 to 100 percent. Outdoor temperatures ranging from 28 to 98 degrees Fahrenheit, and outdoor humidities from 50 to 100 percent, are shown for the same period. Although the combined temperatures and humidities are not ideal, but only tolerable for human comfort, they are far less than suitable for the preservation of the building and its collections. Fluctuations in temperatures and humidities such as these are believed to be responsible for the failing paint and plaster in the basement spaces.

First-floor temperatures were recorded at 65 to 80 degrees during the heating season, when the outdoor temperatures varied from 21 to 64 degrees Fahrenheit. Relative humidities corresponding to the indoor and outdoor temperatures for the same period averaged 20 to 60 percent and 35 to 100 percent, respectively. From April to October, indoor temperatures averaged 80 degrees Fahrenheit, while outdoor temperatures for the same periods ranged from 43 to 85 degrees Fahrenheit. Relative humidities for the indoor and outdoor temperatures, during the periods above, were 25 to 75 percent and 35 to 100 percent, respectively.

On the second floor, hygrothermographs of 1985 and 1986 show indoor temperatures of 60 to 70 degrees Fahrenheit from October to May, and 70 to 80 degrees Fahrenheit from May to September. Relative humidities for the earlier and latter periods were 25 to 65 percent and 40 to 70 percent, respectively. Outdoor temperatures ranged from 24 to 80 percent Fahrenheit from October to May and 65 to 80 degrees Fahrenheit between May and September. Relative humidities for the first and last periods were 35 to 100 percent and 30 to 90 percent, respectively.

Judging from the readings, it is evident that temperatures of the second floor are lower than those of the first and basement floors during the heating season. Contrary to expectations, the humidity levels are higher on this floor than on the other floors and may account for the blistering and peeling paint in several of the second-floor spaces. Examination of the paint indicates that moisture is the cause of the problem, and the source should be eliminated in this area before the problem worsens. Too much moisture is not only harmful to the building interiors, but is harmful to its collections as well.

As stated earlier, the attic is left unheated since its radiators are not connected to the heating source. Consequently, its winter temperatures are at an extreme low in comparison to the rest of the building. During the winter or heating season of 1984 and 1985, hygrothermograph readings showed attic temperatures in the range of 40 to 60 degrees Fahrenheit, and relative humidities from 55 to 100 percent. Complimenting these conditions are outdoor temperatures of 21 to 65 degrees Fahrenheit and relative humidities of 35 to 100 percent, respectively. During the spring and summer months, attic temperatures varied from 65 to 88 degrees, with relative humidities from 65 to 100 percent. In the same area, the relative humidities averaged around 80 percent during the summer months. Outdoor temperatures and humidities at this time were 65 to 80 degrees and 30 to 100 percent, respectively.

The system is obviously malfunctioning and does not provide a suitable environment for the building's occupants, nor for the preservation of the building's fabric and collections. Corrective actions must be taken. However, before any actions are taken, we must first ascertain and solve the problems of the existing steam heating system. Solutions may consist of updating or replacing this system, whichever works best to provide the proper environment for human comfort and the preservation of the building and its collections. Analysis and evaluation of alternative systems providing solutions to the environmental control problems are outlined below.

(4) Analysis of Problems of the Existing Steam Heating System: In the preceding discussions, we have determined that this system is not operating efficiently. Paul Button, mechanical engineer, Denver Service Center (DSC), shares this assessment after inspecting the system during a field trip on

March 3, 1987. Mr. Button states that control of the system is effected by cycling the boiler on space temperatures through a room thermostat located on the walls of a first-floor room. There are no individual radiator controls, and the boiler was observed to cycle approximately 2 minutes out of every 5 minutes, when outdoor air temperatures averaged 30 degrees Fahrenheit under sunny skies. Space temperatures were highest in the basement and first floor, remarkably cooler on the second floor, and unheated in the attic. He also found that although the boiler, condensate receiver set, and radiators all seem to be in good operating condition, the system piping appears highly unsatisfactory. In addition, the major problems as he saw them are as follows:

(a) The piping is very old and has recently developed several leaks.

(b) All piping, as well as the boiler gas flue, are insulated with asbestos.

(c) Modern steam piping practices utilizing steam traps, drip legs, and strainers are completely absent in this system resulting in uneven heating and poor boiler operating efficiency.

d) Analysis and Evaluation of Alternative Systems Providing Solutions to the Environmental Control Problems (Heating Only):

(1) <u>Heating Only</u>

(a) Upgrading Existing Steam Heating System: If the existing system is retained, it should at least be upgraded to include the services and components that increase its operating efficiency. Since the changes are few, the existing cast iron steam boiler and the existing cast iron sectional radiators would remain intact. Moreover, the system operates more efficiently and provides considerably more even heat distribution and greater boiler efficiency; therefore, allowing the occupants more comfort during the heating season. The upgrade would include the following changes:

i) Replace all existing piping in kind.

ii) Insulate and paint new piping.

iii) Flush out existing radiators

iv) Install new thermostatic traps at the return side of the radiators.

v) Shortfalls of System: The system does not provide cooling, ventilation, pollution, nor humidity and zone controls. These are desired year-round for total human comfort and the preservation of the building fabric and collections.

vi) Additional Equipment Needed for the Delivery and Maintenance of a Comfortable Environment: Supplementary portable fans, humidifiers/dehumidifiers with humidistats are needed to help control the environment year-round. The equipment must be used in conjunction with opened or closed windows and doors.

vii) (insert visual and physical impact)

viii) Cost: $180,000.

(b) Conversion of Existing Steam System to Hot-Water Heating System: This system is more costly, yet more efficient than the upgraded steam system above. However, like the upgraded system, several components will be changed (converted) or replaced and proper services rendered to increase the operating efficiency of the heating system. The advantages of this system over the steam heating system is exhibited in the fact that the degree of zone control using hot water is much greater than with steam. New piping will be left exposed since it would have no greater impact on the spaces than the existing piping already has. Should we conceal piping in the walls, greater impact would result from the wall openings or cutouts that must be provided. The conversion of the system would require that we:

i) Install new zoned hot-water piping to replace existing deteriorated steam and condensate piping.

ii) Insulate and paint new hot-water piping.

iii) Convert existing steam boiler to hot-water service.

iv) Flush out and retain existing radiators.

v) Install thermostats and control valves throughout the system.

vi) Shortfalls of System: Like the steam heating system, the hot-water heating system has no provisions for cooling, ventilation, pollution, air distribution, nor humidity controls. These are desired for year-round human comfort, as well as the preservation of building fabric and collections.

vii) Additional Equipment Needed for the Delivery and Maintenance of a Comfortable Environment: Supplementary portable fans and humidifiers/dehumidifiers with humidistats are needed to help control the environment year-round. This equipment must be used in conjunction with opened or closed windows and doors.

viii) Visual and Physical Impact on Building: Little or no further impact. While the boiler and radiators remain in place, new piping fits in the same location as the old piping. Therefore, no additional holes need be cut in the building fabric unless piping is concealed.

ix) Cost: $193,000.

(2) Heating and Air Conditioning: After studying several alternatives for providing heating and air conditioning for the Old State house, Mr. Button writes:

> "It should be noted that any form of central heating, ventilating, and air conditioning (HVAC) system installed in the Old State House will be intrusive to some degree, and that any decision made regarding the various options for providing air conditioning should include structural and aesthetic impact as prime considerations."

The examination of these alternatives can be divided into two areas of technical concern: 1) providing sources of heating and refrigeration, and 2) providing distribution to the building.

If cooling is to be obtained through mechanical refrigeration, this equipment may be located in one of three different locations: 1) the attic, 2) the basement (or sub-basement (boiler room)) or, 3) across the walkway in the basement of the 15 State Street building.

Heating may be accomplished through either reusing the existing boiler in a hot-water application, providing a new boiler in the 15 State Street basement, or connecting to Boston Thermal Corporation steam.

Options for distribution include the installation of two-pipe fan-coil units throughout the building, or installing central air handling equipment (HVAC) in either the attic or the basement, and providing ductwork to the spaces accordingly. (See Preliminary Study Drawings Leading to Architectural/Engineering Recommendations, HVAC and Fan-Coil Options, Sheets 1 through 4.)

Locating a chiller/condensing unit in the 15 State Street basement and running chilled water supply and return lines underground to the Old State House basement appears to be the best means of providing a source of mechanical cooling. Installing this equipment in either the basement or attic of the

Old State House would require extensive structural modifications and objectionable noise and vibration transmission would probably be unavoidable.

Refitting the existing Old State House boiler for hot-water service would be the most expedient method of providing a source of heating, however, if chilled water lines are to be run from 15 State Street for cooling, heated water supply and return lines between the basements should be installed at the same time and reserved for future use. Thus, if at some time in the future it is decided to utilize either Boston Thermal Corporation steam or a new boiler, connections to the new source would be a simple matter.

There is no perfect way to provide distribution of treated air through the building. Any system installed will require modification of the historical structure, and it is here that subjective judgment must be made.

In light of the above discussion, alternative systems for cooling and heating are outlined below.

(a) All-Water/Fan-Coil (Circulating Room Air Only) System: In addition to the boiler and chiller/condensing unit installations as described above, the system's design requires that fan-coil units be installed between or in front of the windows of each floor, provided there is enough space between them and the window to permit periodic maintenance. If they are installed below the windows, the window seats must be substantially altered to allow for periodic servicing of the units. System piping can be concealed in the walls or left exposed. Although its piping is somewhat intrusive, the system when installed will provide more comfort to the occupants. The occupants will be cooler in the summer and warmer in the winter. However, since humidity levels in the spaces can not be accurately controlled, comfort levels may be sporadic at times.

i) Shortfalls of System: Although the system provides zone control through individual units and minimal ventilation, the circulated air is insufficient to remove odors from the spaces. There is little or no humidity control. Consequently, the environment required for total human comfort and the preservation of the building fabric and collections can not be maintained year-round. Supplemental equipment would be required for humidity control. The system is also noisy due to the fans in each unit.

ii) Additional Equipment Needed for the Delivery and Maintenance of a Comfortable Environment: To help control the year-round environment in the building, the fan-coil units must be supplemented with portable fans and humidifiers/dehumidifiers connected to humidistats. The supplemental equipment is desirable if we are to approximate the environmental conditions necessary to provide human comfort and preserve the building fabric and collections.

iii) Visual and Physical Impact on Building: The impact of a fan-coil system on the building is due to the following:

iv) Visual impact is due to the size and contemporary design of unconcealed units that are incompatible with the existing historic decor or period styling of the interiors. This should be of little importance, since there are many additions to the interiors that are contemporary. Other visual impact results from piping, should it be left exposed. However, this should be considered a minor impact since the existing system also has exposed piping.

v) Noise impact is due to the units' fans in the conditioned spaces. For a space currently heated by radiators which make little or no noise, noise generated by the fans of the fan-coil units will take a little time for occupants to adjust to. The sound may interfere with lectures should they continue to be given in the building.

vi) The chance to reduce the physical impact on the structure is controlled by whether or not the system's piping is concealed in or left exposed along the walls. Should the piping be left exposed, there is visual, but little physical, impact on the building's fabric except for the openings cut into the floors and ceilings where vertical runs of piping must pass. On the other hand, if the piping is concealed, the wall's baseboard must first be removed and later replaced. Between the removal and replacement of the baseboard, long lengths of brick must be removed from the walls to accommodate the horizontal and vertical runs of piping.

vii) Cost: $284,500.

(b) All-Air System (HVAC): Unlike the all-water/fan-coil system that requires space for the fan-coil units and piping only, the all-air system requires space for piping, air handling units, long runs of ductwork, and registers and grilles to distribute and regulate the air in the building. These all have their own impact. However, there is far less impact on the structure if the attic and basement house the ductwork. Still, the requirements to supply air to and exhaust air from the building are met only when openings are cut through walls, floors and ceilings to accommodate registers and grilles.

In the attic, ductwork sprawled along the north and south walls will consume at least 400 square feet of floor space. Another 200 square feet of floor space will be consumed by the air handler and the adjacent area required for servicing access. In addition, the grilles supplying outside air to the air handler and duct systems require that two 8-inch by 12-inch openings be provided in the attic end walls or windows, or in the dormer cheeks or windows, for their installation. It is also possible to install grilles at the base of the tower where openings can be cut and noticed less. Other air to the attic storage spaces is supplied by registers installed directly in the main ductwork fronting the space. Also tied into the main ductwork are branch ducts that penetrate the attic floor- and second-floor ceiling.

At the second floor, the branch ducts will terminate into ceiling registers that distribute air to and return air from the spaces. These registers will measure about 50 square inches each, and be installed just in front of the windows. Registers will be selected to match the existing decor of the interiors as closely as possible.

On the west half of the first floor, air will be delivered and removed from the spaces through branch ducts which run from the main ducts of the basement ceiling and terminate above the first floor under the window seats. Since the spaces below the seats are taken up by radiators, the radiators should be removed and the seats and their grilles altered so that air can flow out of grilles in the seat tops as well as return through the grilles in their front. This will alter the historic appearance of the window seats. If the decision is to not terminate the branch ducts below the window boxes, they may just as well terminate into registers installed in the first floor as are the registers in the ceiling of the second floor above. This, however, will impact the structure more.

As for the east end of the first floor, only fan-coil units are proposed for installation. Since the basement space below belongs to the MBTA subways, and its ceiling height is already low, it is unlikely that we will be allowed to install ductwork there. If the decision is made to ignore the historic scene in the first floor at the east end of the Old State House, ductwork can be installed (left exposed) in the ceilings. We must, however, provide for vertical runs from the ductwork in the west end of the basement.

In the basement, heating and cooling will be provided by registers directly installed in the main ductwork located there. This ductwork is connected to an air handler and exhaust grille located in the sub-basement (boiler room) below the basement. The exhaust grille will be that already located in the brick paving at the west and south elevations.

i) Shortfalls of System: Since the system has long runs of ductwork, its weakness lies in the fact that the ductwork takes up a lot of useful space, especially in the attic. Also, with the air handler in the attic on a wooden floor, sound isolation devices would have to be utilized. Moreover, water leaks may develop in the future where the cooling and heating water lines tie into the air handler. Therefore, some type of water catching platform should be constructed around the air handler so that water leaks can not damage the ceiling of the second floor.

ii) Additional Equipment Needed for the Delivery and Maintenance of a Comfortable Environment: No additional equipment is needed. The system provides full environmental controls to include HVAC as well as humidity control. Nonetheless, the system may operate more efficiently if the structure was insulated, especially in the attic where snow remains on the roof during the heating season.

iii) Visual and Physical Impact on Building: Impacts on the building are as stated in the preceding sections. There are openings that must be cut in the floors, ceilings, and walls, or glass that must be removed from windows. The space to be lost in the attic and the clashing visual appearance of the registers, grilles, and ductwork on the historic scene are all of consequence with an all-air system.

vi) Cost: $365,000.

(c) All-Air System (Ventilation Only) with Existing Steam Heating System: In addition to temperature, human thermal comfort consists of several factors. Among other considerations, relative humidity and air movement both have a profound effect. Although something as subjective as human comfort is obviously difficult to quantify, efforts have been made to combine the effects of all the primary factors affecting comfort into a single scale of measurements known as "effective temperature." ASHRAE and other sources have published data equating changes in air movement to corresponding changes in effective temperature, and a plot of this relationship is attached. To put some meaning into these numbers, a standard window fan will move air at around 200 feet per minute (fpm). However, experience shows that the cooling effect of a fan is only felt directly in the heart of the flow, and that one only has to move a few feet from that flow to feel almost no effect at all. Herein lies the problem with attempting to use a central system to provide cooling comfort by air movement alone. That same 200 fpm (equating to a roughly 7 degree Fahrenheit drop in effective temperature) would have to be provided throughout the entire occupied zone of the building, requiring enormous amounts of air to be moved.

To illustrate, in order for this effect to be generated in Keayne Hall, an air volume flow of (8.5)(32)(200) equaling 54,400 cubic feet per minute (cfm) would be required. Obviously, this number is ludicrous, but even an air flow of 30 fpm resulting in 2 to 2-1/2 degree Fahrenheit drop in effective temperature would require a volume flow of (8.5)(32)(30) equals 8,160 cfm in Keayne Hall. This compares to the approximately 4,000 cfm required by a full HVAC system.

With this in mind, the question remains: Can a system providing some measure of comfort using only air movement be designed to fit within the constraints of the Old State House? All the above evidence to the contrary, it would appear the answer is a qualified "yes." In the almost purely psychological field of human comfort, any air flow, no matter how small, if felt on the skin, produces a cooling effect; an individual will feel considerably more comfortable with minimal air flow than in stagnant air under the same conditions. This is particularly true in times of high relative humidity.

Taking all of the above into consideration, as well as the physical constraints of the Old State House (in particular, problems with air intake and exhaust size constrictions as well as diffuser size and flow considerations), a possible system would as shown in the Preliminary Study Drawings Leading to Architectural/Engineering Recommendations, Sheet 5. This system would provide approximately 4,000 cfm to the building by means of intake through the attic, supply through both ends of the second-floor ceiling, flow through the doorways and through the staircase, down to Keayne Hall, and exhaust through several of the window boxes into the basement where a power exhaust fan would return the air to the outside through the boiler room to the street.

It should again be stressed that what is shown on the drawing does not represent a total comfort system, nor in fact does it even come very close. The system shown will only provide a minimum air flow through the building to alleviate stagnation. When one considers these benefits contrasted with the impact on the structure the installation of this system would require, it may be difficult to justify its implementation in any form.

i) Shortfalls of System: Like the HVAC all-air system, the efficiency of this system is weakened by long runs of ductwork which take up a lot of space in the attic. Space required for intake air to the air handlers will visually and physically impact the building, along with the noise impact generated by these units. Some type of sound isolation must be provided between the units and the building.

ii) Additional Equipment Needed for the Delivery and Maintenance of a Comfortable Environment: Additional equipment, such as humidifiers/dehumidifiers with humidstats, are needed to control the environment year-around. The ventilation air alone is not expected to provide the desired degree of cooling comfort during the summer months. Supplemental fans will be required to assist in cooling the building unless the windows and doors are opened; however, open windows and doors will negate the reasons for the installation of a ventilation system. The existing steam heating or the proposed hot-water heating system will be used during the winter months.

iii) Visual and Physical Impact on the Building: The visual and physical impact on the building will result from the introduction of two 260-square-inch openings in the building fabric such as the wall or a window opening. These are required for "intake air" to the air handlers of the ventilation system. Other impact results from the space required to run ductwork and the holes in the building for registers that distribute the air throughout the building. Noise pollution is also a product of the system, although it can be isolated.

iv) Cost: $400,000.

e) Recommendations: Concern for both the building and its collections has delayed the NPS, DSC's recommendation of one environmental control system over another. However, since there exists an alternative system that will, without further impact and minimal cost, lend itself to the preservation of the building and the collections, it must be given consideration if we are to achieve our goals in keeping with the preservation spirit and adhering to the mandate that the building "must be preserved." NPS-28 (Chapter 5, page 4) states that the installation of systems or physical modifications should be considered only when 1) they are the only viable options, 2) they will cause no appreciable physical damage to the structure, 3) they will cause no unacceptable visual intrusion on the historic scene, and 4) they do not alter the qualities that qualify the structure for the National Register.

As a starting point, we realize that the existing steam heating system must at least be repaired if we are to begin to meet our goals. In addition, the repaired system must be more efficient than before with little impact on the structure and the collections when achieving these results. Although all of the systems (hot-water heating system, all-water/fan-coil system, an all-air system (HVAC), or ventilation only with existing steam heating system) are more efficient than the existing steam heating system, only the hot-water system or a similar system can achieve some results with little or no impact on the building and the collections.

Therefore, it is recommended that the existing steam heating system be converted to a hot-water heating system to increase efficiency. This conversion will preserve all historic radiators, modify the boiler, and provide for new piping and fittings to be installed in the same location as those of the existing system. However, for temperature and humidity control, the system requires that the museum staff manipulate doors and windows in conjunction with portable fans, humidifiers and dehumidifiers with humidistats. Exhibit items of the collection that are too sensitive in the open environment should be enclosed in climatized exhibit cases or storage cabinets if not on display.

An alternative recommendation to the above is to install an environmental control system that will provide heating, minor cooling, filtering and ventilation of the air so that the windows can remain closed to protect the collections and building interiors from pollutants in the outside air. However, such a system must be studied further for its impact on the building and programming goals. This system should be explored before a final selection or recommendation is made for the installation or update of an environmental control system. The A/E (architect/engineer) and the NPS will perform this study.

Final selection of the recommended system, or any other environmental control system, is left up to the NPS, the city of Boston, and the Bostonian Society management as they assess the impacts of each on the building and collections. The designers and writers of the above study will be available for consultation.

2. Plumbing: Since the writing of the original HSR by Morgan Phillips in 1977, several changes have been made to upgrade the existing plumbing system at the Old State House. Out of the three toilet rooms in the building, two have had several fixtures replaced. In the second-floor toilet and one of the first-floor toilets, the water closet and lavatory were replaced. In addition, branch supply piping serving these fixtures has also been replaced, along with a new water heater that was installed in the basement toilet.

Still noticeable, however, are the old waste piping and main supply lines of the plumbing system that are in place. Although, there are no noticeable leaks nor other problems in the system at this time, it is conceivable that deterioration has set in on the piping due to its age. Consequently, the piping should all be replaced during the renovation of the building. Other piping and fixtures should be installed at this time, as needed, to fulfill the requirements set by the building program.

F. ELECTRICAL: The existing electrical system at the Old State House is in generally good condition, except for the attic section which is aged and does not comply with the current electrical code. Electrical service is 120/208-volt, three-phase, from underground utilities owned and operated by the Boston-Edison Electrical Company. All branch circuits are served from a 400-ampere panelboard in the electrical closet, located in the storeroom just off the south end of the rotunda at the basement floor. This panelboard was installed in 1975 when the electrical wiring and services of the basement, first, and second floor spaces were upgraded.

These newly rewired spaces are served with "armored cable" wiring, fished and concealed in the walls and ceilings. The wiring connects to 125-volt, 20-ampere duplex receptacles, single pole and three-way switches, and ceiling outlets which are either track or surface mounted incandescent lighting. Currently, the system is operating properly, however, there are concerns relative to its compliance with the National Electrical Code of the National Fire Protection Association (NEC-NFPA 70-1987), and the effects of incandescent lighting on the collections.

Code concerns derive from the type of wiring installed in the new system. Article 333-6 of the National Electrical Code states that armored cable wiring is not permitted in Places of Assembly, except as provided in Article 518. However the latter article permits the installation of AC wiring in buildings or portions of buildings that are not required to be fire-rated construction by the applicable building code. Should the applicable code (Commonwealth of Massachusetts--State Building Code) and the Building Official, city of Boston, require the Old State House to be fire rated, the building will also have to be rewired with code-acceptable wiring.

Another concern is that the short circuit capacity of the power company system is being increased throughout the city of Boston. Therefore, the building service panel short circuit interrupting capacity should be also increased.

Lighting effects on the collections are discussed in a 1983 study by Edward McManus, Conservator. The study was prepared for the Bostonian Society and titled "A Lighting Evaluation for the Old State House in Boston." In this document, Mr. McManus states that levels of ultraviolet light (UV) and visible light from the incandescent lighting are too high, and pose a threat to the objects exhibited in the building. Consequently, he recommends solutions to these problems. While most of his recommendations are well taken, several others (including proposing the installation of tinted UV film over the windows and the installation of window shades on the windows) are not conducive to preservation standards. Therefore these should not be implemented until all possible alternative solutions having less impact on the building are explored. However the remaining recommendations should be implemented. These are as follows:

1. <u>Recommendations</u>

a) Inform staff members of the properties of light and its effects on the collection.

b) Place incandescent lights on a rheostat control system.

c) Replace 150-watt PAR flood lights with 75-watt floods.

d) Install diffuser screens over flood lights.

e) Rearrange exhibits so that the most light sensitive items are protected.

f) Rotate paintings between storage and exhibit at six-month intervals.

g) Take periodic readings of light levels (semiannually) or when lighting conditions change.

G. FIRE DETECTION AND SUPPRESSION SYSTEMS, AND SECURITY SYSTEMS

1. <u>Fire Detection and Suppression System</u>: The six-zoned fire detection and suppression system in the building was installed in 1975 under the direction of the architectural firm of Stahl-Bennett, Inc., Boston, Massachusetts. Heat and smoke detectors of the system are of the "Rate of Rise" type used with manual alarm stations. The fire suppression system is composed of a series of manual water or chemical fire extinguishers. An analysis and recommendations for this system are outlined in division "F" of the "Code Analysis" section of this report. This section should be consulted for details. In addition, the system should be designed to sound an alarm at a central location in the office of the city of Boston's Real Property Division.

2. <u>Security System</u>: The security or intrusion system for the building is generally a series of motion detectors located throughout the first and second floors. Currently, the system is functioning, but is not adequate to fulfill the intrusion alarm requirements for the building since it is limited

to the interiors and the building perimeters are left unprotected. Consequently, the existing security system should be expanded to include perimeter alarm protection installed at the first-floor and basement windows and doors. The alarms should ring at a central location in the offices of the city of Boston's Real Property Division.

H. SPECIALTIES

1. Lion and Unicorn: The present lion and unicorn are apparently those installed in 1921 as replacements for those applied in 1882 when the building was restored to its "colonial appearance." No record of more recent replacement has been found. These carved wood figures are in good condition and appear to be well maintained; however, they will require some refinishing like other wood pieces at the building.

2. Parapet Scrolls: The scrolls on the parapets of the west gable are apparently those installed by Clough in 1882. No record of more recent replacement has been found. The current conditions of these scrolls require that they at least be repainted after proper preparations are made. Finishes covering the wood have weathered in some areas.

3. Figurehead Keystones: The 16 figureheads that comprise the four keystones of the four ox-eye windows on the gable ends are cast-stone replacements made by George Sherwood in

1957. They are weathering fairly well, and remain in good condition; however, some light cleaning is needed to remove minor stains from the surfaces of these figures. Light cleaning using low pressure water and a bristle brush should suffice for cleaning these stone pieces. Concerning the original figurehead keystones, some are stored in the attic, and a number are at the Boston Museum of Fine Arts. Some of those in the attic are badly eroded with pieces missing.

4. <u>Sundial and Clock</u>: The sundial, like much of the east gable end on which it sits, dates from George Sherwood's 1957 program of repairs. The sundial replaced the early 19th-century clock face and surrounding decoration; most of the garlanded decorations, and parts of the face and hands, are stored in the attic. More importantly, Simon Willard's signed and dated clock works remain undisturbed behind the sundial. All parts of the clock have not been located and inventoried at this time, but there are plans to do this. In any case, if all parts can be located, the clock should be repaired and reinstalled. (See suggested period of restoration for details.) It can be repaired and reinstalled by "day labor" rather than as a part of the upcoming construction contract.

5. <u>Weather Vane</u>: The swallow-tail banner weather vane is probably a prize remnant from the 18th century, as discussed in the section, "The Revolutionary Period, Volume I." Currently,

this item is in good condition since it was refinished as part of the 1982 tower restoration.

6. Flagpole: The existing flagpole is installed at the east elevation of the building overhanging the balcony at an angle. This unit is in good condition and its location makes for easy servicing, unlike the earlier flagpole that was attached to the roof and removed in 1986. Since there is no known historic precedence for locating the flagpole, it should remain in its current location. However, the stability of its current connection should be checked and adjusted, if necessary.

I. PHOTOGRAPHS AND EXISTING CONDITIONS DRAWINGS: Illustrations follow.

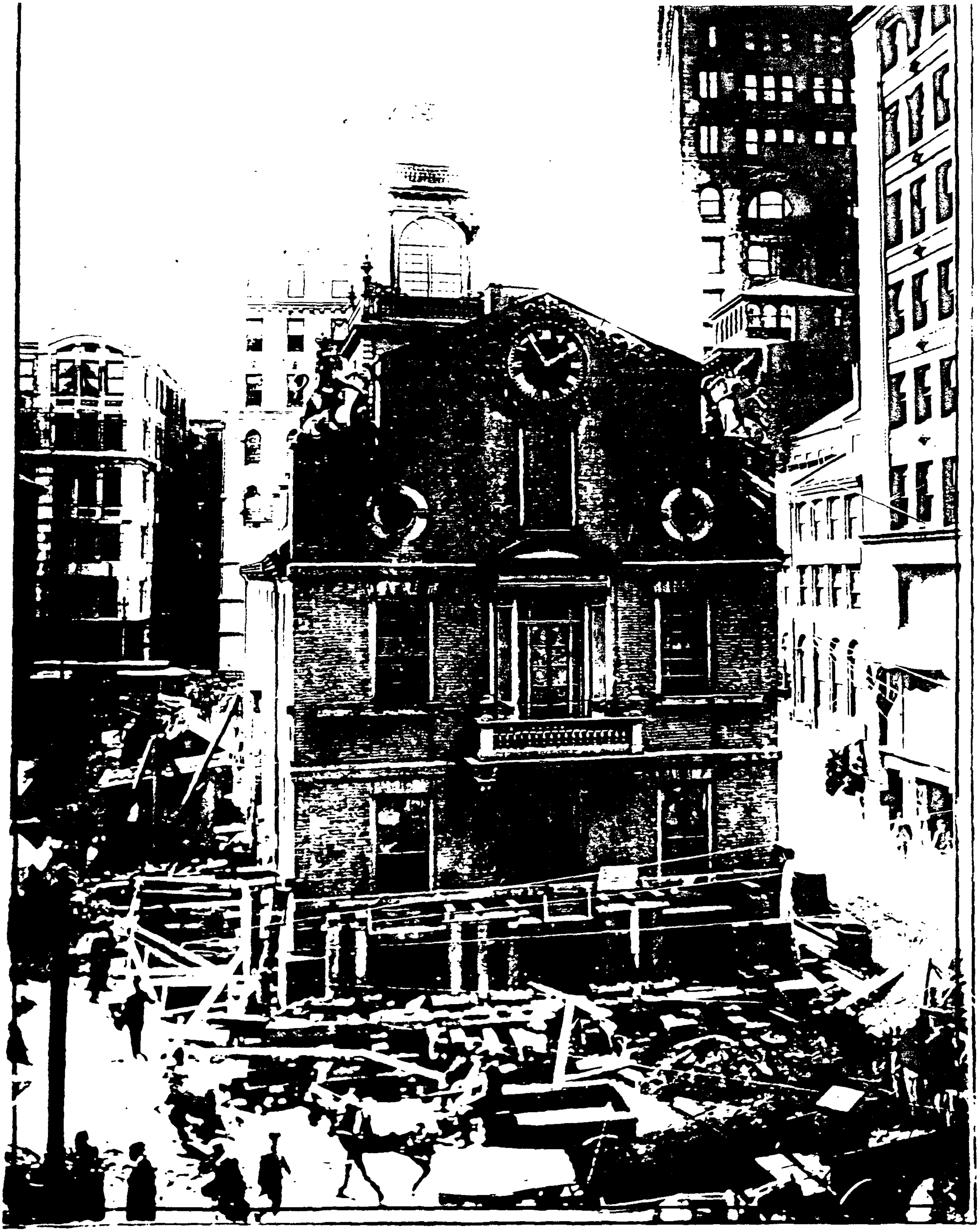


ILLUSTRATION 1. OLD STATE HOUSE: SOUTH AND EAST WALL UNDER-PINNING AND SHORING 1902-04.

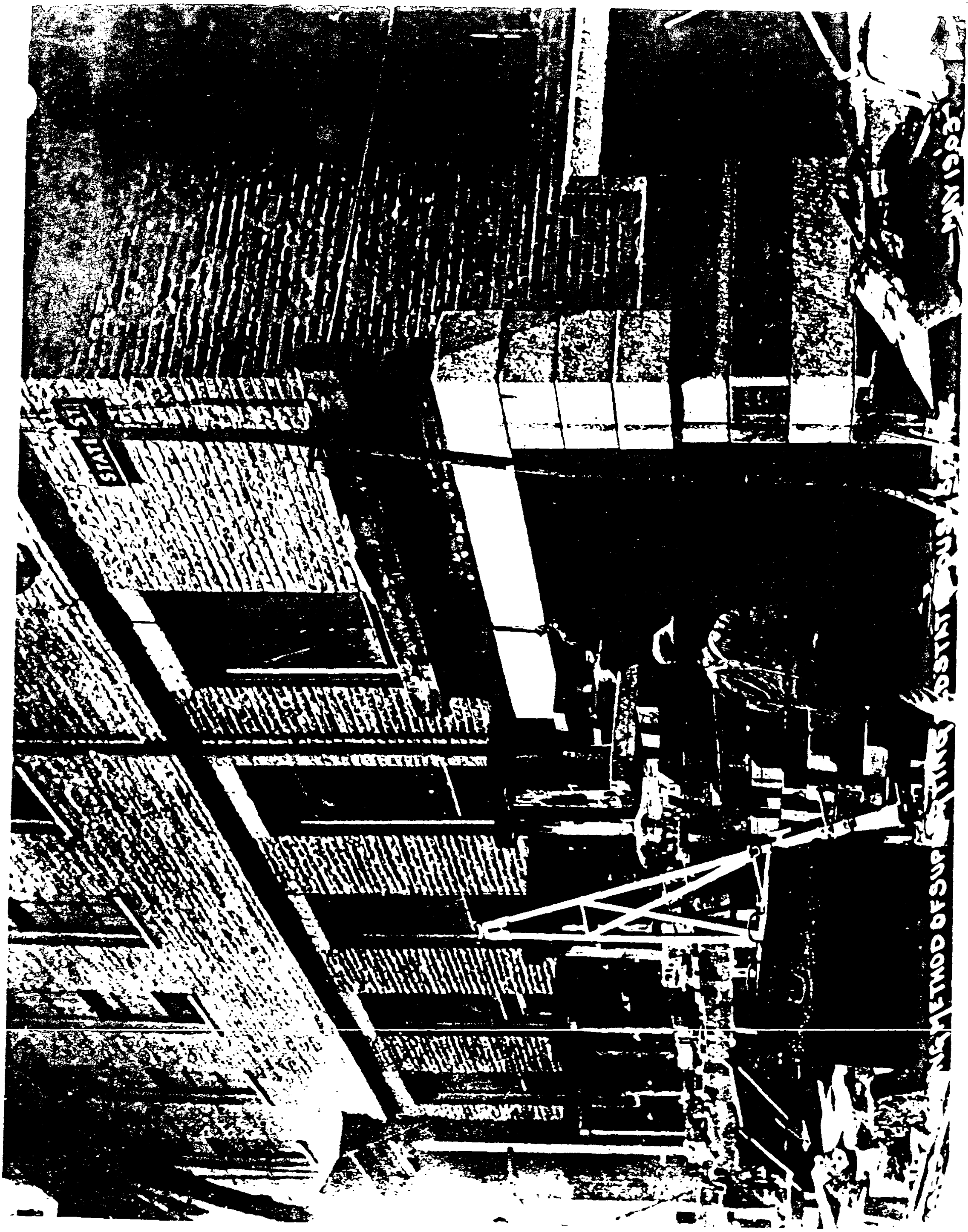


ILLUSTRATION 2. OLD STATE HOUSE: CLOSEUP OF SOUTH AND EAST WALL UNDERPINNING AND SHORING 1902-04.

ILLUSTRATION 3. OLD STATE HOUSE: SOUTH WALL UNDERPINNING AND SHORING 1902-04.

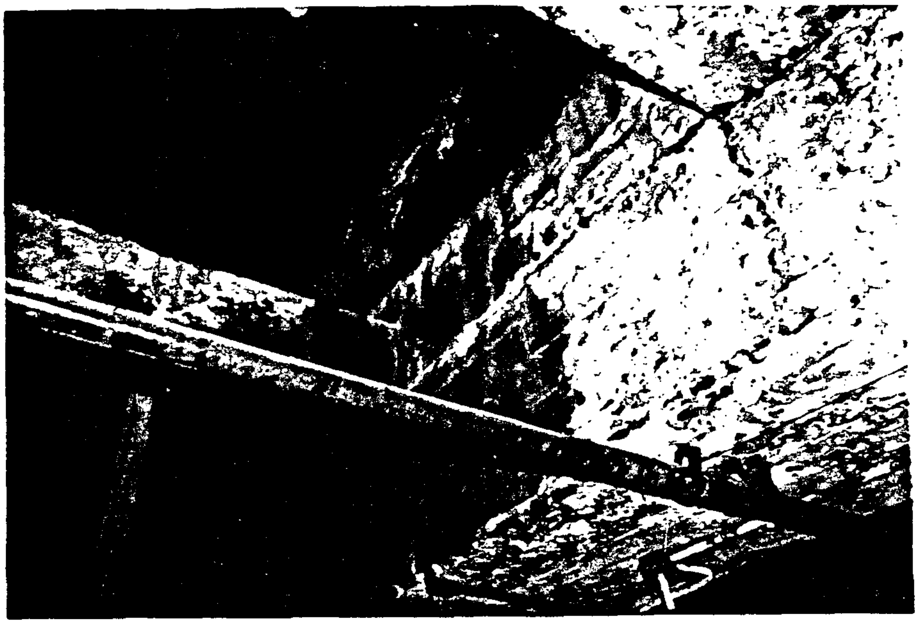


ILLUSTRATION 4. OLD STATE HOUSE: BOILER ROOM, CRACKED CONCRETE CLADDING OVER HORIZONTAL STEEL BEAMS, 1987.

ILLUSTRATION 5. OLD STATE HOUSE: BOILER ROOM, DETERIORATED CONCRETE-CLAD I-BEAM SUPPORTING SIDEWALK, 1987.

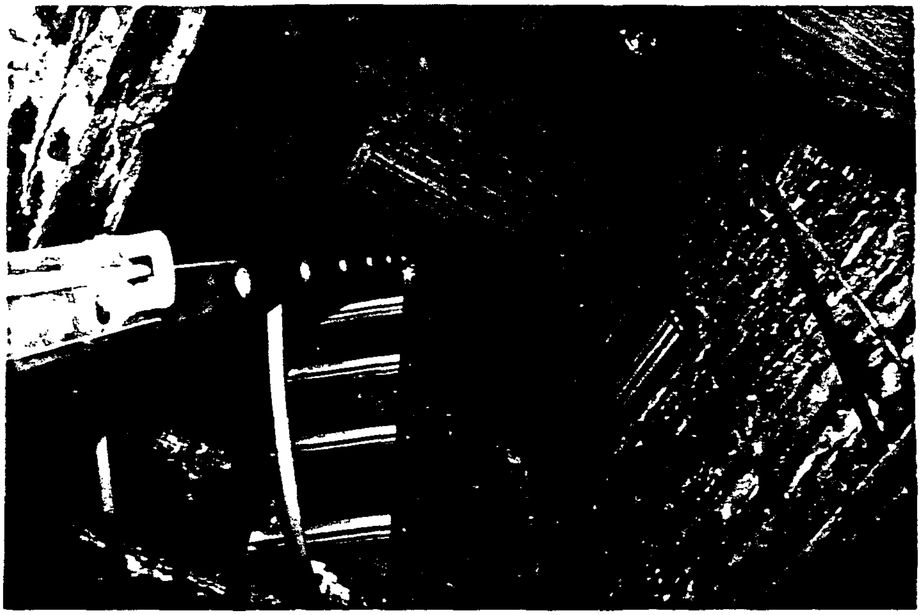


ILLUSTRATION 6. OLD STATE HOUSE: BOILER ROOM, DETERIORATED REINFORCED-CONCRETE FRAMING AROUND SIDEWALK OPENING, 1987.

ILLUSTRATION 7. OLD STATE HOUSE: SOUTH WALL, WEST END, BRICKWORK NEEDING REPOINTING, 1987.

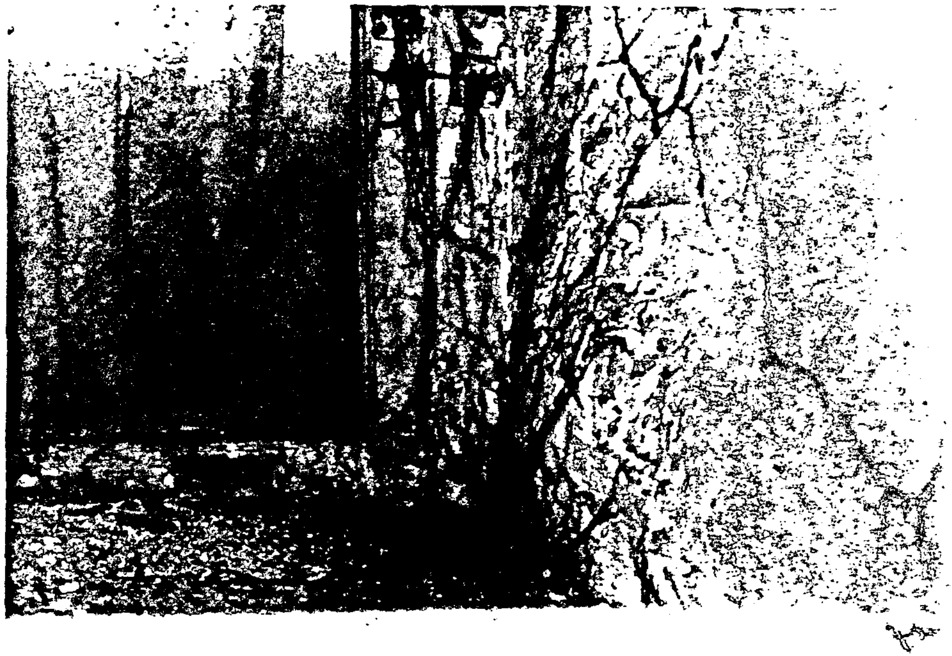


ILLUSTRATION 8. OLD STATE HOUSE: BASEMENT, NORTH WALL WINDOW, MOISTURE DAMAGE, 1987.

ILLUSTRATION 9. OLD STATE HOUSE: BASEMENT, ROTUNDA, NORTH SIDE, WATER DAMAGE, 1987.

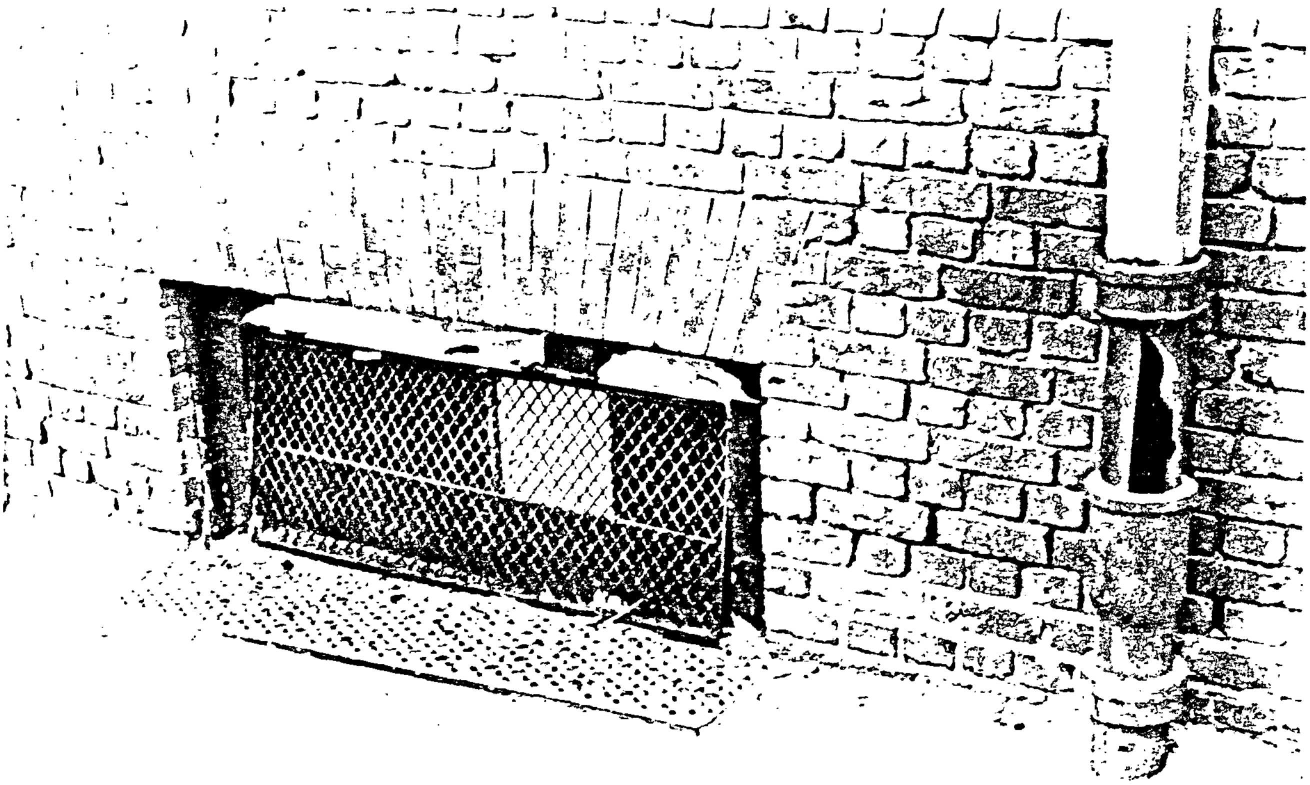


ILLUSTRATION 10. OLD STATE HOUSE: NORTH WALL, WEST END, BROKEN DRAINPIPE, 1977. PIPE CURRENTLY (1987) REPAIRED.

ILLUSTRATION 11. OLD STATE HOUSE: SOUTH WALL, STANDING WATER IN GUTTER, 1987.

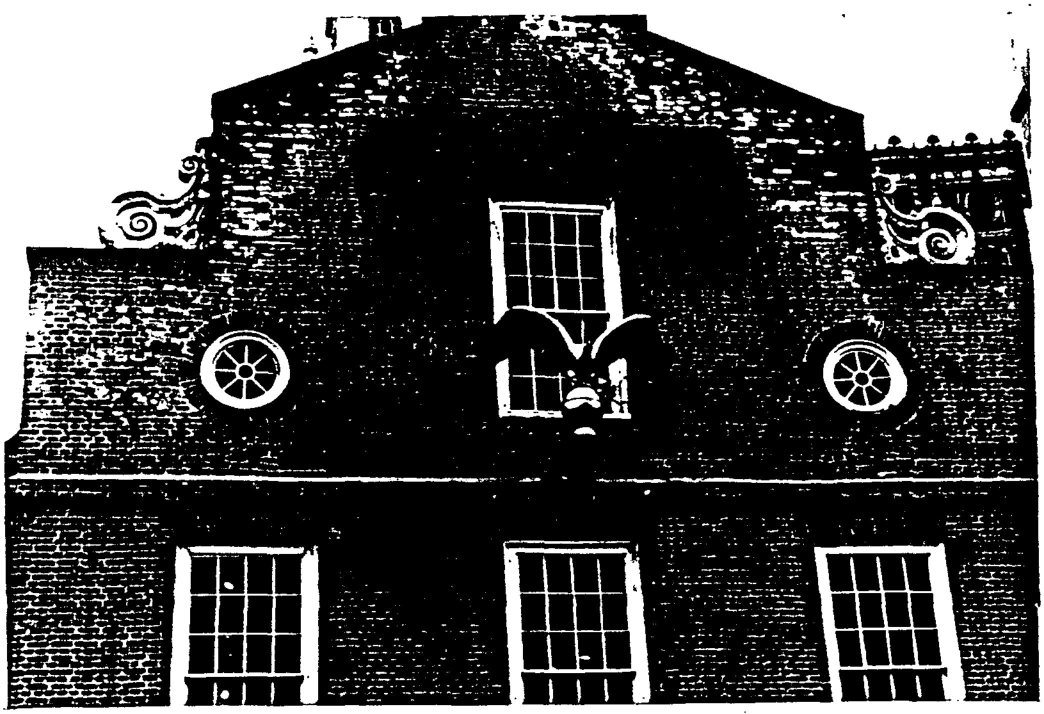


ILLUSTRATION 12. OLD STATE HOUSE: WEST WALL, PARAPET EFFLORESCENCE, 1987.

ILLUSTRATION 13. OLD STATE HOUSE: EAST PARAPET, JUNCTION WITH NORTH ROOF SLOPE, OLD FLASHING, 1987.

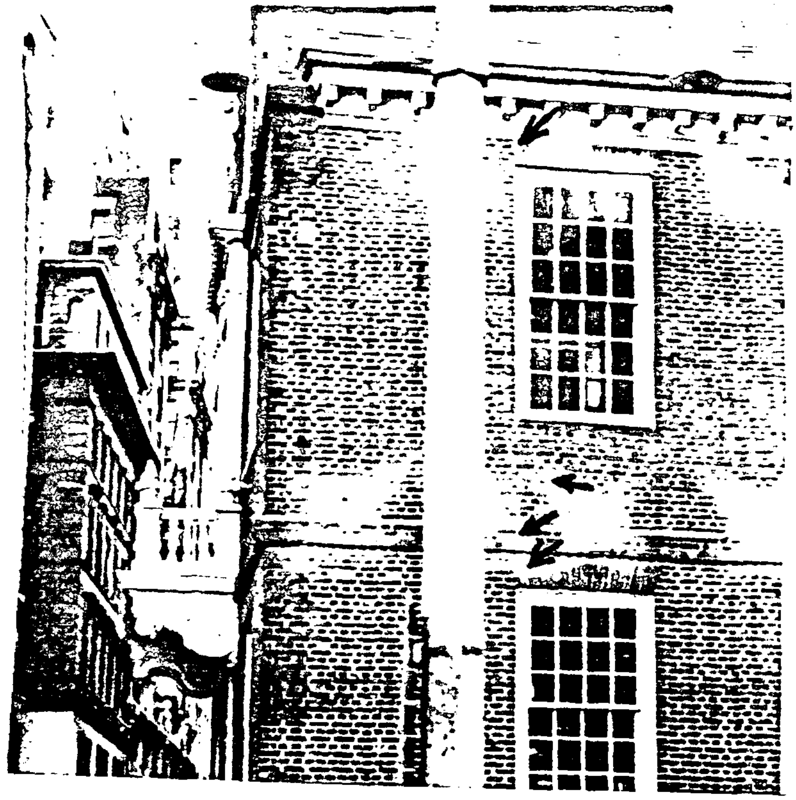


ILLUSTRATION 14. OLD STATE HOUSE: NORTH WALL, EAST END, CRACK IN BRICKWORK (FOLLOWS ARROWS), 1987.

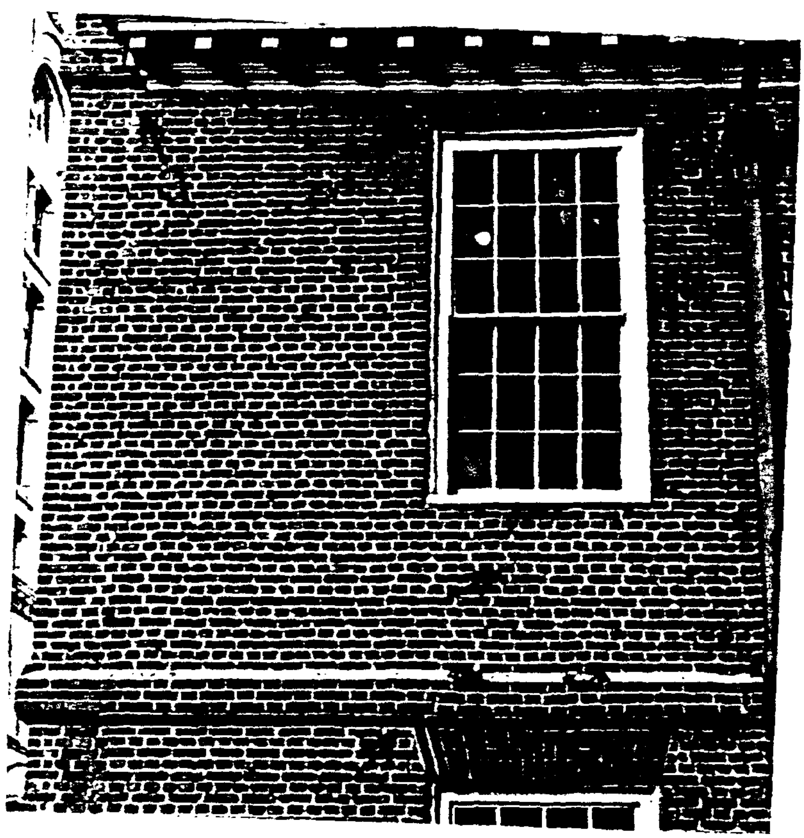


ILLUSTRATION 15. OLD STATE HOUSE: SOUTH WALL, WEST END, CRACK IN BRICKWORK (FOLLOWS ARROWS), 1987.

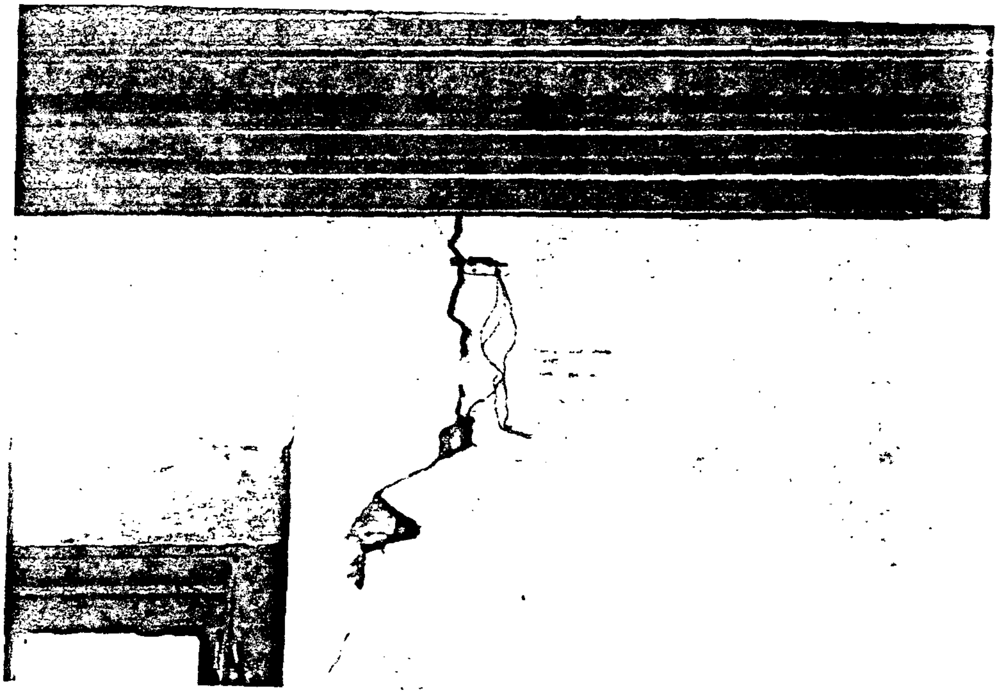


ILLUSTRATION 16. OLD STATE HOUSE: COUNCIL CHAMBER, NORTH WALL, CRACK IN PLASTER, 1987.

ILLUSTRATION 17. OLD STATE HOUSE: REPRESENTATIVE'S HALL, SOUTH WALL, CRACKS IN PLASTER, 1987.

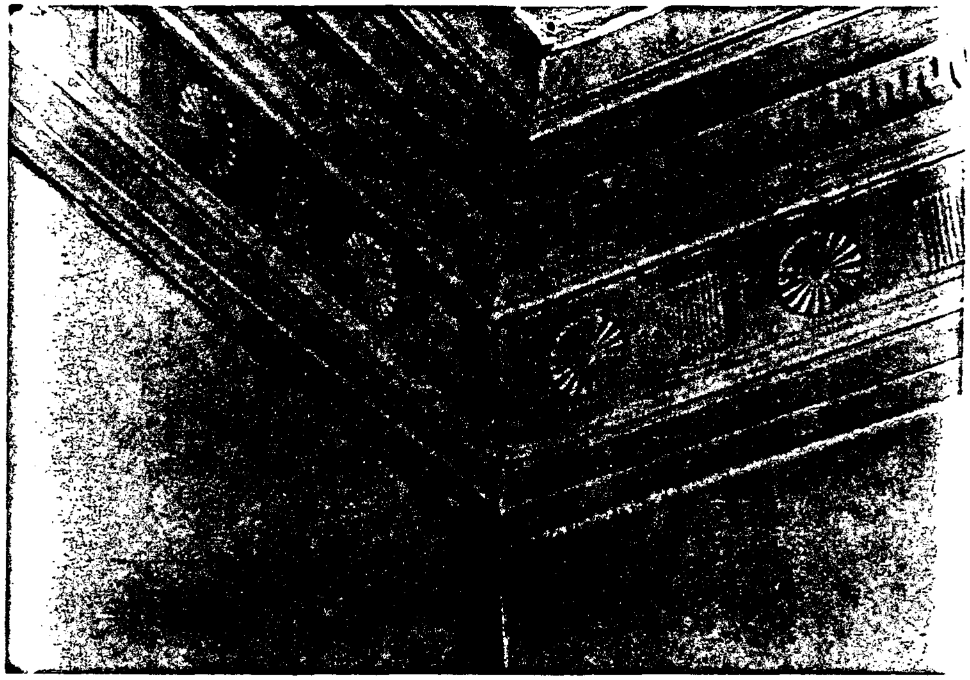


ILLUSTRATION 18. OLD STATE HOUSE: REPRESENTATIVE'S HALL, INTERSECTION OF SOUTH AND WEST WALLS, CHIP OF TWISTED 1975 PAINT, 1987. CONDITIONS SIMILAR.

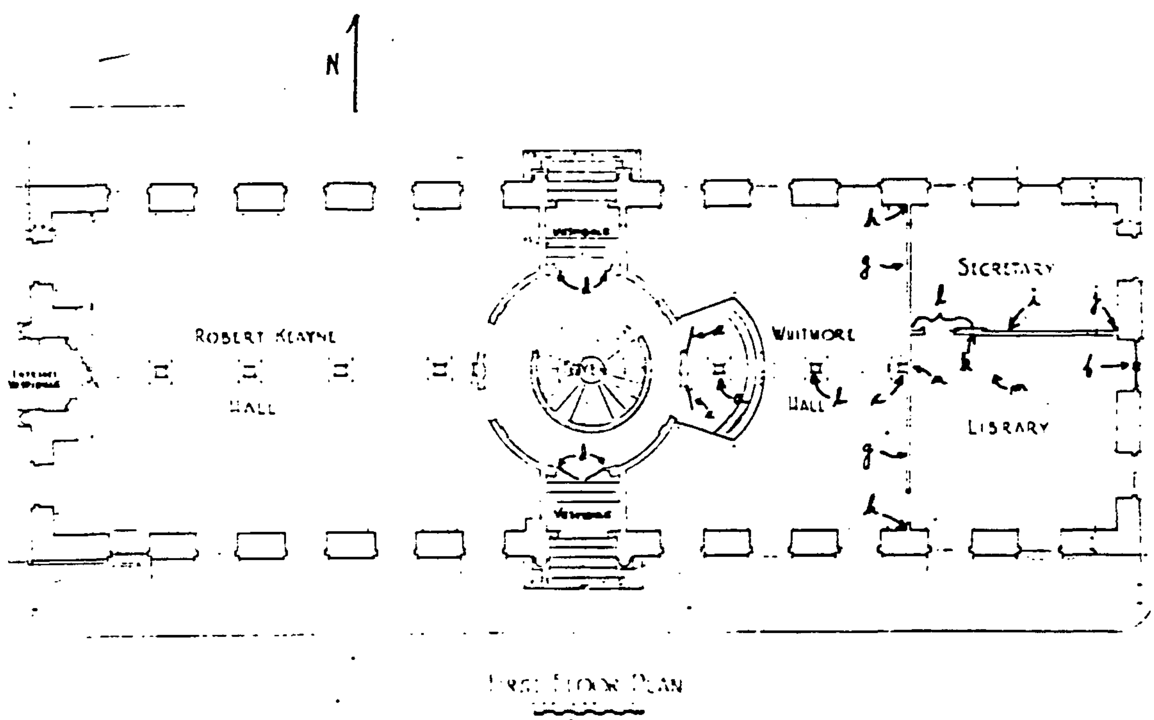


ILLUSTRATION 19. OLD STATE HOUSE: FIRST-FLOOR PLAN (1932?/1977), 1977. CONDITIONS SIMILAR TODAY.

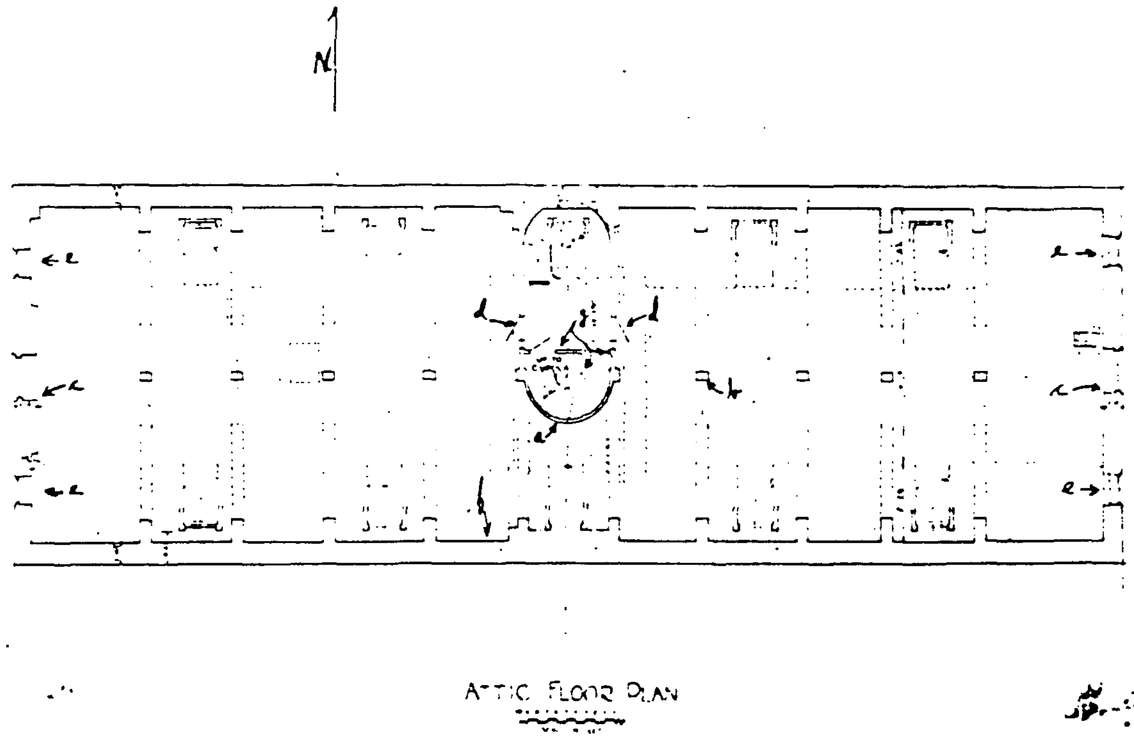


ILLUSTRATION 20. OLD STATE HOUSE: ATTIC-FLOOR PLAN (1932?/1977), 1977. CONDITIONS SIMILAR TODAY.

ILLUSTRATION 21. OLD STATE HOUSE: EAST WALL, BALCONY PILASTER, 1977.

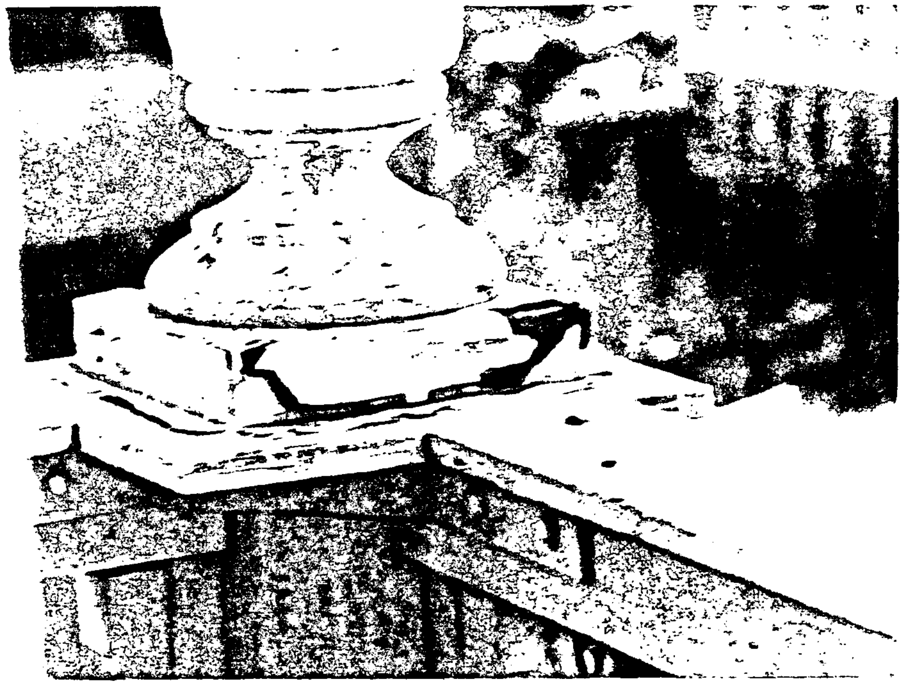


ILLUSTRATION 22. OLD STATE HOUSE: EAST WALL, BALCONY FINIALS, 1987.

ILLUSTRATION 23. OLD STATE HOUSE: EAST WALL, DOOR OPENING ONTO BALCONY, SASH CONDITIONS, 1987.

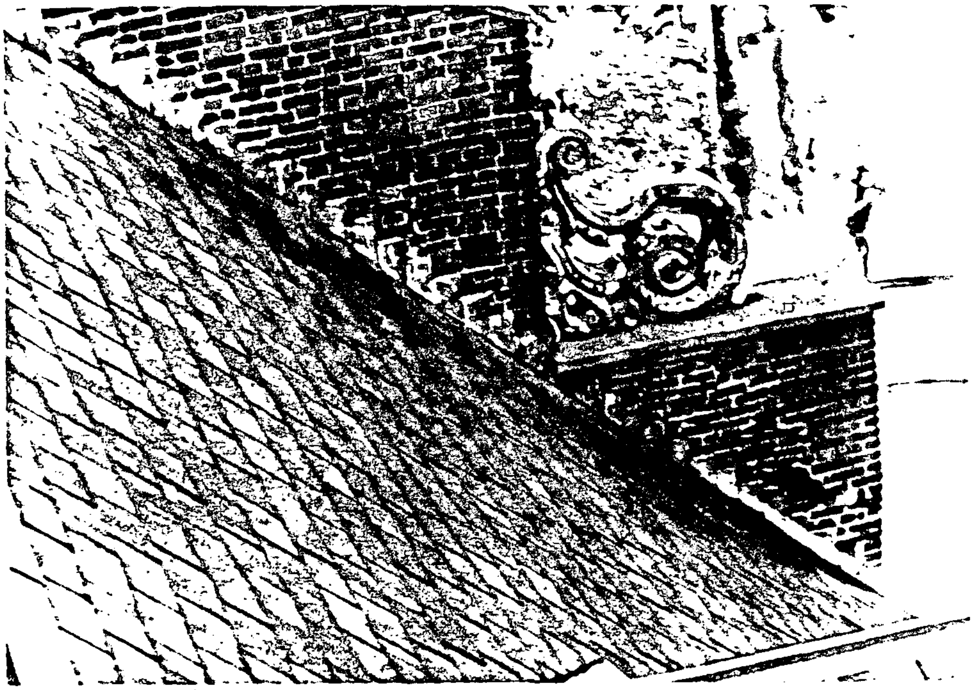


ILLUSTRATION 24. OLD STATE HOUSE: ROOF AND PARAPET, LOOKING WEST FROM TOWER, 1987.

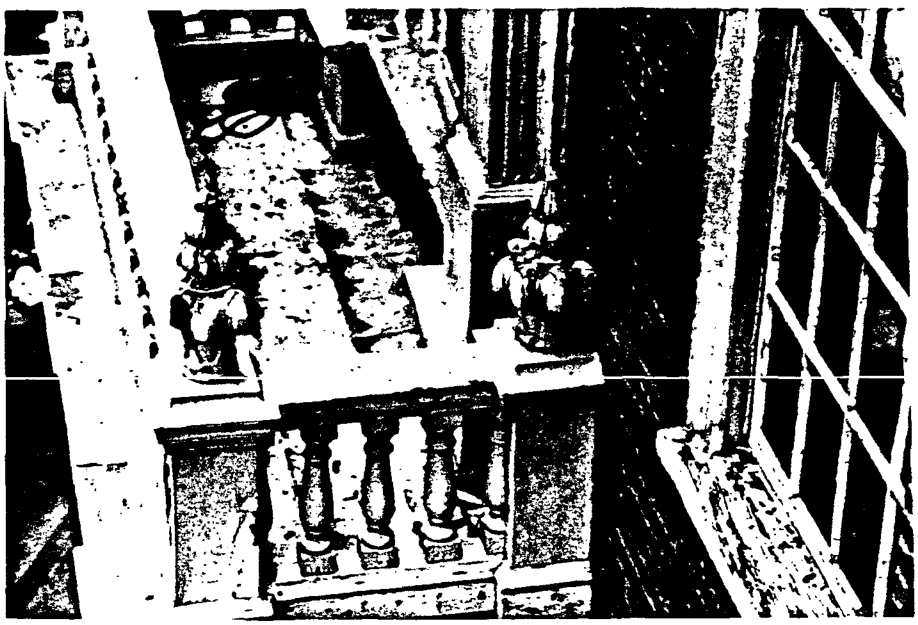


ILLUSTRATION 25. OLD STATE HOUSE: EAST WALL, UPPER SURFACE OF BALCONY, 1987.

ILLUSTRATION 26. OLD STATE HOUSE: CRACKS IN BALCONY FLOOR, 1977. CONDITIONS SIMILAR TODAY.

ILLUSTRATION 27. OLD STATE HOUSE: COPPER ROOFS OF TOWER, BENT EDGING AND OPENING OF JOINTS, 1987.

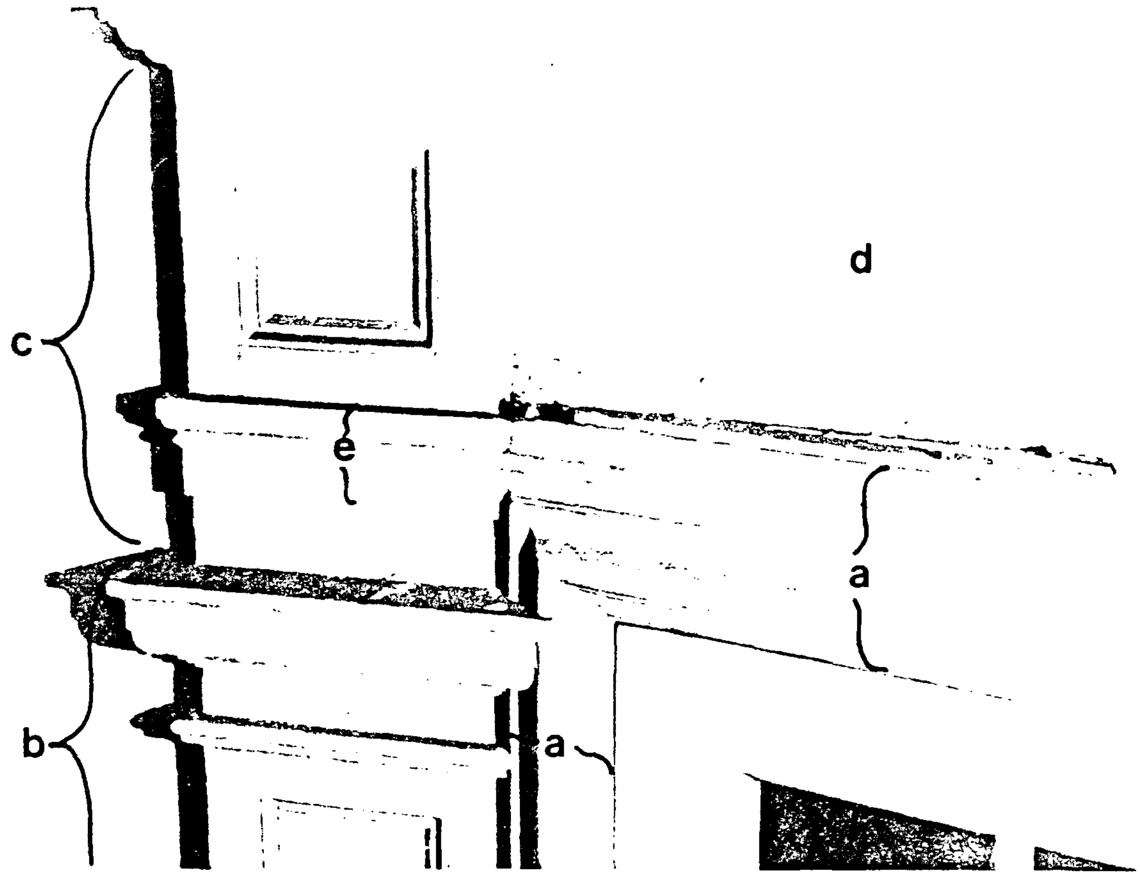


ILLUSTRATION 28. OLD STATE HOUSE: SOUTH ENTRANCE, EAST PILASTER IN ROTUNDA AND DOOR CASINGS, 1977. CONDITIONS SIMILAR TODAY.

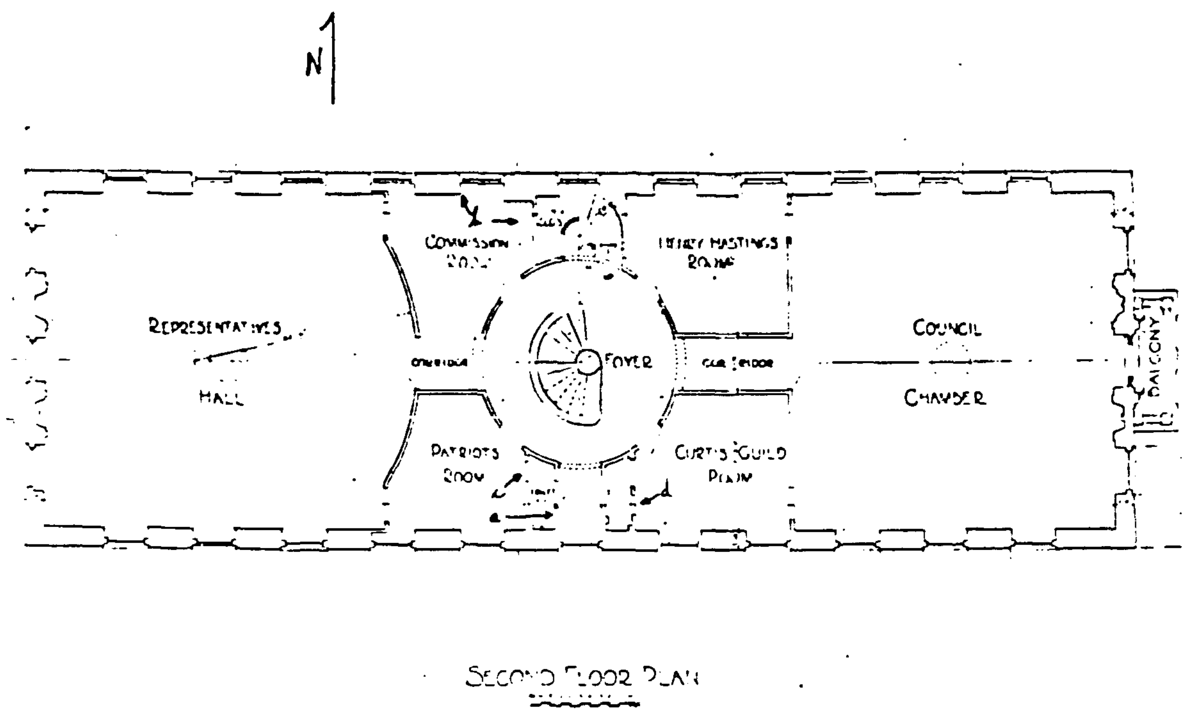


ILLUSTRATION 29. OLD STATE HOUSE: SECOND-FLOOR PLAN (1932?/ 1977), 1977. CONDITIONS SIMILAR TODAY.

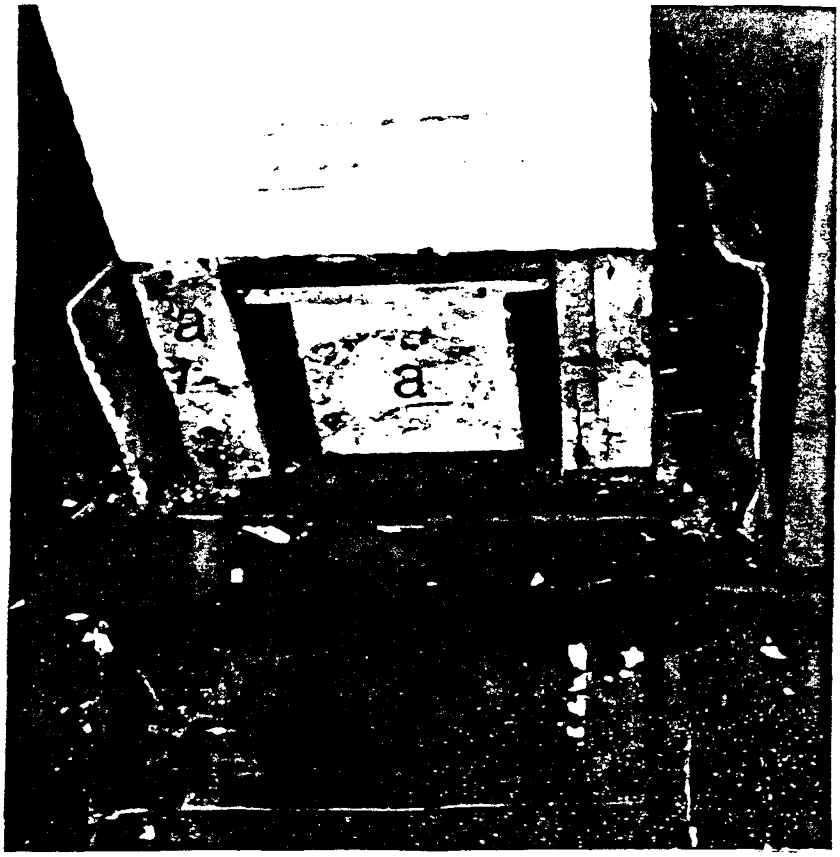


ILLUSTRATION 30. OLD STATE HOUSE: WHITMORE HALL, SECOND COLUMN FROM WEST, SOUTH SIDE, 1977.

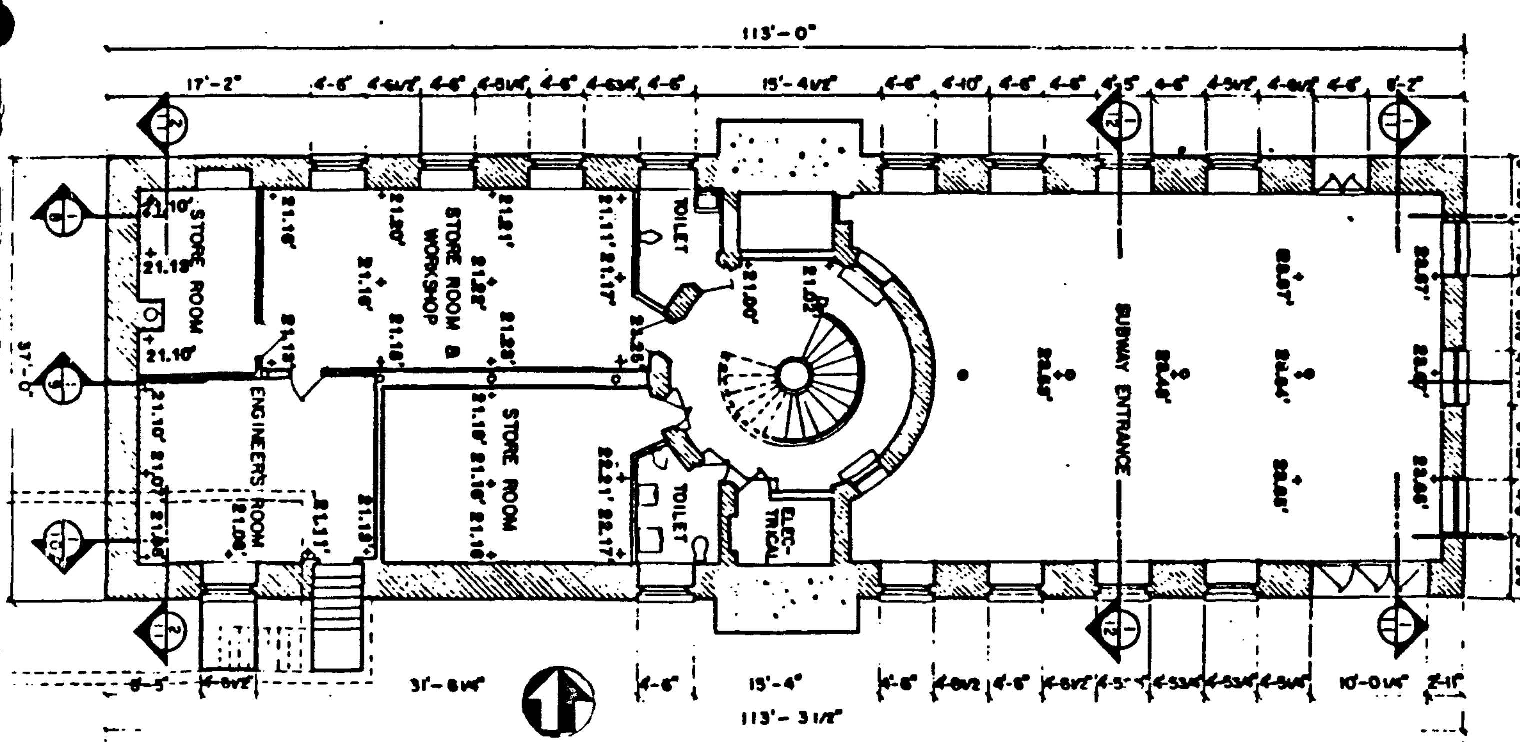


ILLUSTRATION 31. OLD STATE HOUSE: VARYING ELEVATIONS AT BASEMENT FLOOR, 1987.

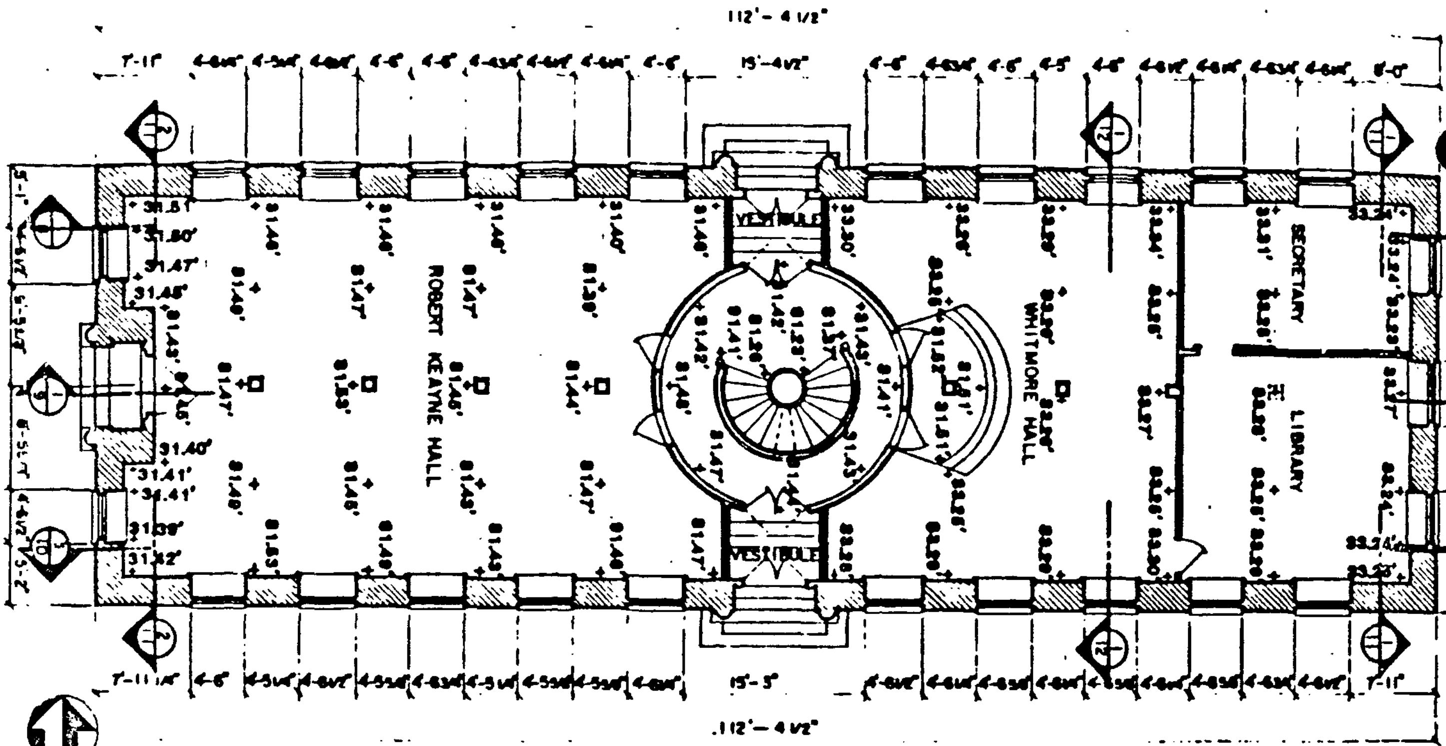


ILLUSTRATION 32. OLD STATE HOUSE: VARYING ELEVATIONS AT FIRST FLOOR, 1987.

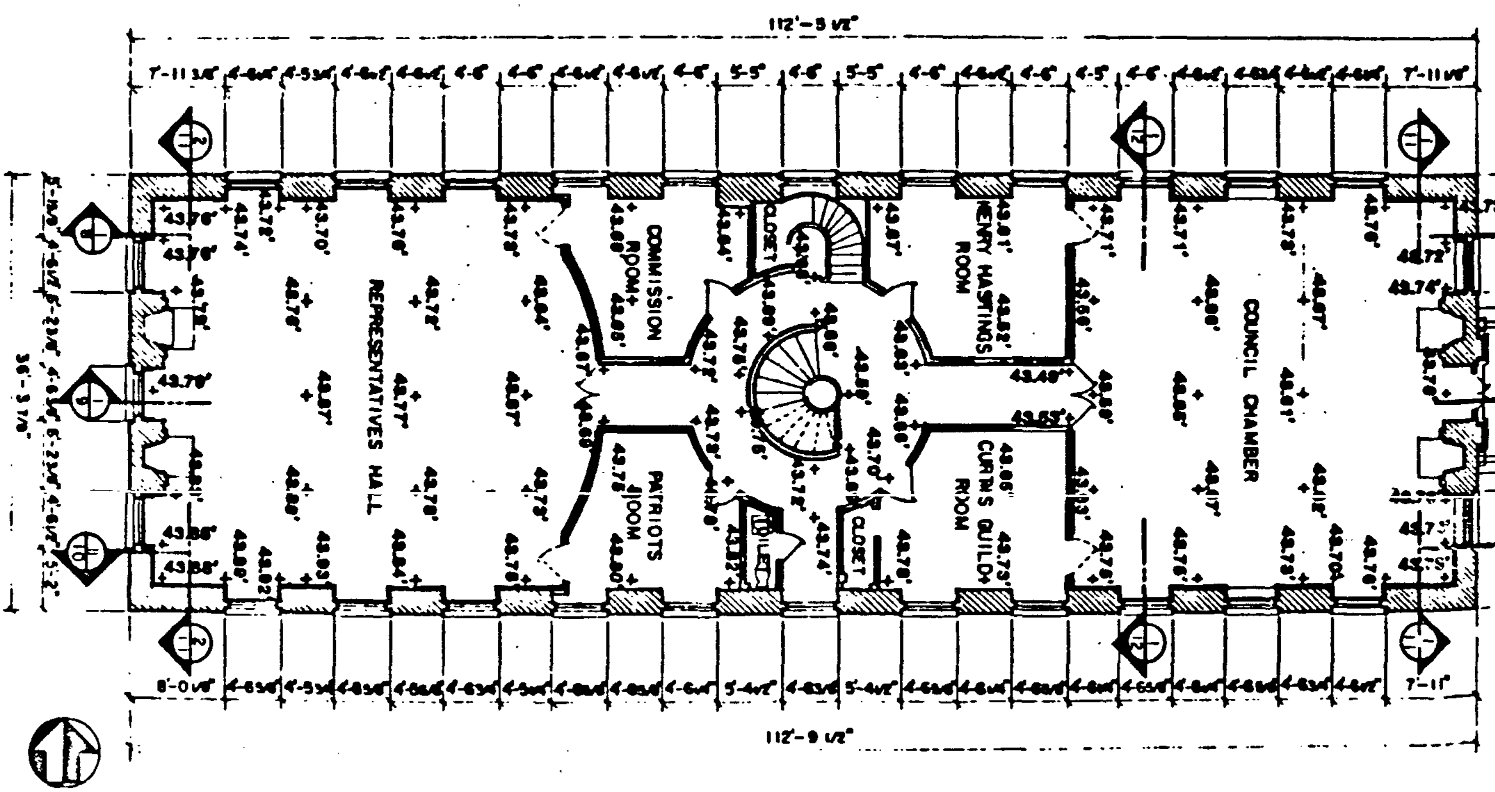


ILLUSTRATION 33. OLD STATE HOUSE: VARYING ELEVATIONS AT SECOND FLOOR, 1987.

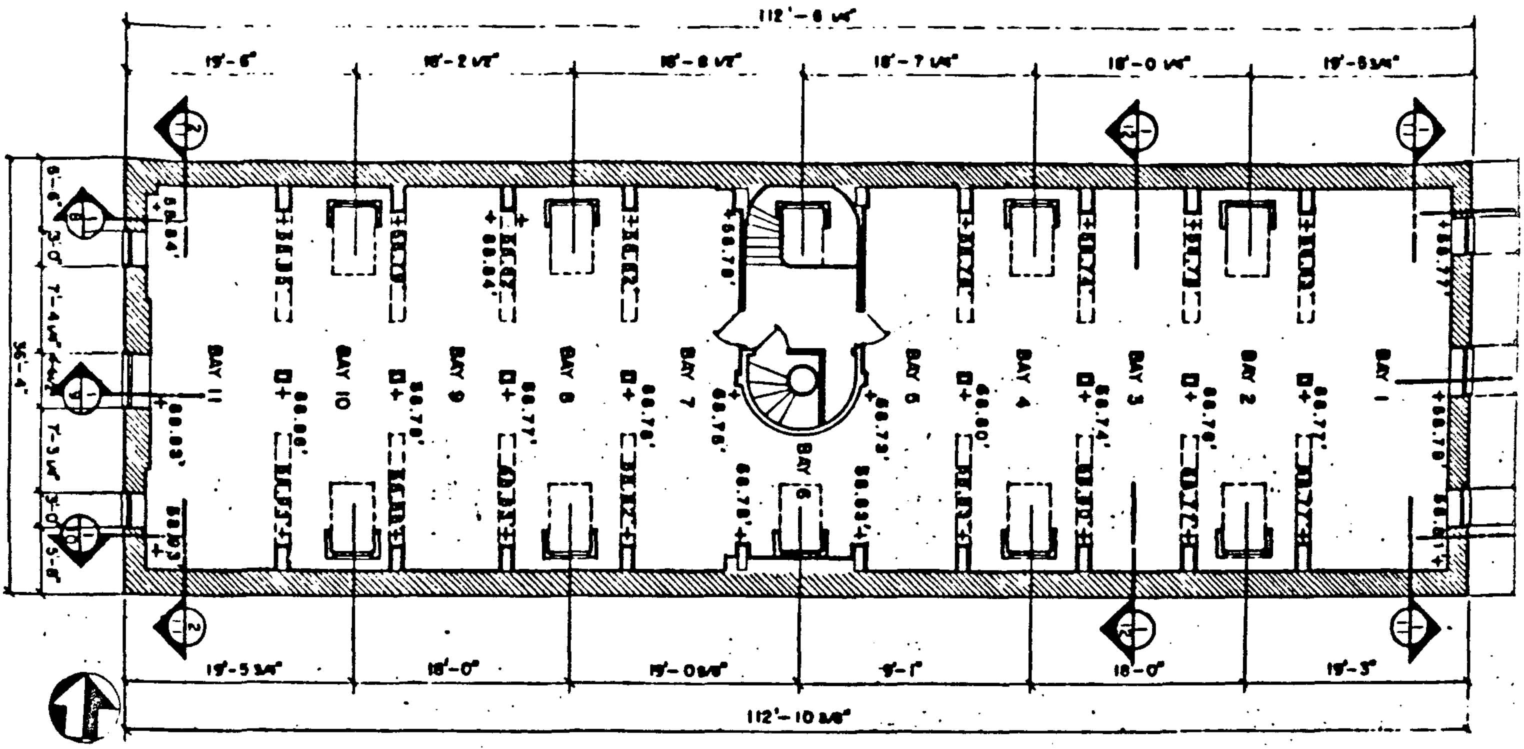


ILLUSTRATION 34. OLD STATE HOUSE: VARYING ELEVATIONS AT ATTIC FLOOR, 1987.

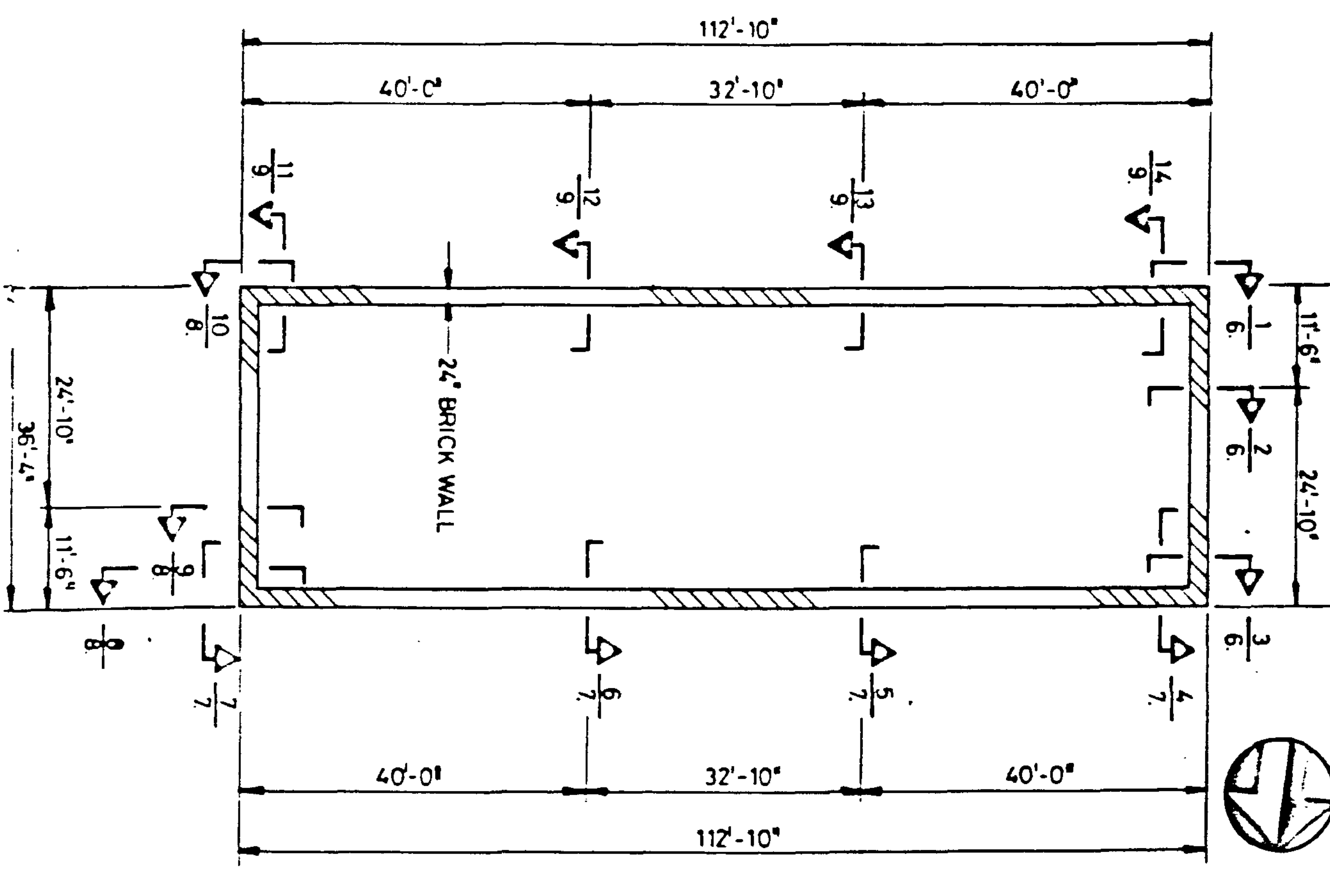


ILLUSTRATION 35. OLD STATE HOUSE: BASIC BUILDING PLAN, 1987.

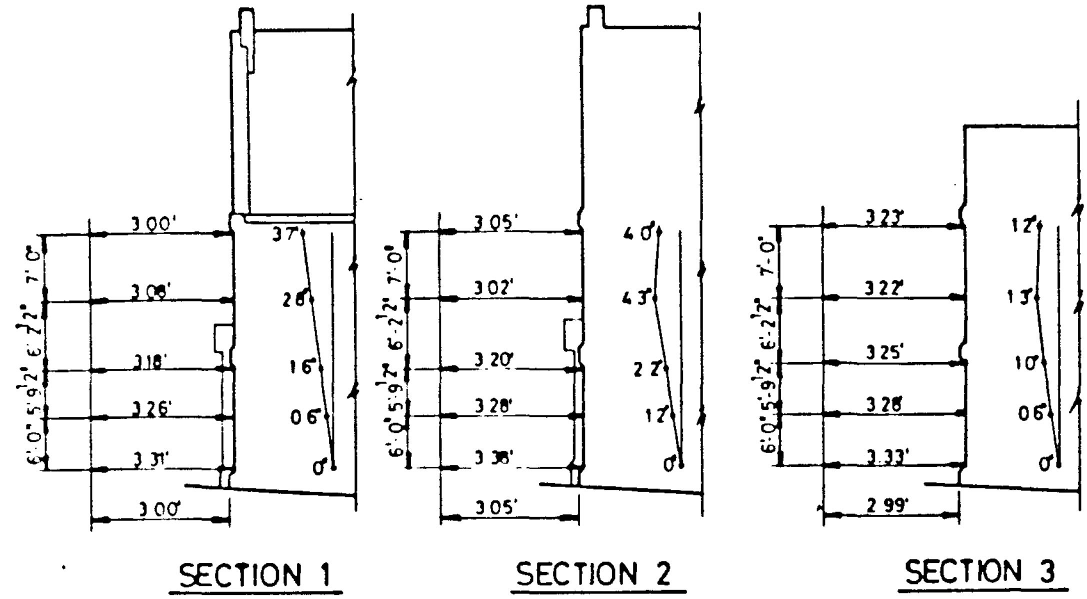


ILLUSTRATION 36. OLD STATE HOUSE: DIMENSIONS AT POSITIONS ALONG WEST WALL, 1987.

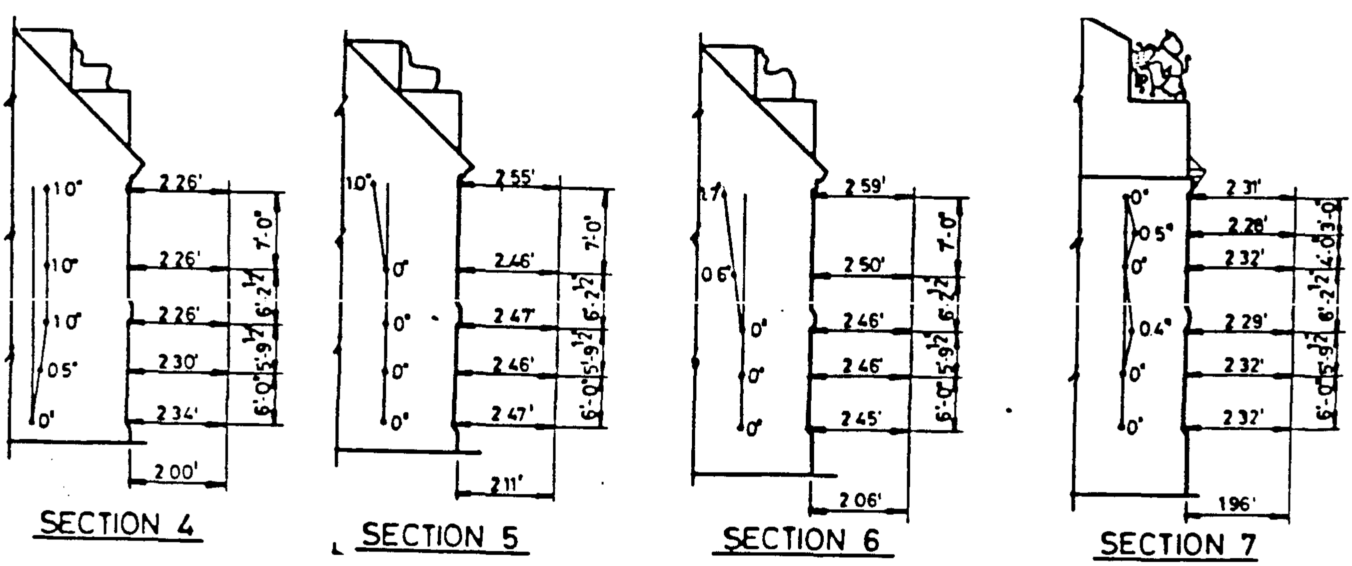


ILLUSTRATION 37. OLD STATE HOUSE: DIMENSIONS AT POSITIONS ALONG NORTH WALL, 1987.

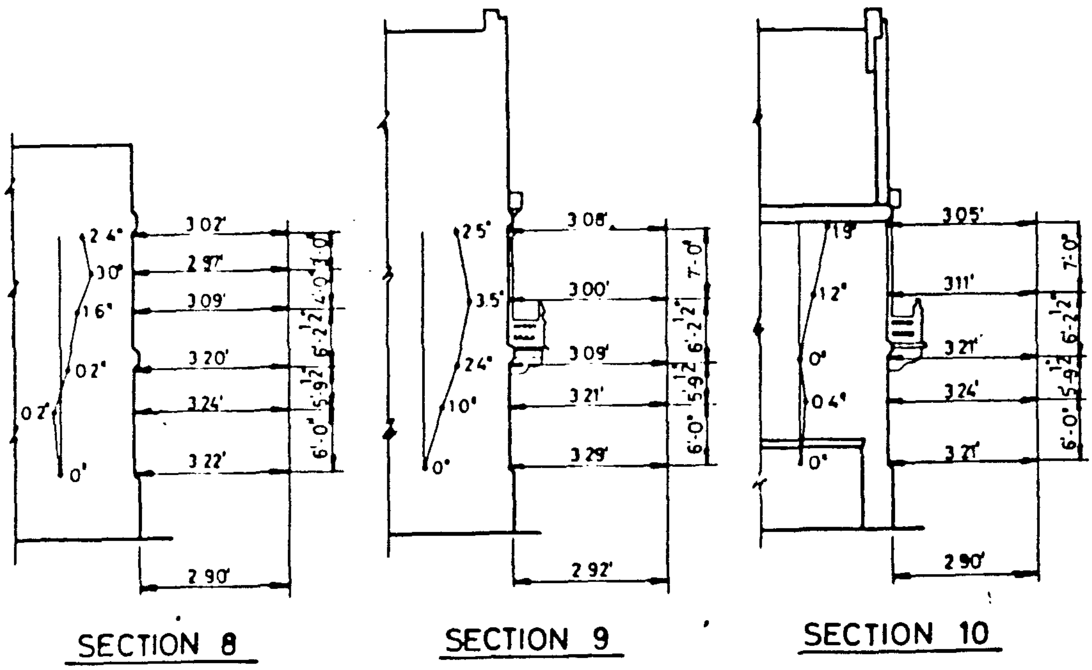


ILLUSTRATION 38. OLD STATE HOUSE: DIMENSIONS AT POSITIONS ALONG EAST WALL, 1987.

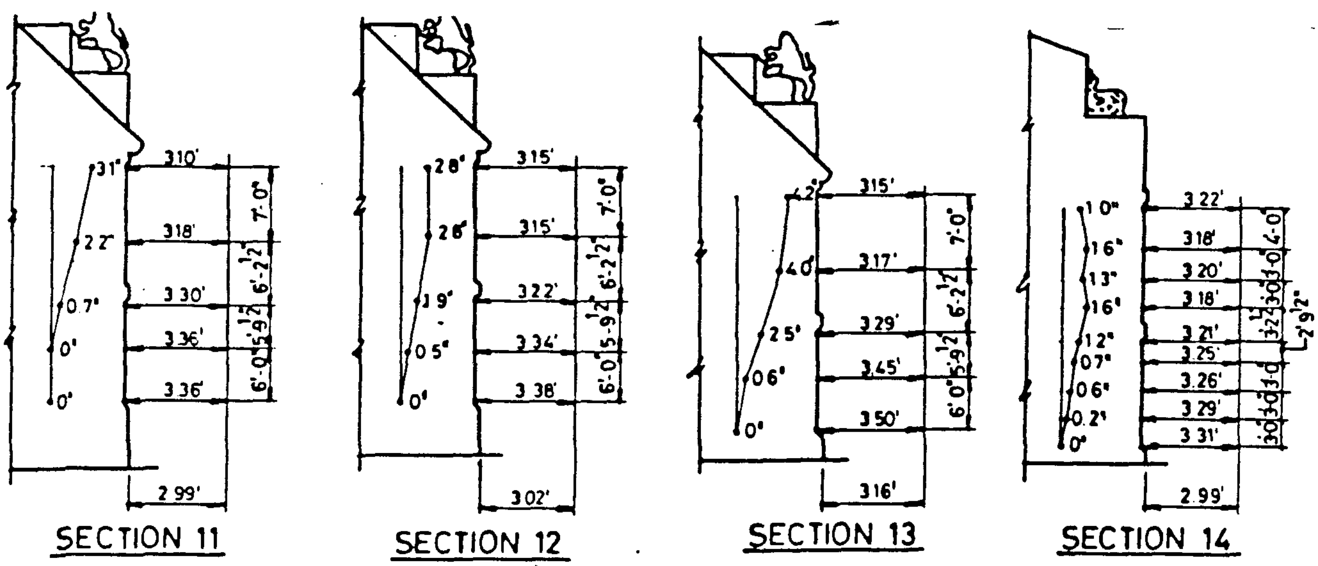


ILLUSTRATION 39. OLD STATE HOUSE: DIMENSIONS AT POSITIONS ALONG SOUTH WALL, 1987.

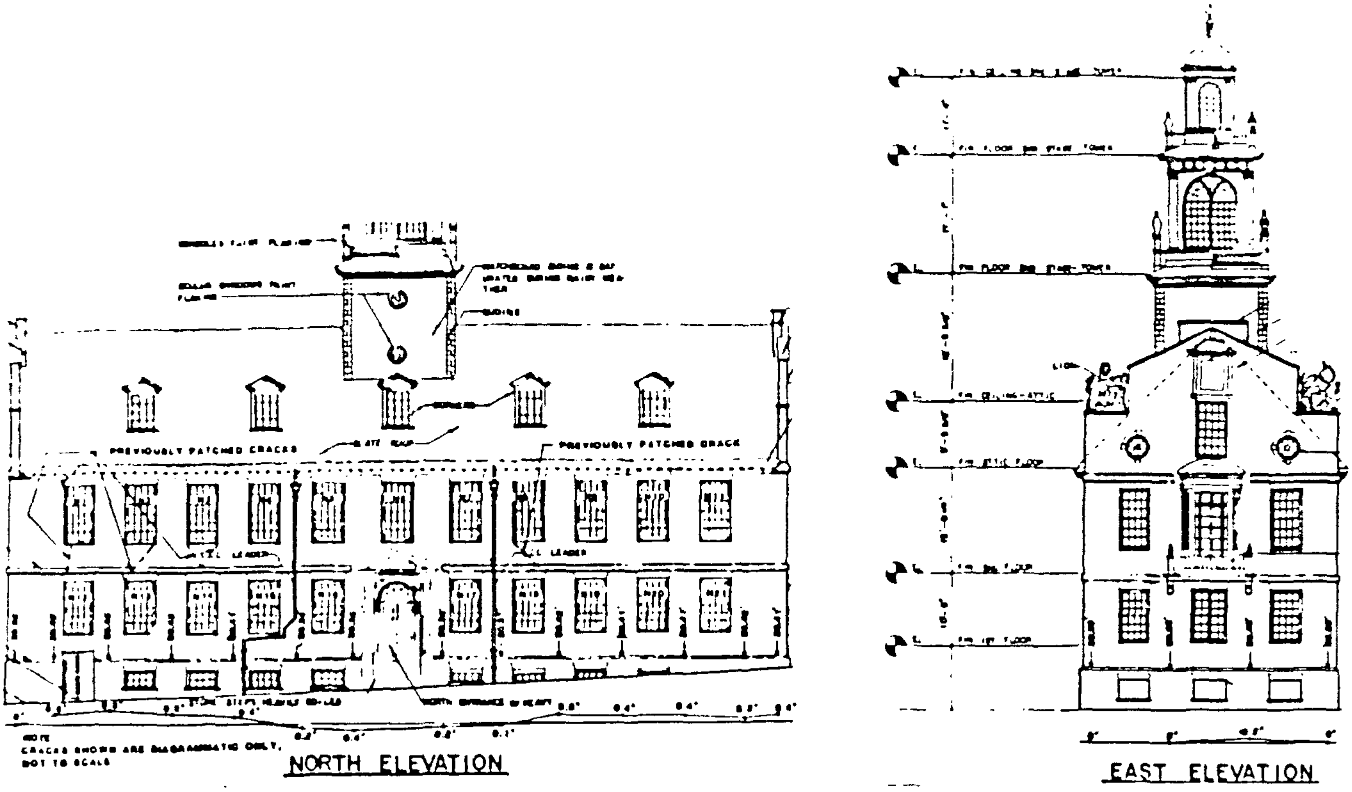


ILLUSTRATION 40. OLD STATE HOUSE: ELEVATIONS AT WATER TABLE RELATIVE TO THEIR DIFFERENCES IN INCHES, 1987.

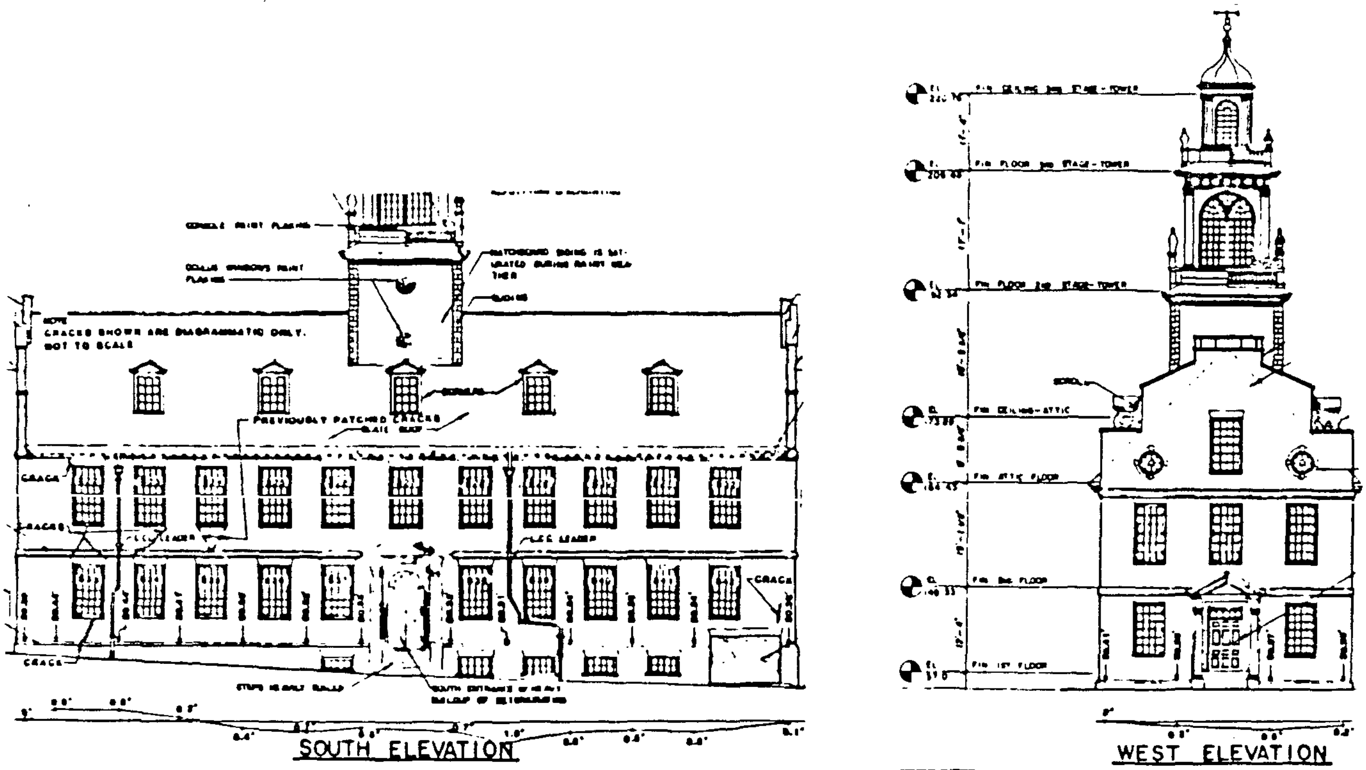


ILLUSTRATION 41. OLD STATE HOUSE: ELEVATIONS AT WATER TABLE RELATIVE TO THEIR DIFFERENCES IN INCHES, 1987.

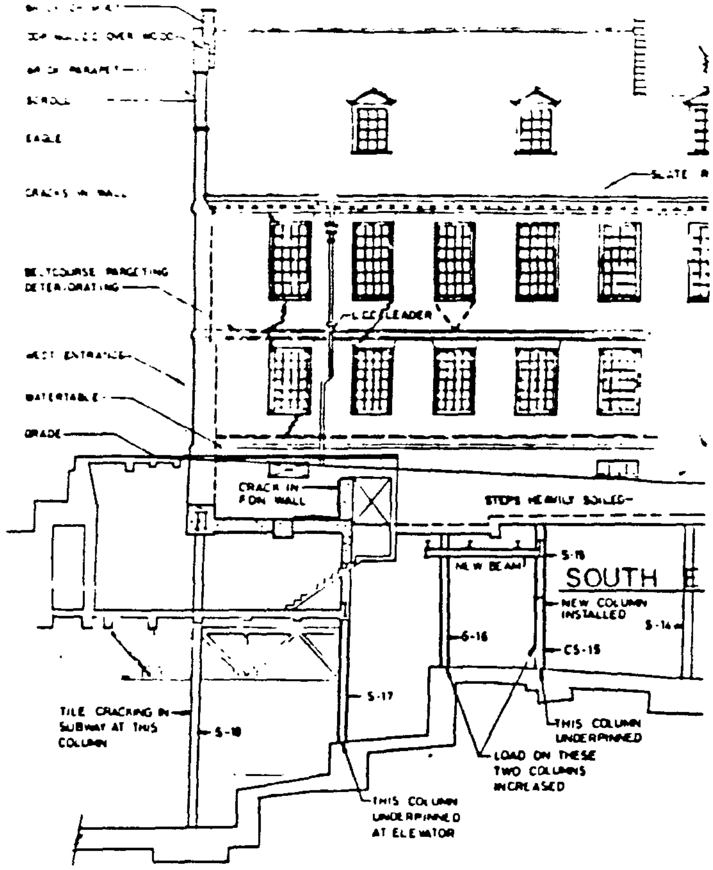


ILLUSTRATION 42. OLD STATE HOUSE: ELEVATION ON SOUTHWEST CORNER SHOWING 1976 STATION RENOVATIONS, 1987.

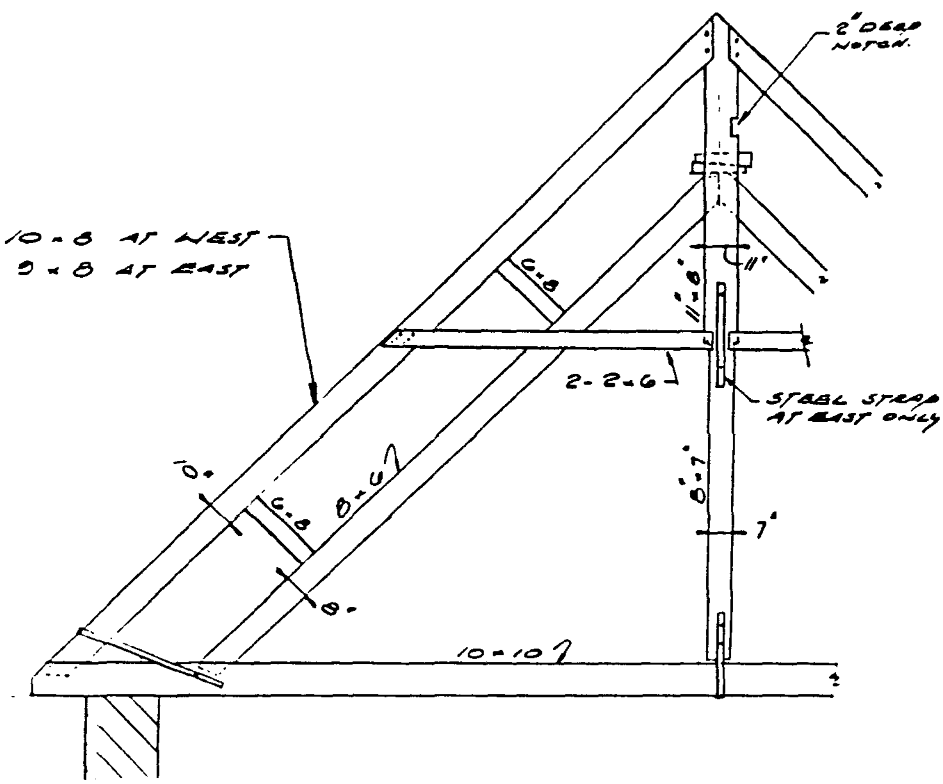


ILLUSTRATION 43. OLD STATE HOUSE: EXISTING CONDITIONS AT TYPICAL ROOF TRUSS, 1987.

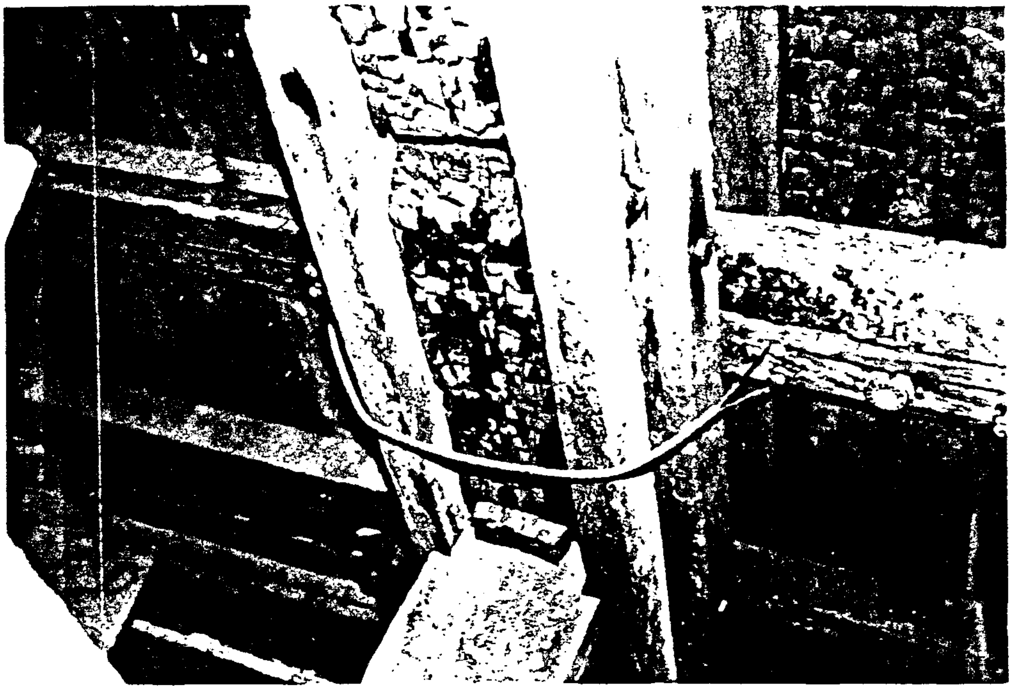


ILLUSTRATION 44. OLD STATE HOUSE: REINFORCED UPPER CHORD OF TRUSS, 1987.

ILLUSTRATION 45. OLD STATE HOUSE: TRUSS BEARING AT EAVES, 1987.

ILLUSTRATION 46. OLD STATE HOUSE: NOTCH IN TRUSS KING POST, 1987.

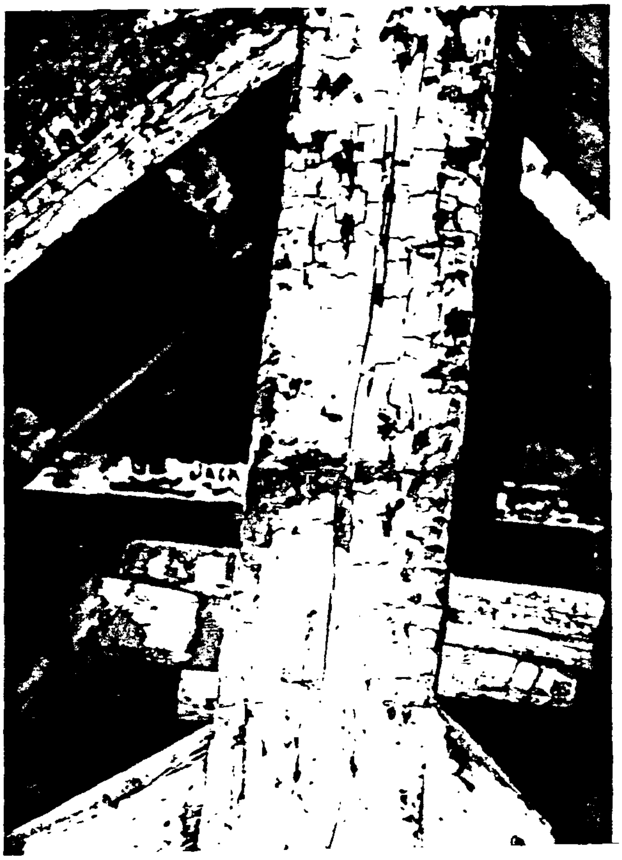


ILLUSTRATION 47. OLD STATE HOUSE: WOODEN WEDGES AT TRUSS KING POST, 1987.

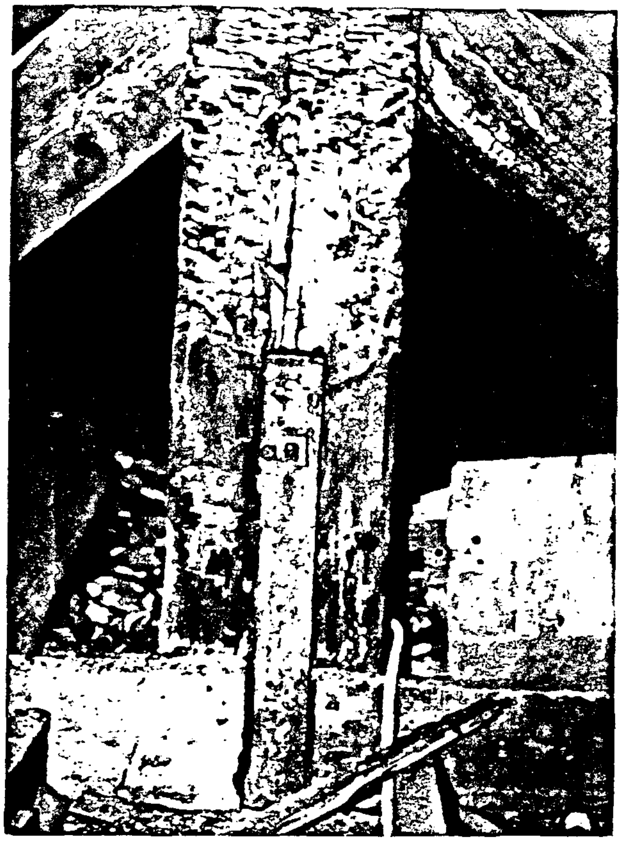


ILLUSTRATION 48. OLD STATE HOUSE: STEEL STRAP AT ATTIC CEILING, 1987.

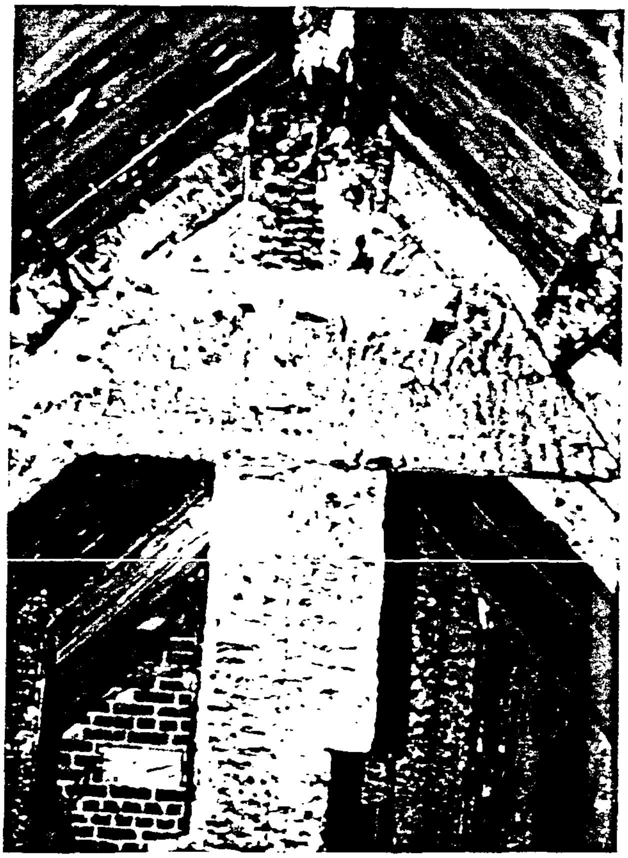


ILLUSTRATION 49. OLD STATE HOUSE: FIRE DAMAGE AT ROOF TRUSS, 1987.

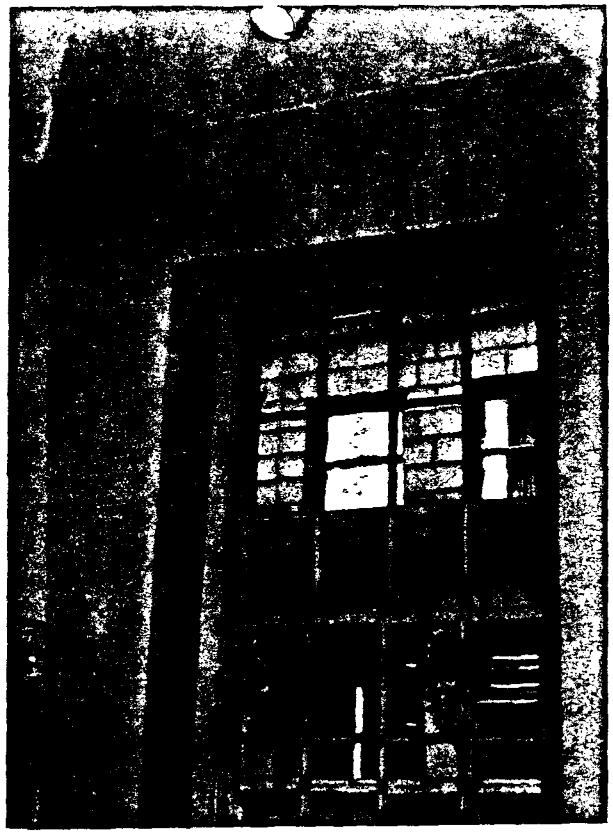


ILLUSTRATION 50. OLD STATE HOUSE: CRACKS IN PLASTER IN PATRIOT'S ROOM, 1987.

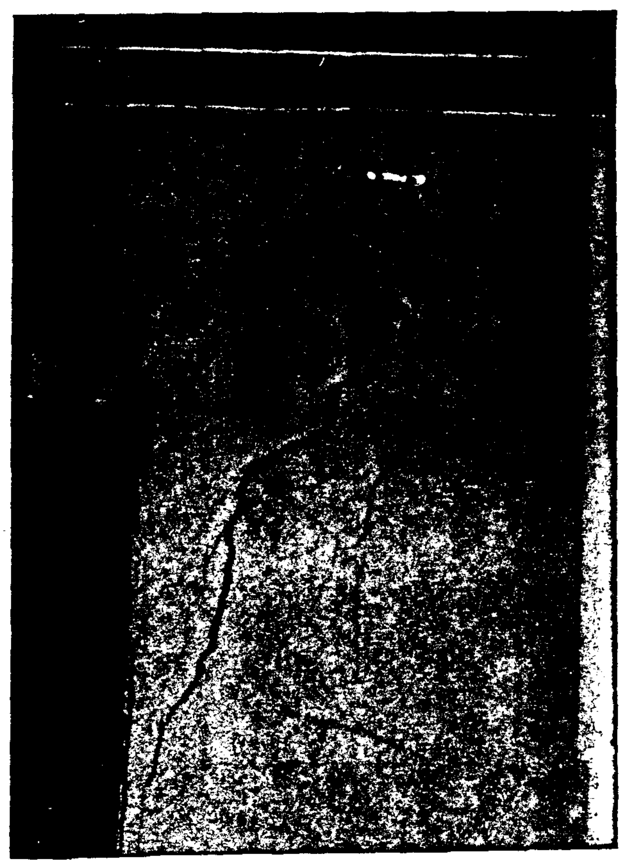


ILLUSTRATION 51. OLD STATE HOUSE: CRACKS IN PLASTER AT NORTH WALL NEAR NORTHEAST CORNER AT SECOND FLOOR, 1987.

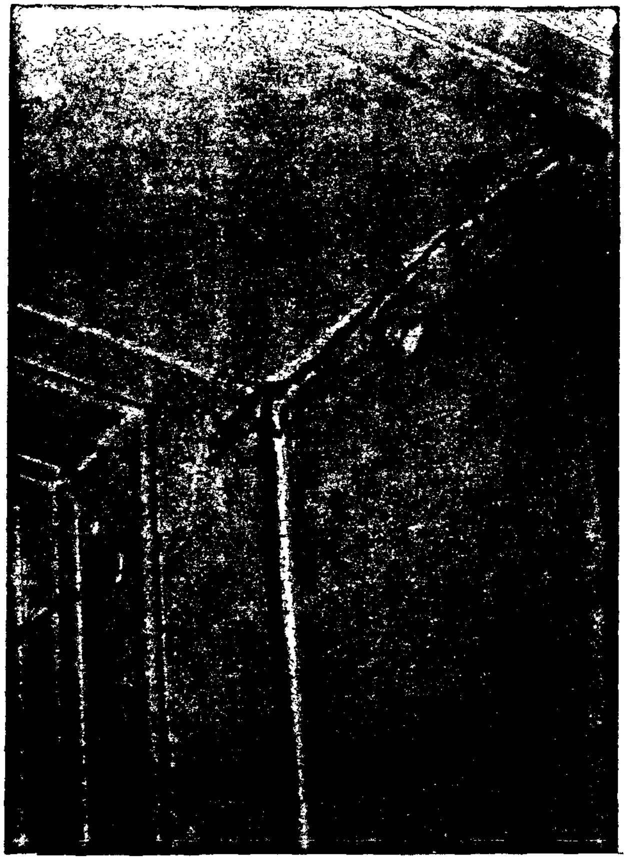


ILLUSTRATION 52. OLD STATE HOUSE: CRACK IN PLASTER AT SOUTH WALL NEAR SOUTHWEST CORNER, 1987.

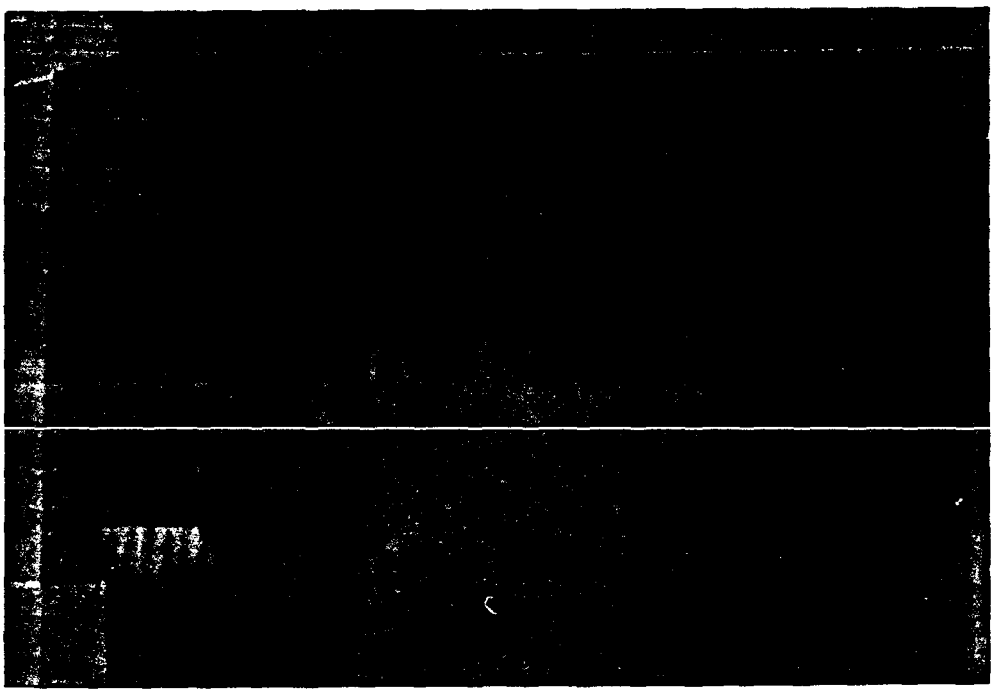


ILLUSTRATION 53. OLD STATE HOUSE: CRACK IN PLASTER AT SOUTH WALL NEAR SOUTHWEST CORNER, 1987.

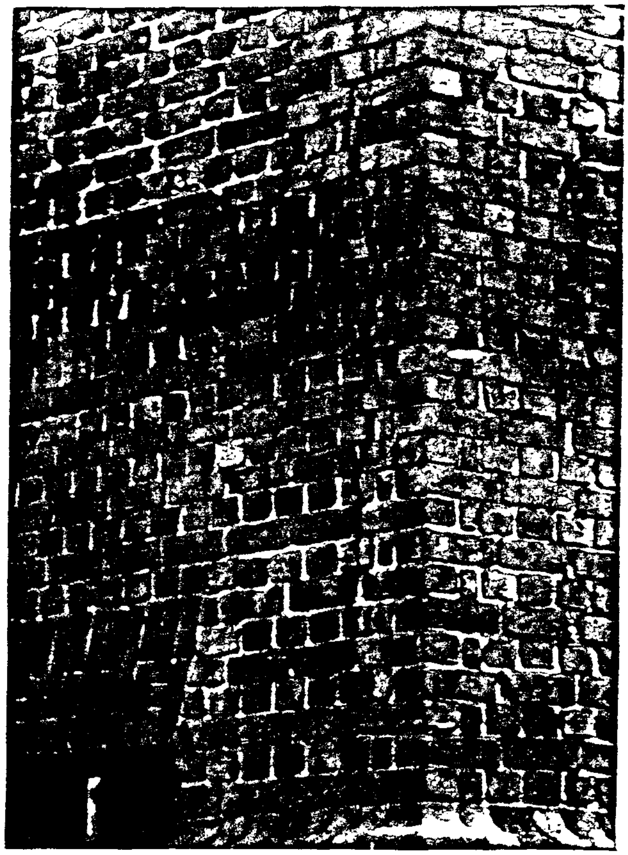


ILLUSTRATION 54. OLD STATE HOUSE: CRACK IN SOUTH WALL AT SOUTHWEST CORNER, 1987.

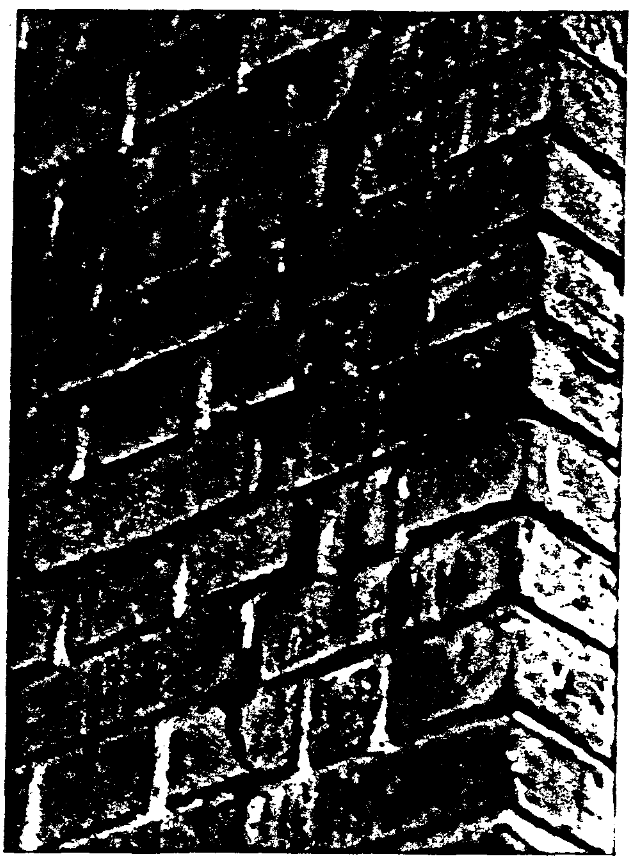


ILLUSTRATION 55. OLD STATE HOUSE: DETAIL OF CRACK SHOWN IN ILLUSTRATION 54, 1987.

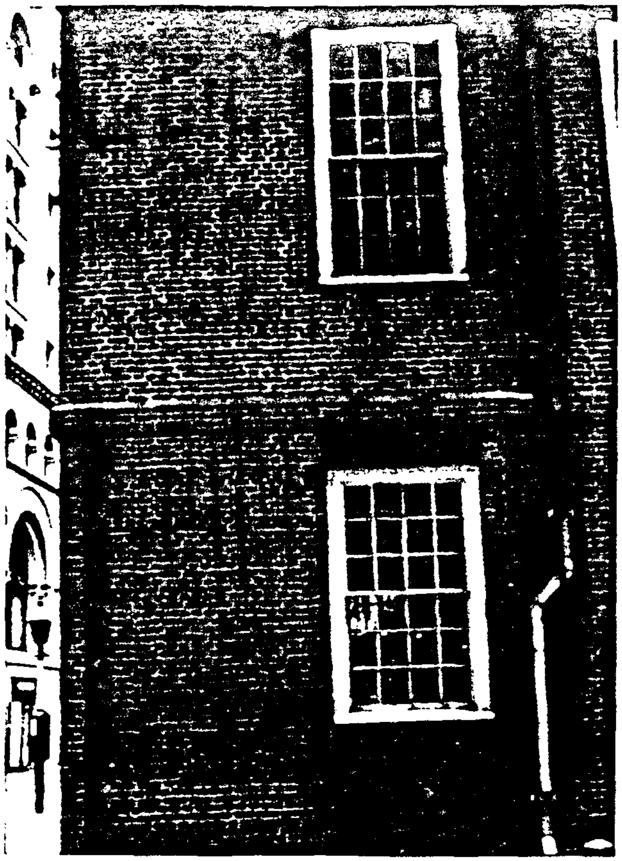


ILLUSTRATION 56. OLD STATE HOUSE: CRACK IN SOUTH WALL AT SOUTHWEST CORNER, 1987.

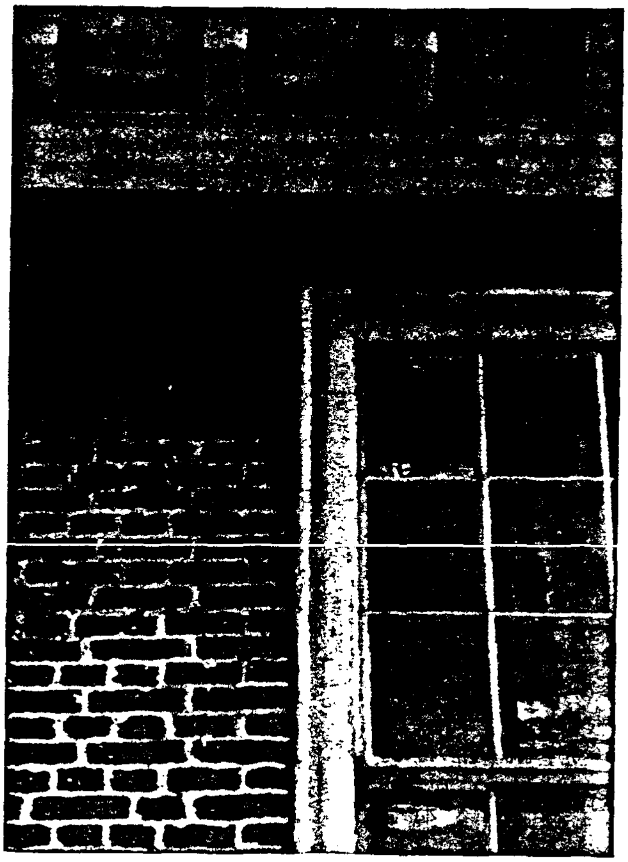


ILLUSTRATION 57. OLD STATE HOUSE: DETAIL OF ILLUSTRATION 56 SHOWING CRACK ABOVE SECOND-FLOOR WINDOW, 1987.

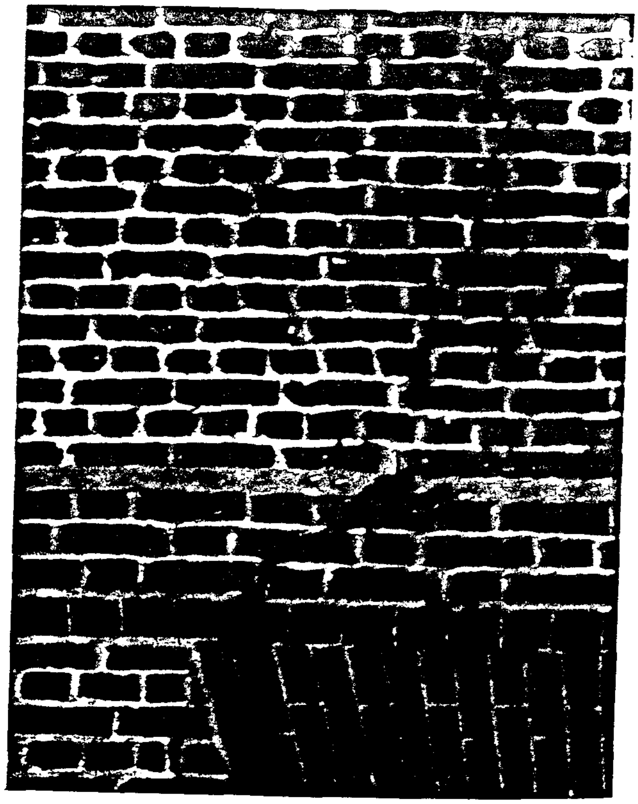


ILLUSTRATION 58. OLD STATE HOUSE: DETAIL OF ILLUSTRATION 56 SHOWING CRACK OVER FIRST-FLOOR WINDOW, 1987.

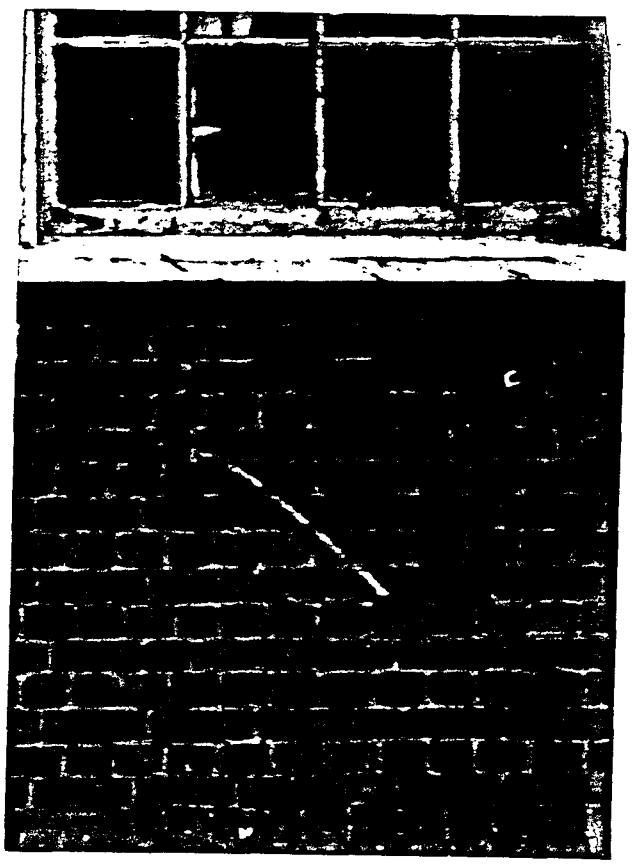


ILLUSTRATION 59. OLD STATE HOUSE: DETAIL OF ILLUSTRATION 56 SHOWING CRACK UNDER FIRST-FLOOR WINDOW, 1987.

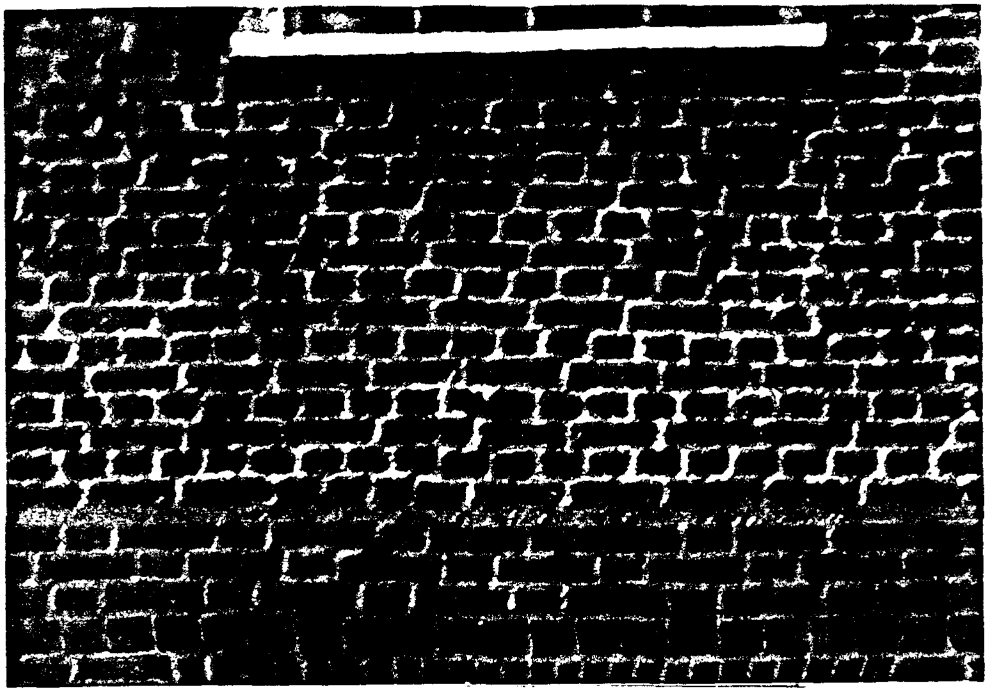


ILLUSTRATION 60. OLD STATE HOUSE: DETAIL OF ILLUSTRATION 56 SHOWING CRACK UNDER SECOND-FLOOR WINDOW, 1987.

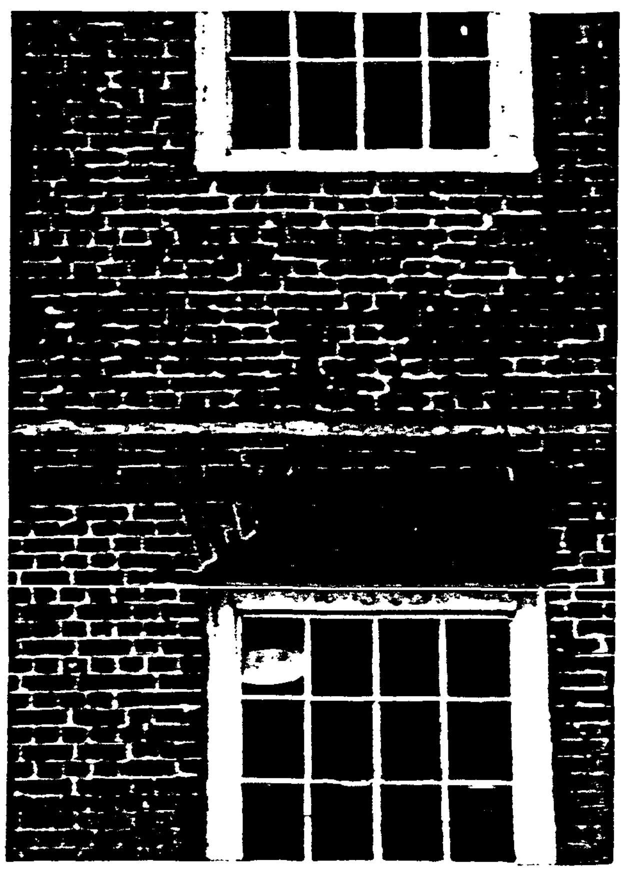


ILLUSTRATION 61. OLD STATE HOUSE: PATCHED CRACK IN NORTH WALL NEAR NORTHEAST CORNER, 1987.

ILLUSTRATION 62. OLD STATE HOUSE: CRACK IN SUBWAY WALL UNDER SOUTHWEST CORNER, 1987.

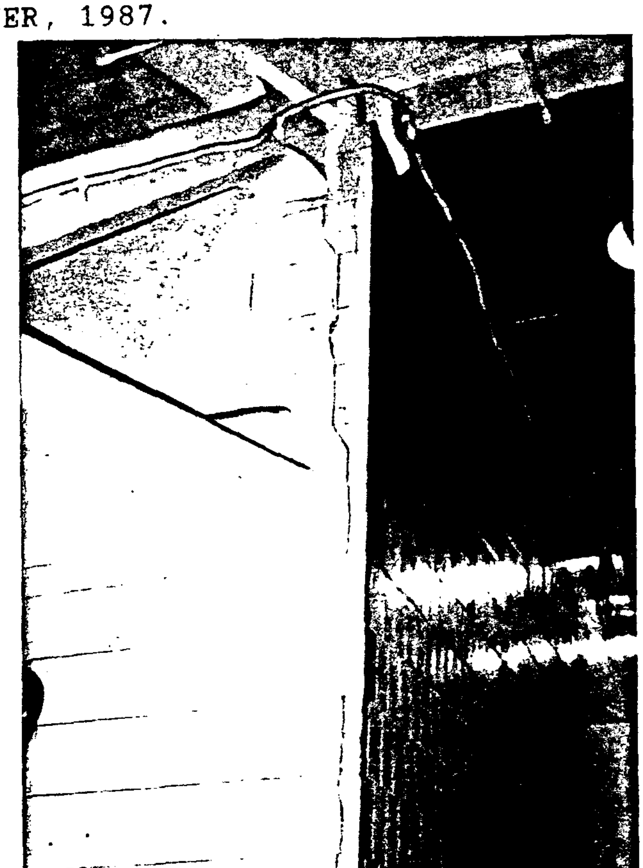
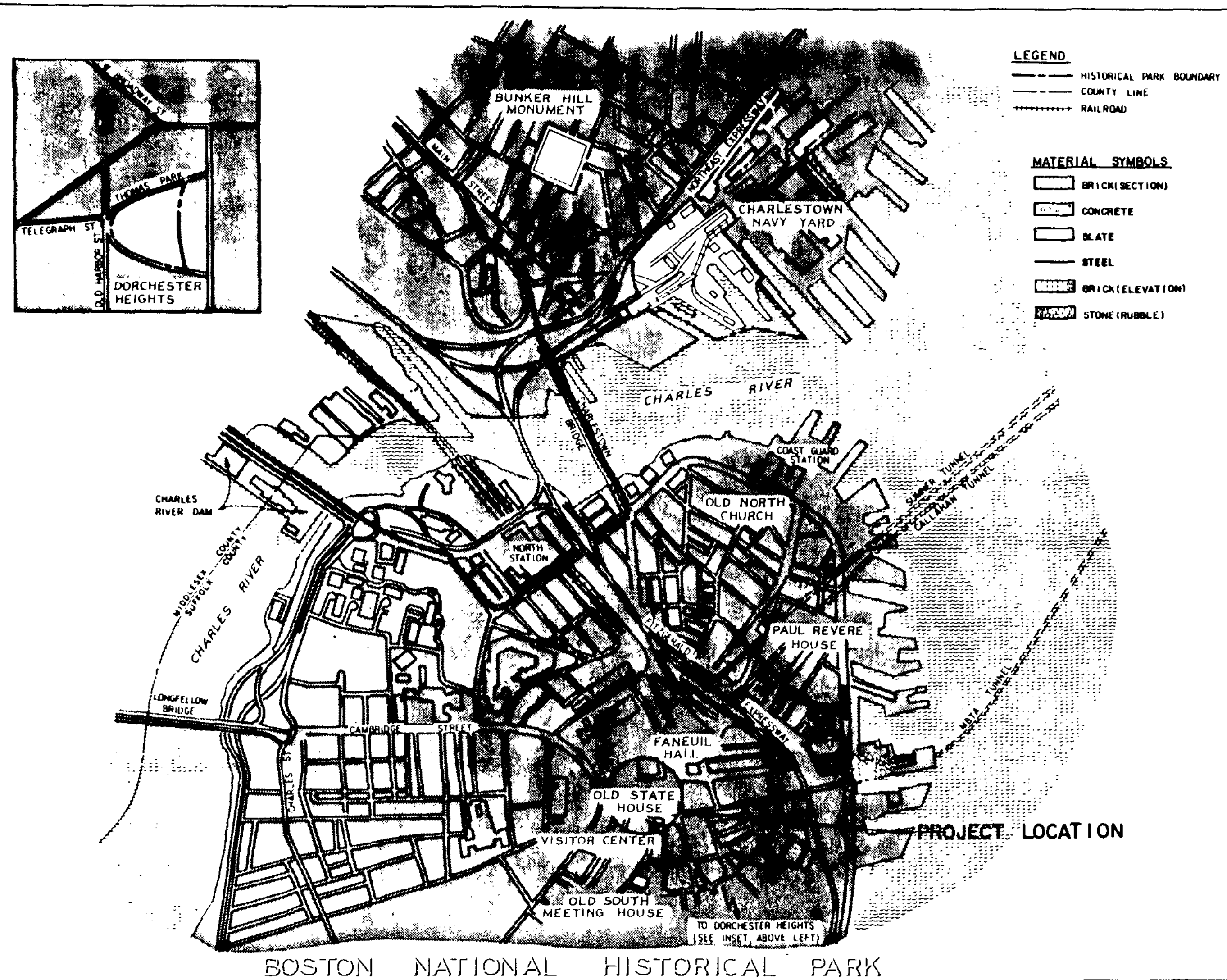
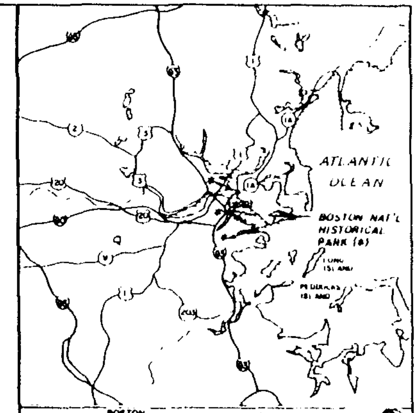


ILLUSTRATION 63. OLD STATE HOUSE: UPPER PART OF WALL SHOWN IN ILLUSTRATION 62, 1987.



BOSTON NATIONAL HISTORICAL PARK



DRAWING INDEX

SHT NO	SUB-SHT NO	TITLE
1		COVER SHEET
		CIVIL
2	C-1	SITE PLAN
3	C-2	FOUNDATION PLAN
		ARCHITECTURAL
4	A-1	FLOOR PLANS
5	A-2	ROOF AND TOWER PLANS
6	A-3	ELEVATIONS (SOUTH AND EAST)
7	A-4	ELEVATIONS (NORTH AND WEST)
8	A-5	SECTION AND DETAILS (LOOKING NORTH)
9	A-6	SECTION AND DETAILS (LOOKING NORTH)
10	A-7	SECTION AND DETAILS (LOOKING SOUTH)
11	A-8	SECTIONS (LOOKING EAST AND WEST)
12	A-9	SECTION AND DETAILS (AT TRUSSES)
13	A-10	WINDOW SCHEDULE
14	A-11	DOOR SCHEDULE
15	A-12	MOLDING PROFILES
16	A-13	MOLDING PROFILES
		STRUCTURAL
17	S-1	FRAMING PLANS (FLOORS AND ROOF)
		MECHANICAL
18	M-1	HEATING PLANS
19	M-2	PLUMBING PLANS
		ELECTRICAL
20	E-1	LIGHTING PLANS
21	E-2	FIRE AND INTRUSION

SCALE OF FEET 500 0 500 1000

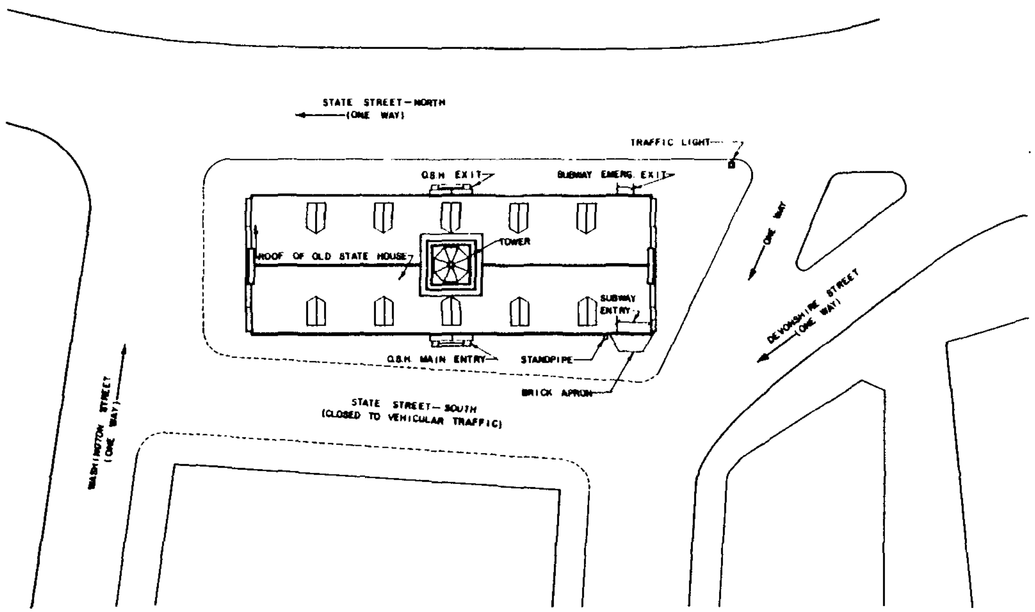
150 0 150 300 SCALE OF METERS

HISTORIC STRUCTURE REPORT DRAWINGS	DESIGNED	TITLE OF DRAWING: EXISTING CONDITIONS	DRAWING NO 457 25,025
UNITED STATES DEPARTMENT OF THE INTERIOR	DRAWN CZ DRAFTING BR	LOCATION WITHIN PARK: OLD STATE HOUSE - 206 WASHINGTON STREET	PKG NO 134
NATIONAL PARK SERVICE DENVER SERVICE CENTER	TECH REVIEW H. LAFLEUR	NAME OF PARK: BOSTON NATIONAL HISTORICAL PARK	SHEET 1
	DATE 3/88	REGION: NORTH ATLANTIC; COUNTY: SUFFOLK; STATE: MASSACHUSETTS	OF 21

BASIC DATA DWG NO 457/82,000A SHT 1 OF 6, COVER REVISED AND REDRAWN 11/84

HSR DRAWINGS, EXISTING CONDITIONS, SHEET 2

182b



SITE PLAN

SCALE 1/16"=1'-0"

DESIGNED EXISTING DRAWN J. MARSH TECH. REVIEW H. LAFLEUR DATE 3/88	SUB SHEET NO C-1	TITLE OF SHEET SITE PLAN EXISTING CONDITIONS-OLD STATE HOUSE	DRAWING NO 437/28,028 PKG NO 132 SHEET 2 OF 21

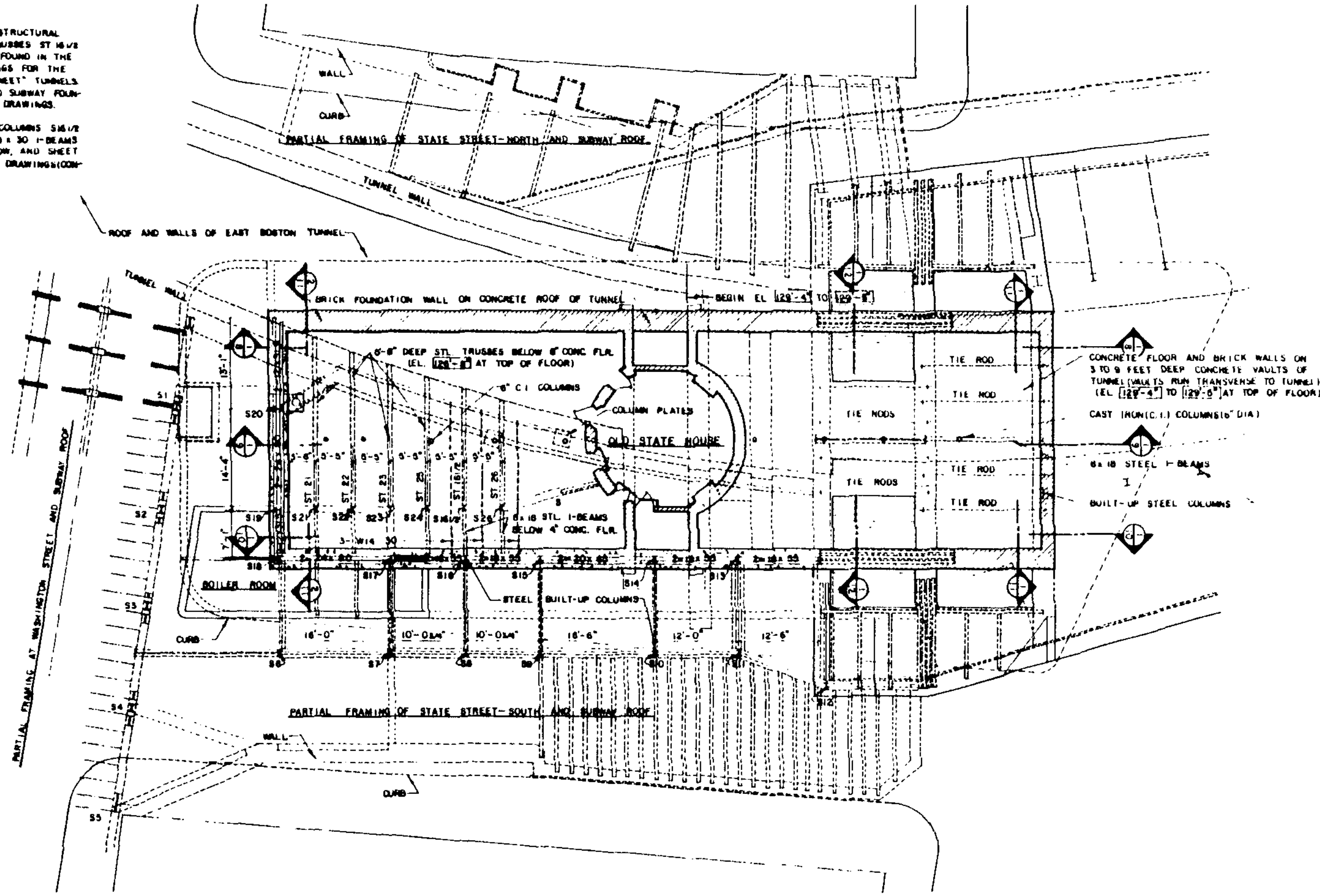
HSR DRAWINGS, EXISTING CONDITIONS, SHEET 3

182c

GENERAL NOTES

1. DETAILS AND SCHEDULES FOR ALL "STRUCTURAL FRAMING" (COLUMNS S1 THRU S26, TRUSSES ST 16 1/2 THRU ST 26, I-BEAMS, ETC.) CAN BE FOUND IN THE 1902 TO 1907 CONSTRUCTION DRAWINGS FOR THE "EAST BOSTON" AND "WASHINGTON STREET" TUNNELS. OTHER SUPPORTS FOR BUILDING AND SUBWAY FOUNDATIONS ARE ALSO FOUND IN THESE DRAWINGS.

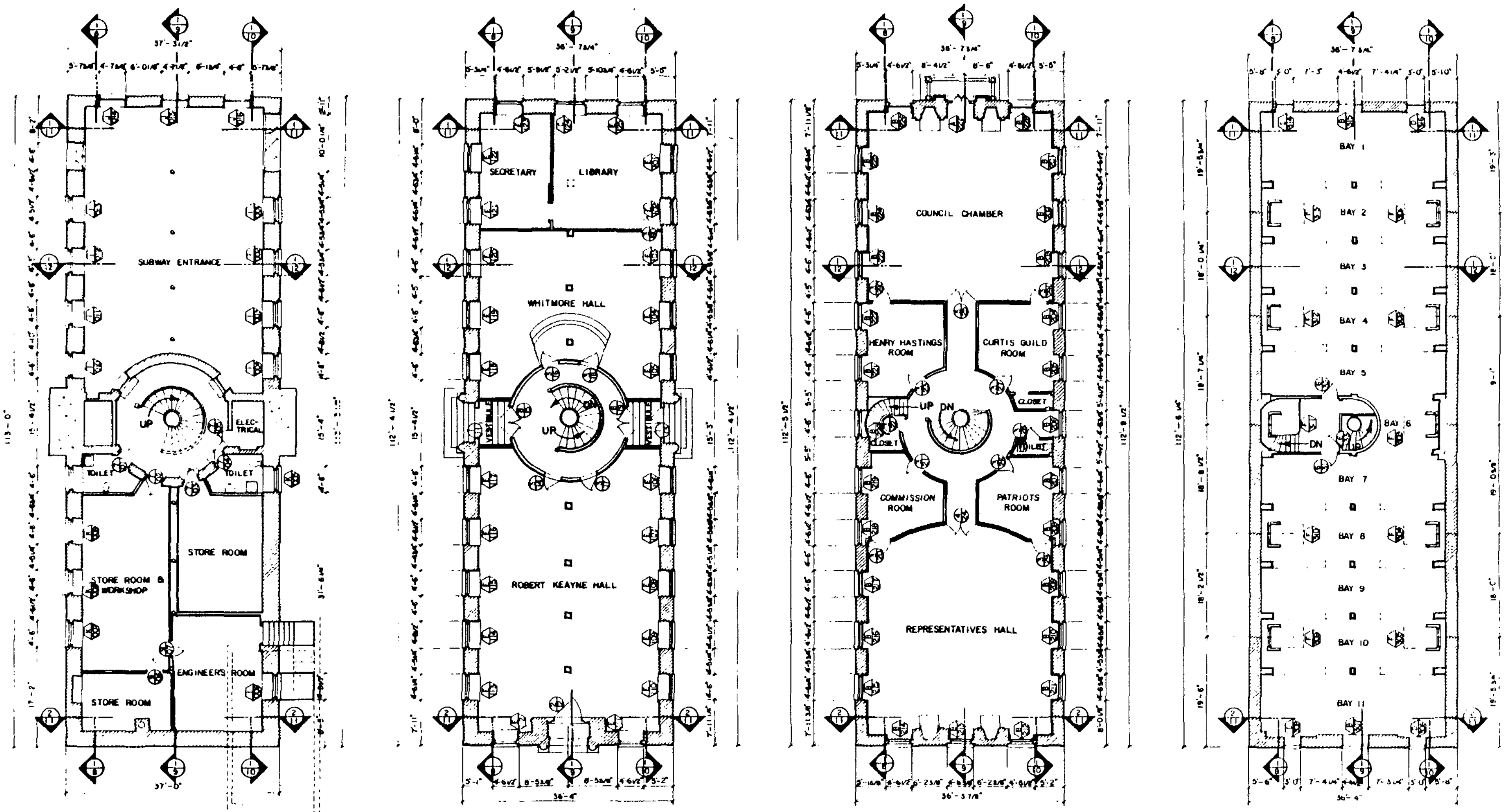
2. TRUSSES ST 16 1/2 AND ST 26, AND COLUMNS S16 1/2 AND S26 WERE REPLACED BY 3- W14 x 30 I-BEAMS IN 1976. SEE FOUNDATION PLAN BELOW, AND SHEET S3, STATE STREET MODERNIZATION DRAWINGS (CONTRACT NO. SM-530) FOR DETAILS.



FOUNDATION PLAN AND ADJACENT SUBWAY ROOF AND FRAMING

SCALE 1/8" = 1'-0"

DESIGNED	SUB SHEET NO	TITLE OF SHEET	DRAWING NO
EXISTING	C-2	FOUNDATION PLAN EXISTING CONDITIONS—OLD STATE HOUSE	427 25,025
DRAWN: J. MARSH			PAG NO 1.26
TECH REVIEW: H. LAFLEUR			SHEET 3 OF 21
DATE: 3/88			



BASEMENT FLOOR PLAN

FIRST FLOOR PLAN

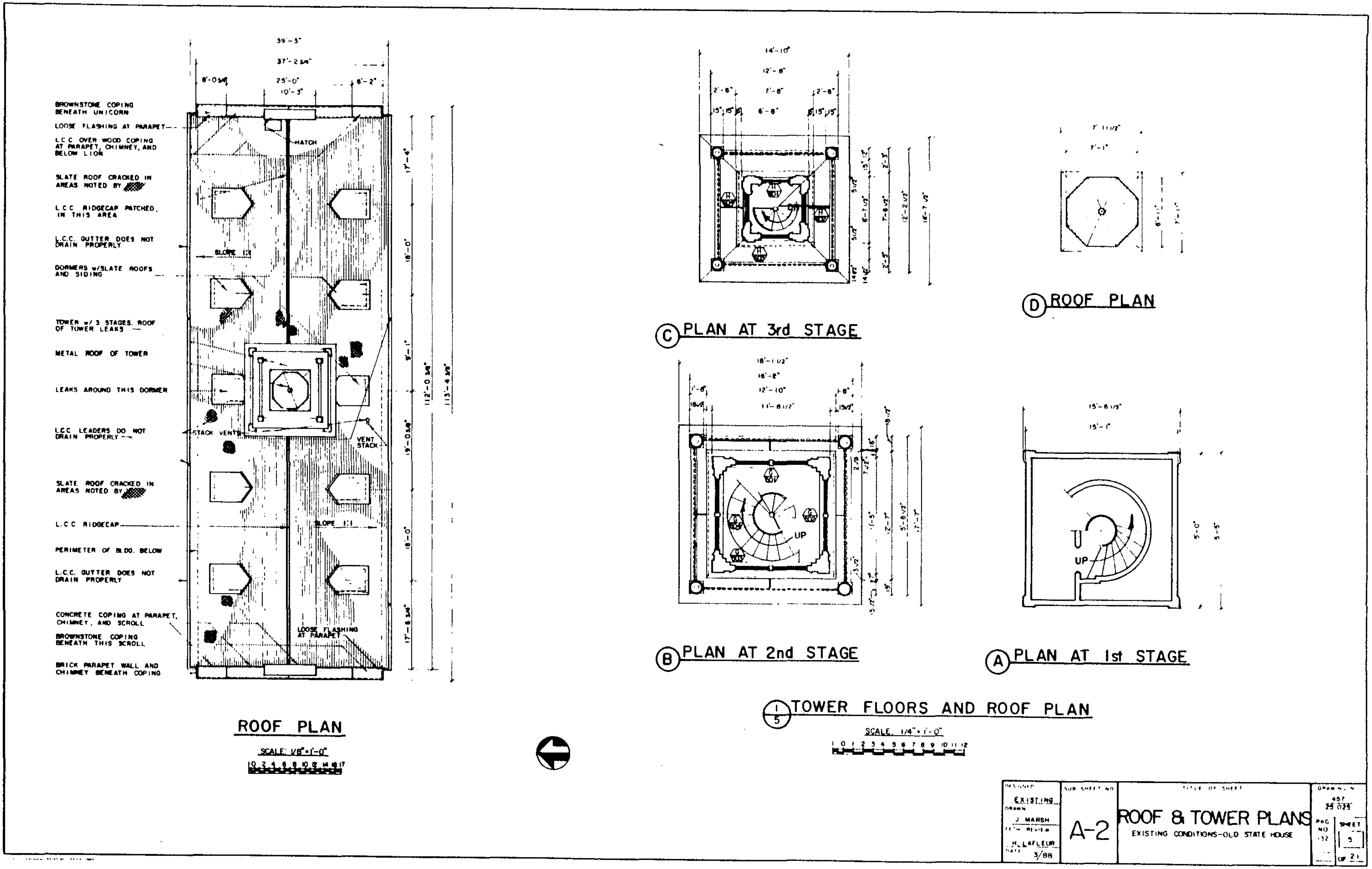
SECOND FLOOR PLAN

ATTIC FLOOR PLAN

DESIGNED: EXISTING DRAWN: J. MARSH TECH REVIEW: H. LAFLEUR DATE: 3/88	SUB SHEET NO: A-1	TITLE OF SHEET: FLOOR PLANS EXISTING CONDITIONS-OLD STATE HOUSE	DRAWING NO: 437 25,025 PKG NO: 132 SHEET 4 OF 21

HSR DRAWINGS, EXISTING CONDITIONS, SHEET 5

182e



HSR DRAWINGS, EXISTING CONDITIONS, SHEET 6

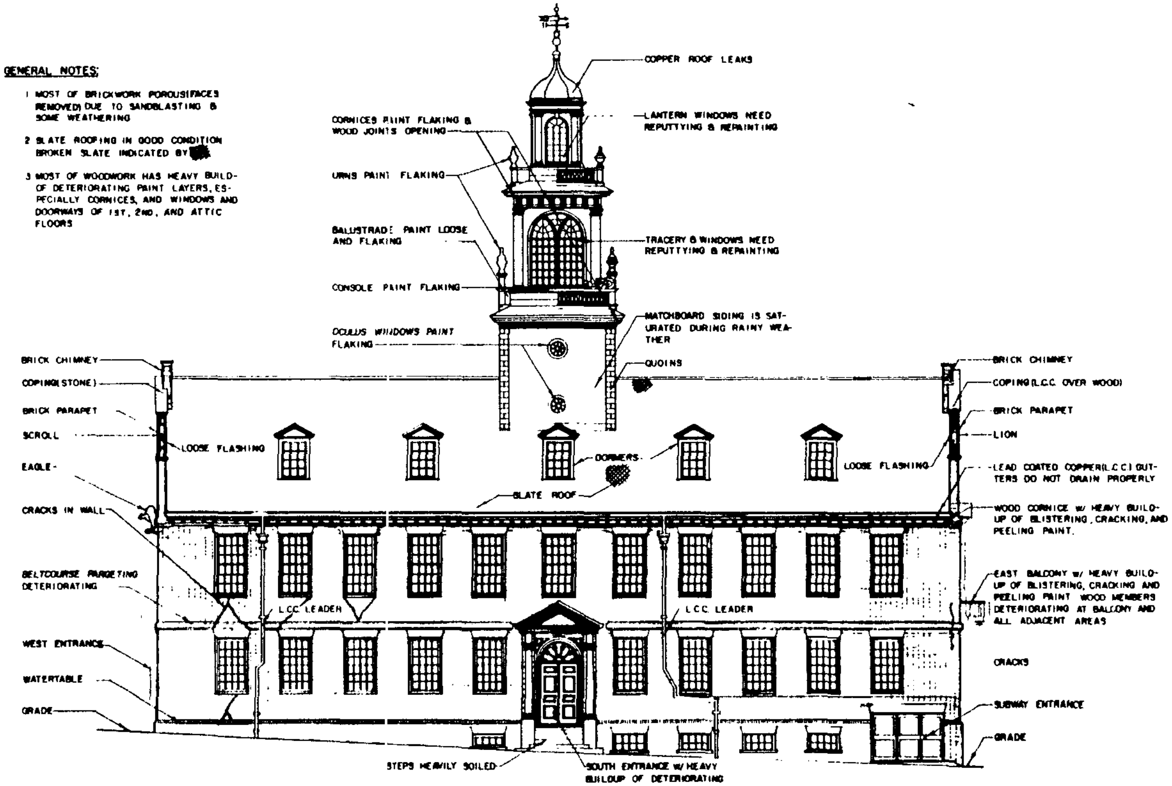
182f

GENERAL NOTES:

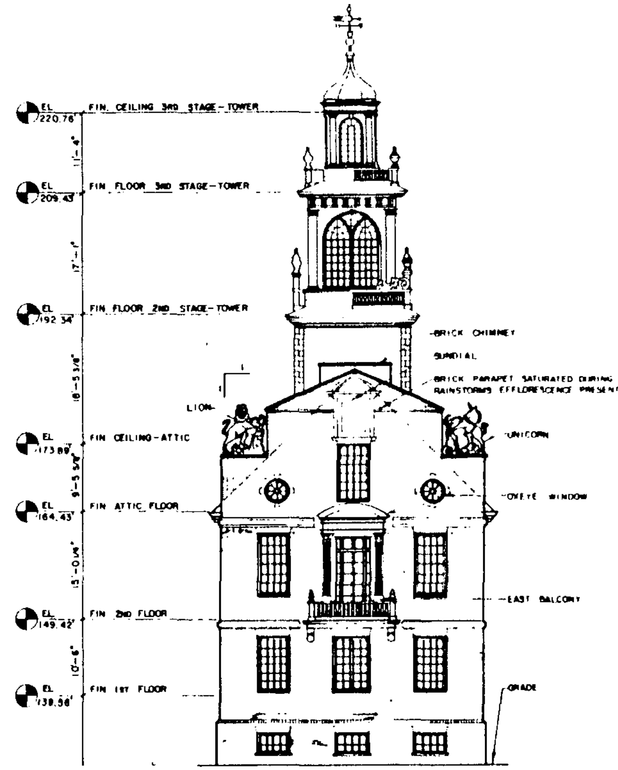
1 MOST OF BRICKWORK POROUS(FACES REMOVED) DUE TO SANDBLASTING & SOME WEATHERING

2 SLATE ROOFING IN GOOD CONDITION BROKEN SLATE INDICATED BY

3 MOST OF WOODWORK HAS HEAVY BUILD-OF DETERIORATING PAINT LAYERS, ESPECIALLY CORNICES, AND WINDOWS AND DOORWAYS OF 1ST, 2ND, AND ATTIC FLOORS



SOUTH ELEVATION



EAST ELEVATION

SCALE 1/8"=1'-0"

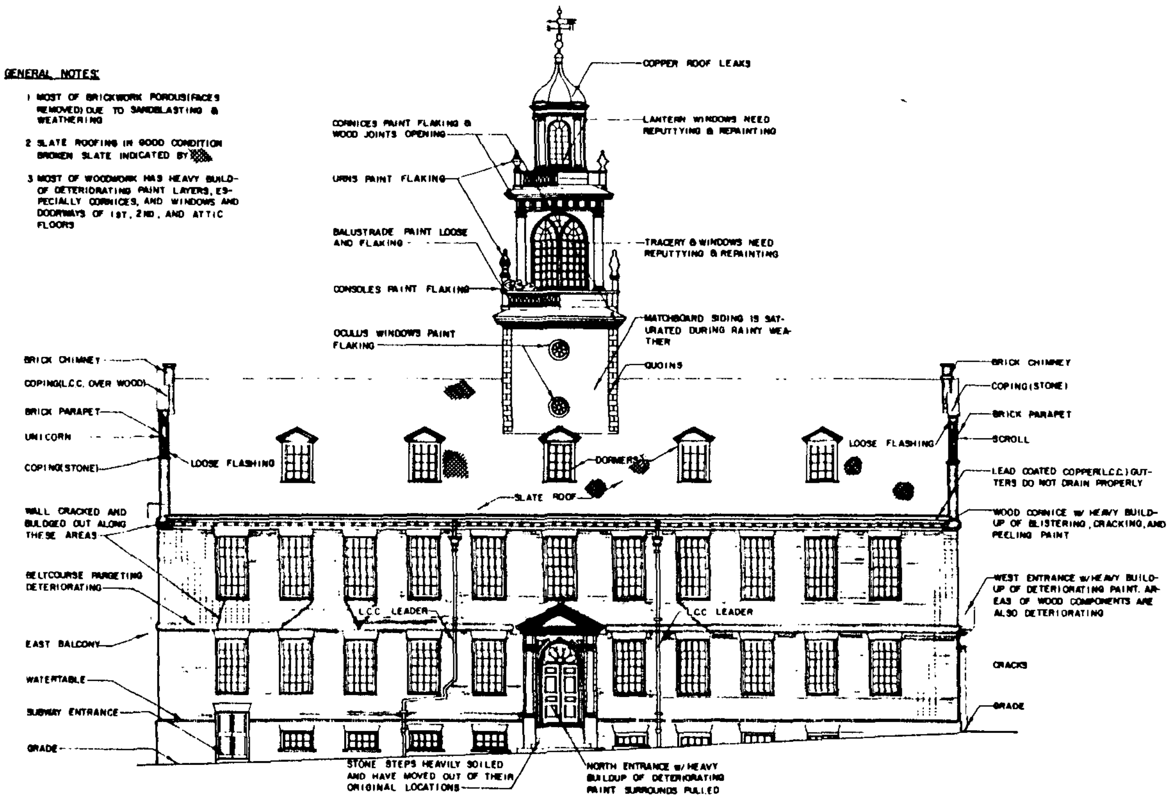
DESIGNED EXISTING DRAWN J. MARSH TECH. REVIEW H. LAFLEUR DATE 3/88	SUB SHEET NO. A-3	TITLE OF SHEET ELEVATIONS EXISTING CONDITIONS-OLD STATE HOUSE	437 25 025 PKG NO. 132 SHEET 6 OF 21

HSR DRAWINGS, EXISTING CONDITIONS, SHEET 7

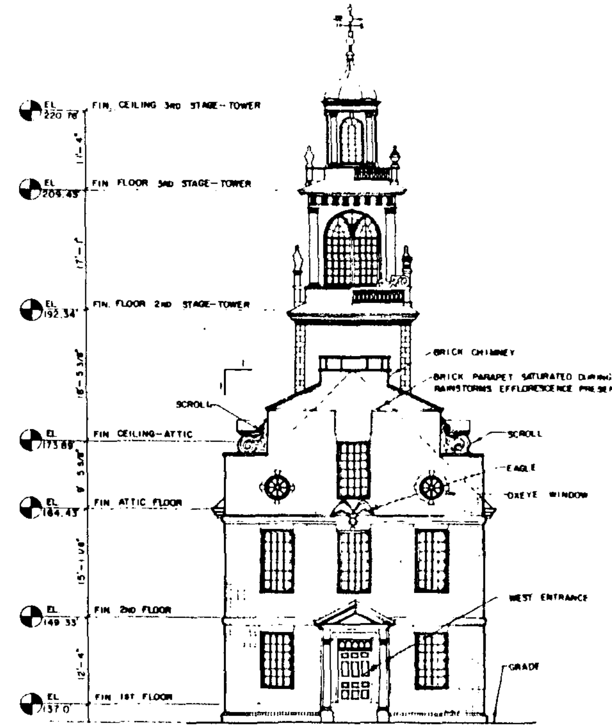
182g

GENERAL NOTES:

1 MOST OF BRICKWORK POROUS (FACES REMOVED) DUE TO SANDBLASTING & WEATHERING
2 SLATE ROOFING IN GOOD CONDITION BROKEN SLATE INDICATED BY
3 MOST OF WOODWORK HAS HEAVY BUILD-OF DETERIORATING PAINT LAYERS, ESPECIALLY CORNICES, AND WINDOWS AND DOORWAYS OF 1ST, 2ND, AND ATTIC FLOORS



NORTH ELEVATION



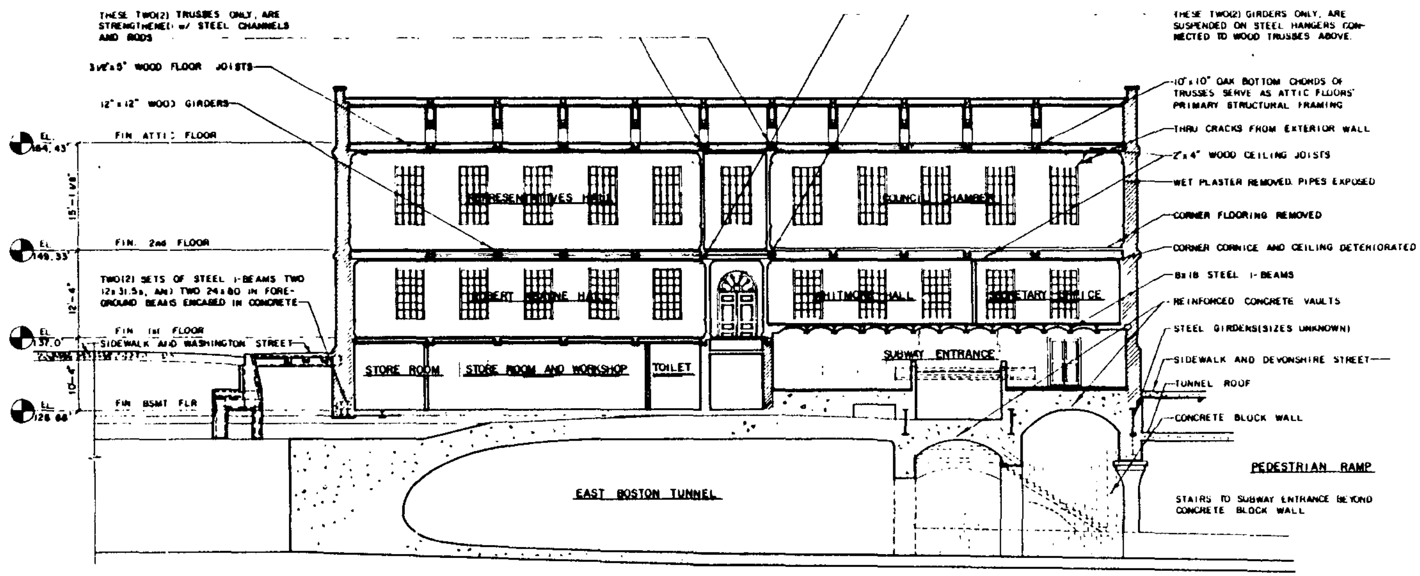
WEST ELEVATION

SCALE: 1/8"=1'-0"

DESIGNED EXISTING DRAWN J. MARSH TECH. REVIEW H. LAFLEUR DATE 3/88	SUB SHEET NO. A-4	TITLE OF SHEET: ELEVATIONS EXISTING CONDITIONS-OLD STATE HOUSE	457 35,025 PKG NO. 132 SHEET 7 OF 21

HSR DRAWINGS, EXISTING CONDITIONS, SHEET 8

182h



1/8 SECTION-LOOKING NORTH

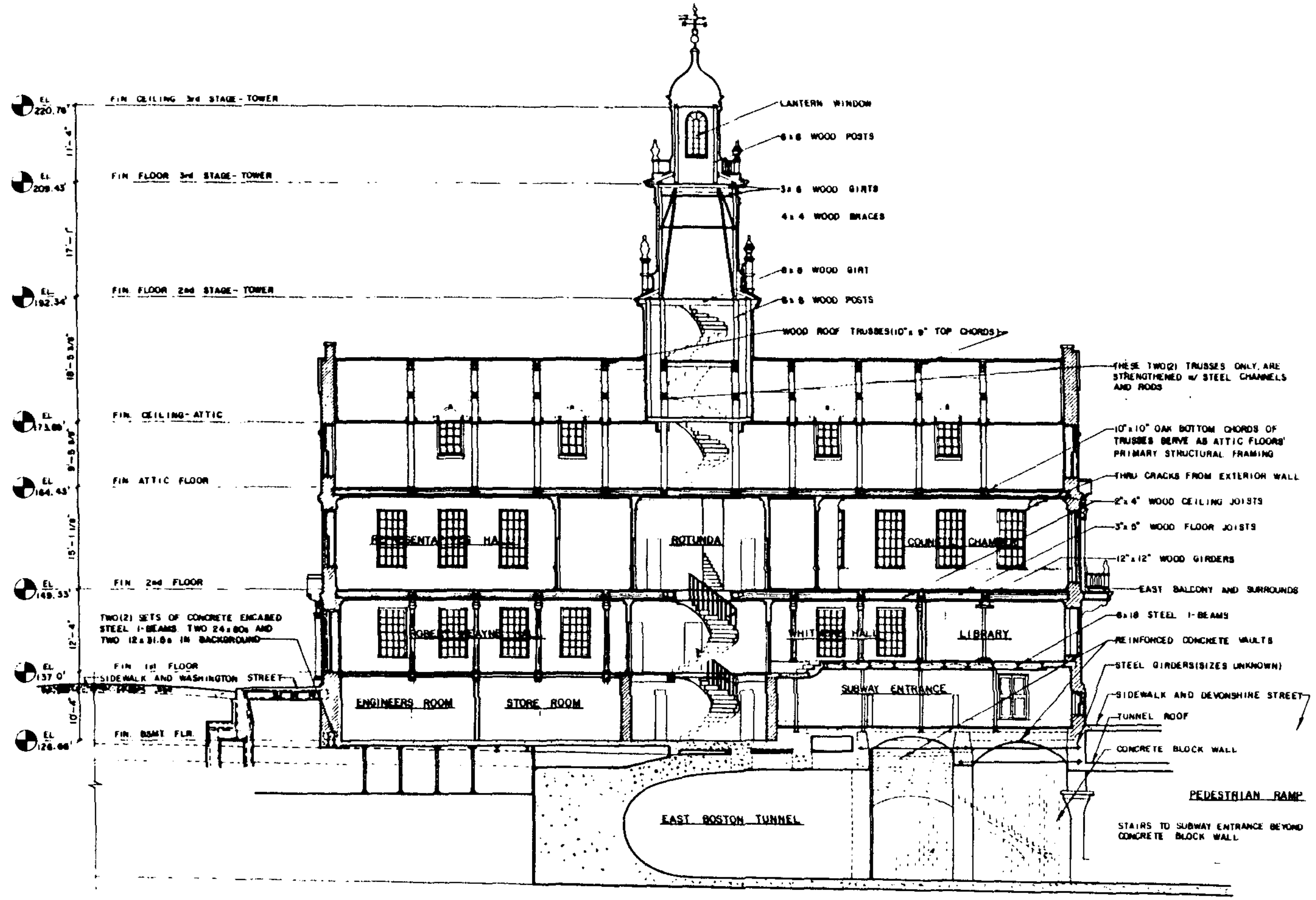
SCALE 1/8"=1'-0"

0 2 4 6 8 10 12 14 16 17

DESIGNED EXISTING / DRAWN J MARSH / TECH REVIEW H. LAFLEUR / DATE 3/88	SUB SHEET NO A-5	TITLE OF SHEET: SECTION & DETAILS — EXISTING CONDITIONS-OLD STATE HOUSE	DRAWING NO 457 / 25,025 — PKG NO 13c — SHEET 8 OF 21

HSR DRAWINGS, EXISTING CONDITIONS, SHEET 9

1821



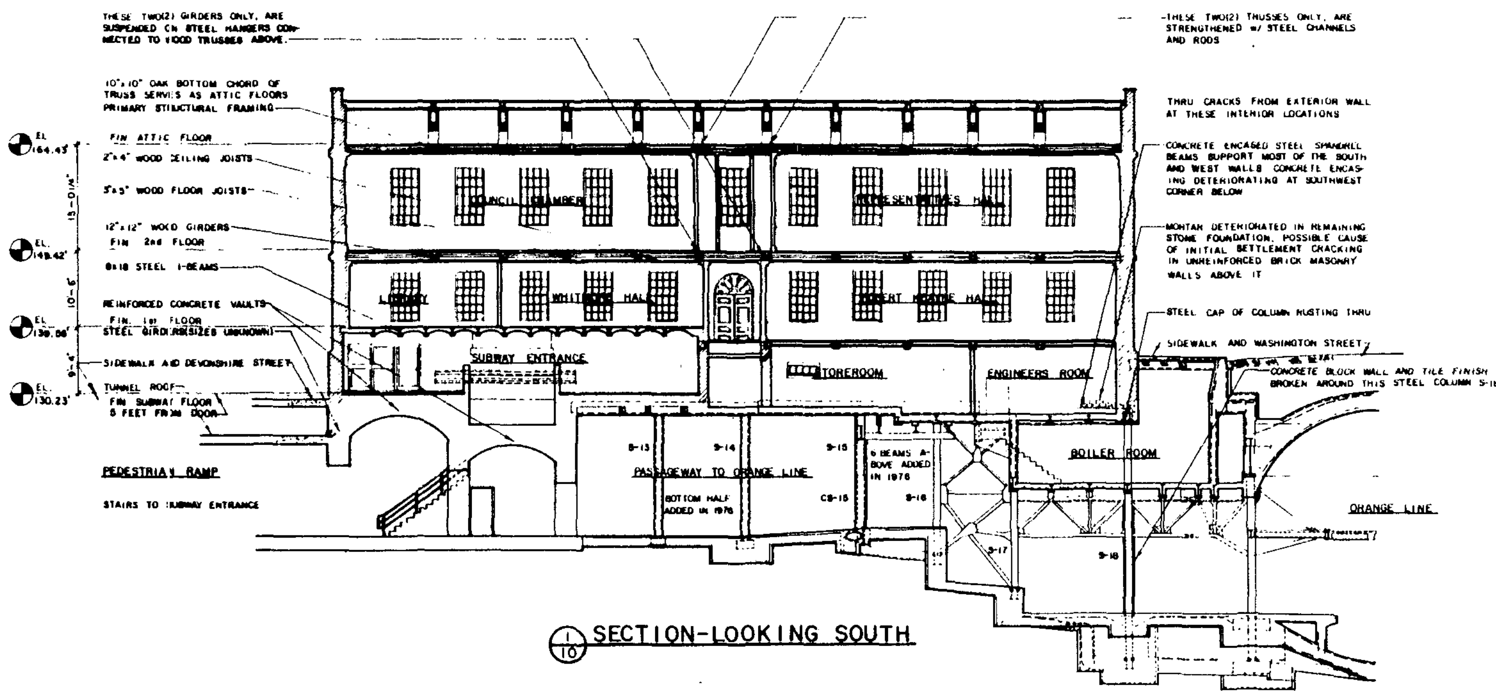
SECTION-LOOKING NORTH (1/9)

SCALE: 1/8"=1'-0"

DESIGNED	SUB SHEET NO.	TITLE OF SHEET	DRAWING NO.
EXISTING	A-6	SECTION & DETAILS	43/25,025
DRAWN J. MARSH		EXISTING CONDITIONS-OLD STATE HOUSE	PRG. NO. 13
TECH. REVIEW H. LAFLEUR			SHEET 9
DATE 3/88			of 21

HSR DRAWINGS, EXISTING CONDITIONS, SHEET 10

182j



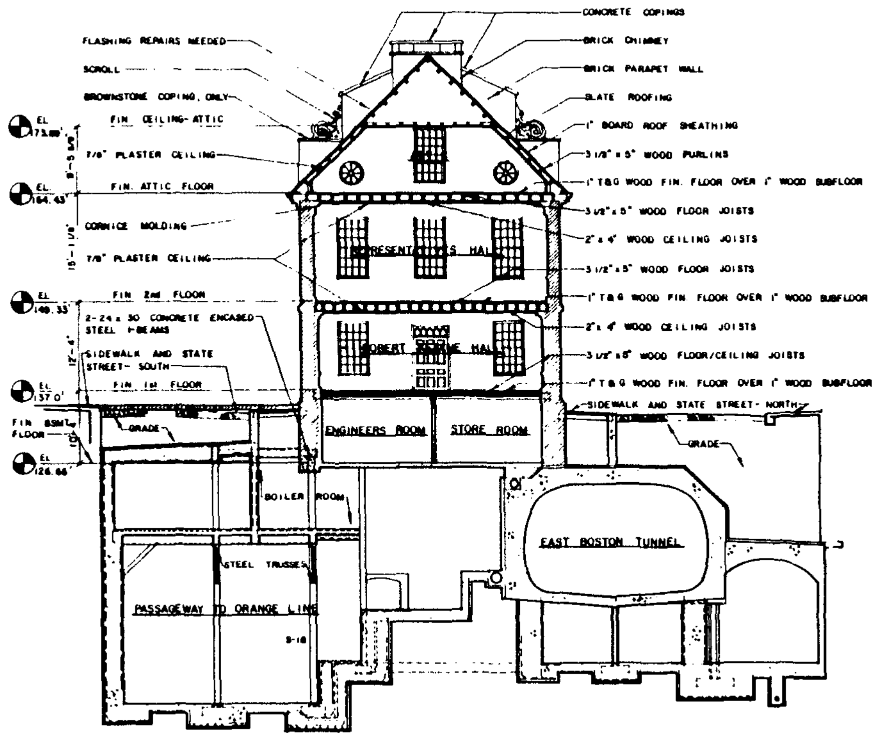
1/10 SECTION-LOOKING SOUTH

SCALE 1/8"=1'-0"

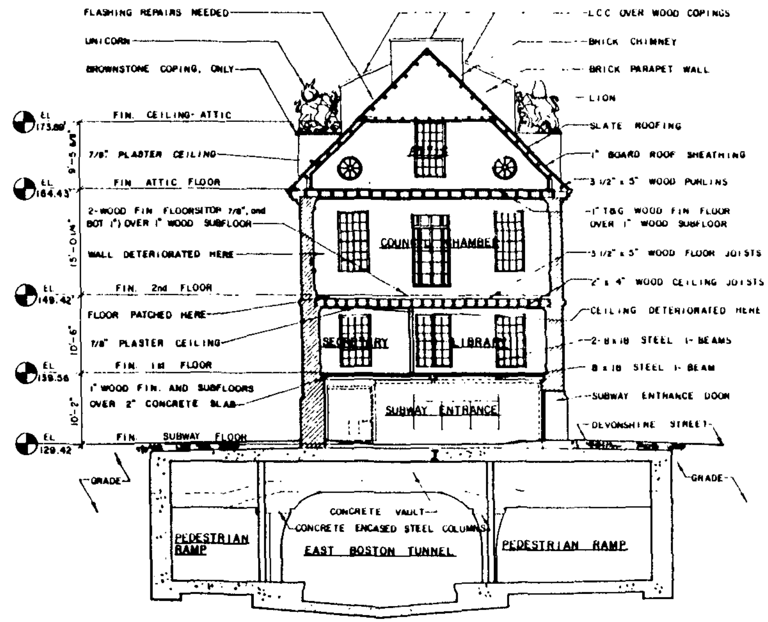
DESIGNED: EXISTING DRAWN: J. MARSH TECH REVIEW: H. LAFLEUR DATE: 3/88	SUB SHEET NO: A-7	TITLE OF SHEET: SECTION & DETAILS EXISTING CONDITIONS-OLD STATE HOUSE	DRAWING NO: 45/25,025 PROJ NO: 134 SHEET 10 of 21

HSR DRAWINGS, EXISTING CONDITIONS, SHEET 11

182k



1/10 SECTION-LOOKING WEST



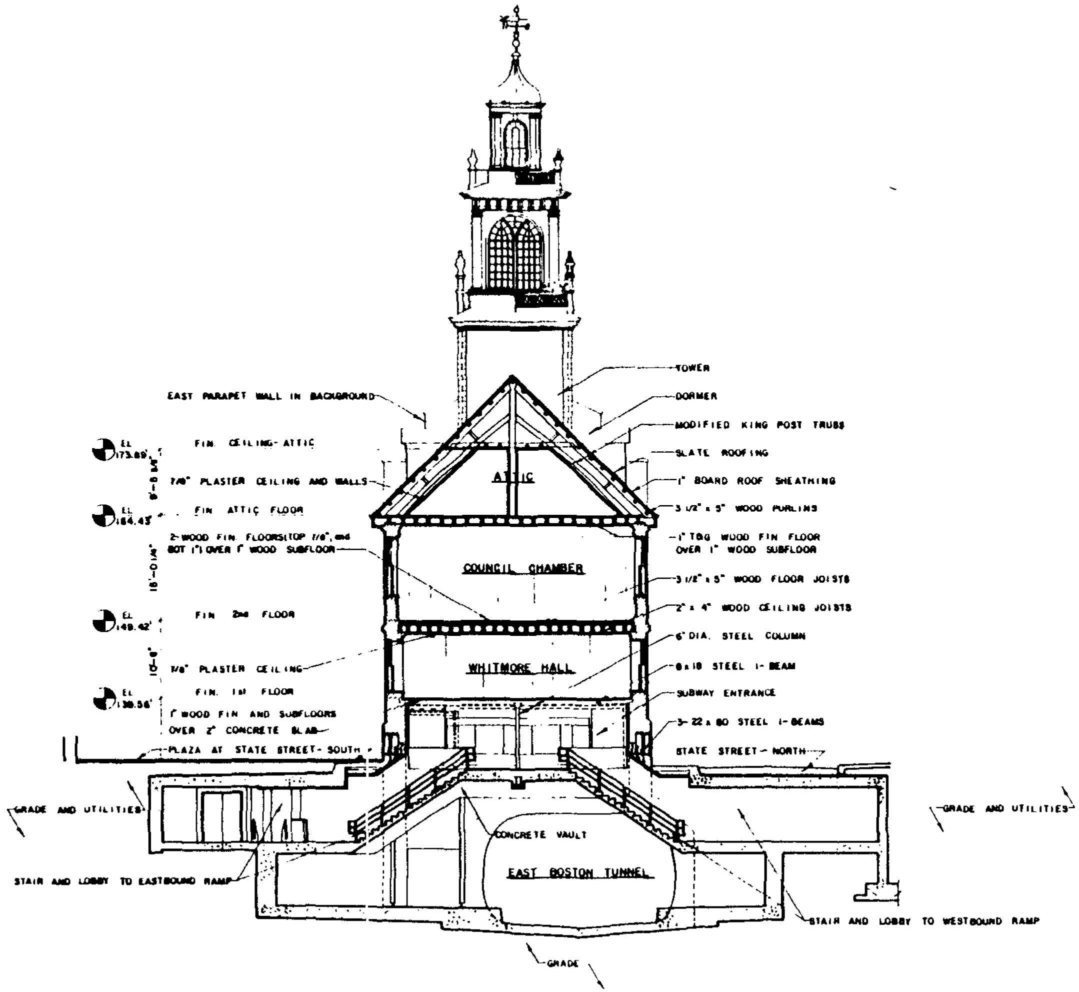
2/10 SECTION-LOOKING EAST

SCALE 1/8"=1'-0"

DESIGNED	SUB SHEET NO.	TITLE OF SHEET	
EXISTING	A-8	SECTIONS	457 25,025
DRAWN J. MARSH		EXISTING CONDITIONS-OLD STATE HOUSE	PAG NO 126
TECH REVIEW H. LAFLEUR			SHEET 11 of 21
DATE 3/88			

HSR DRAWINGS, EXISTING CONDITIONS, SHEET 12

1821



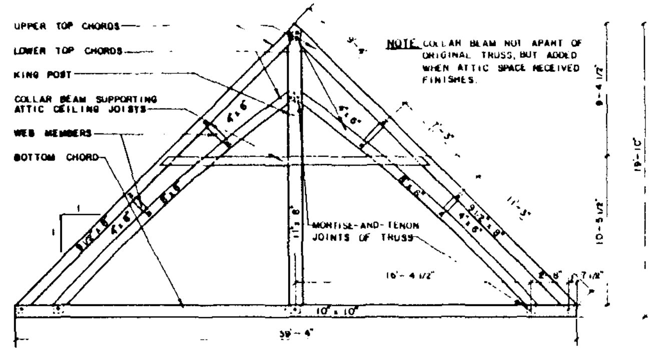
1/12 SECTION AT TRUSS

SCALE: 1/8" = 1'-0"

GENERAL NOTES:

(1) TYPICAL TRUSS, AS DRAWN WITH BOTH LOWER TOP CHORDS CURVED AND ALL MORTISE-AND-TENON JOINTS, IS MOST REPRESENTATIVE OF THE UNALTERED TRUSS BETWEEN BAYS 1 AND 2 (SEE ROOF FRAMING PLAN). OTHER TRUSSES RECEIVED ALTERATIONS RESULTING IN THE REPLACEMENT OF AT LEAST ONE CURVED CHORD WITH A STRAIGHT CHORD NAILED OR BOLTED INTO THE TRUSS SYSTEM. IN OTHER TRUSSES SPLIT OR WEAKENED WOOD MEMBERS ARE STRENGTHENED BY BOLTING PIECES TOGETHER OR TO SUPPLEMENTARY STEEL MEMBERS.

(2) ORIGINAL TRUSS MEMBERS ARE OAK. REPLACEMENT OR SUPPLEMENTARY TRUSS MEMBERS ARE WALNUT OR STEEL.

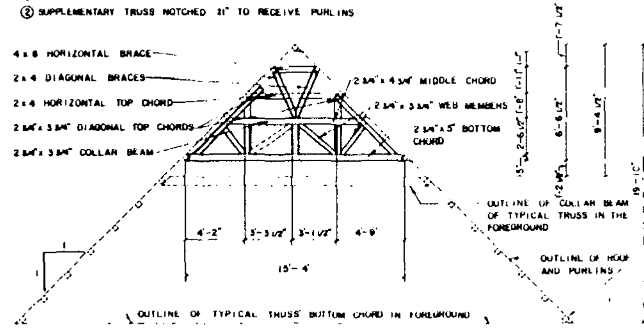


2/12 DETAIL OF TYPICAL TRUSS

GENERAL NOTES:

(1) SUPPLEMENTARY TRUSS LOCATED IN "BAY 1", ONLY. SEE ROOF FRAMING PLANS

(2) SUPPLEMENTARY TRUSS NOTCHED 3" TO RECEIVE PURLINS



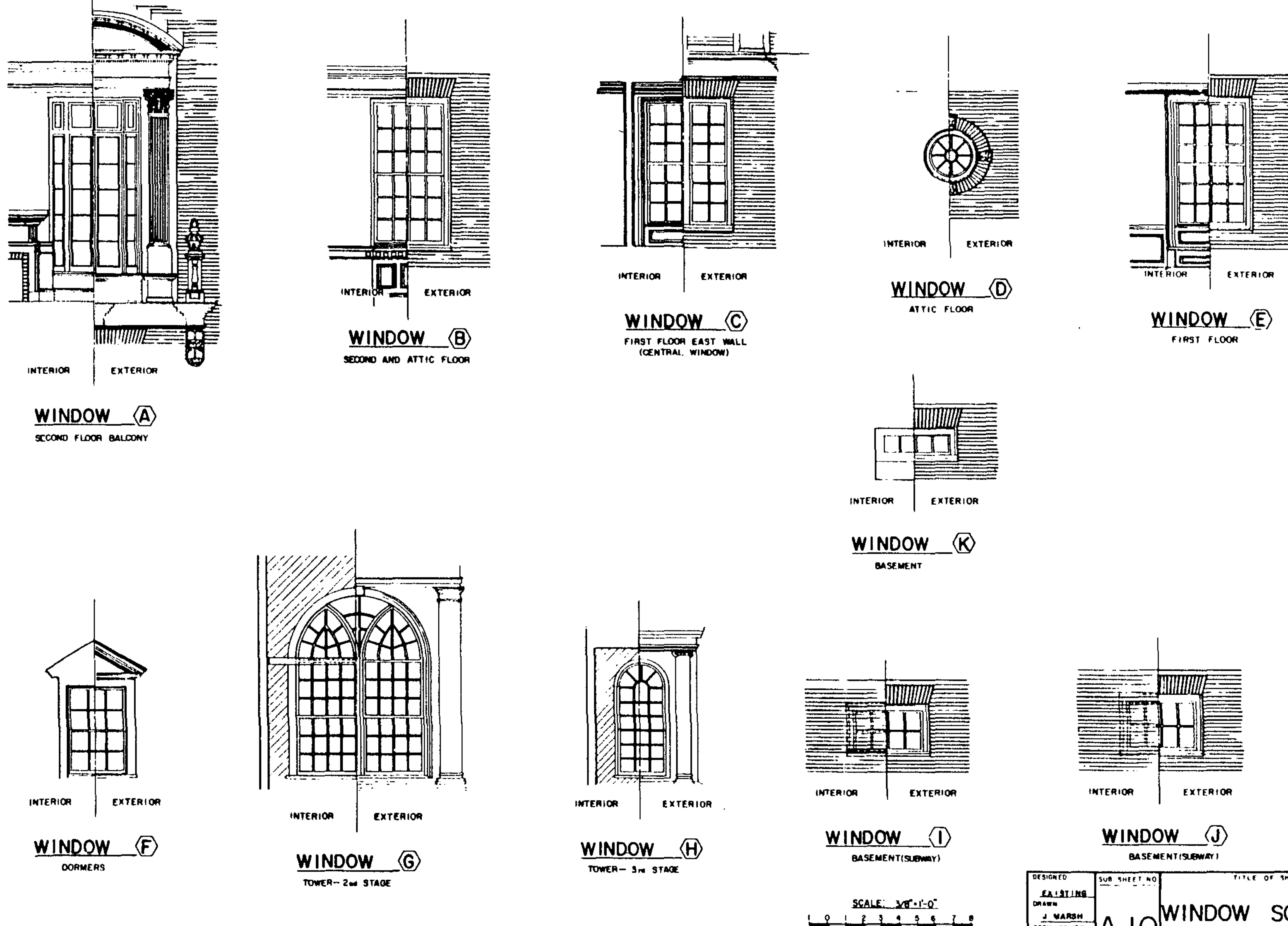
3/12 DETAIL OF SUPPLEMENTARY TRUSS

SCALE: 1/4" = 1'-0"

DESIGNED: EXISTING DRAWN: J. MARSH TECH REVIEW: H. LAFLEUR DATE: 3/88	SUB SHEET NO: A-9	TITLE OF SHEET: SECTION & DETAILS EXISTING CONDITIONS-OLD STATE HOUSE	DRAWING NO: 427 25,025 PKG NO: 122 SHEET 12 OF 21

HSR DRAWINGS, EXISTING CONDITIONS, SHEET 13

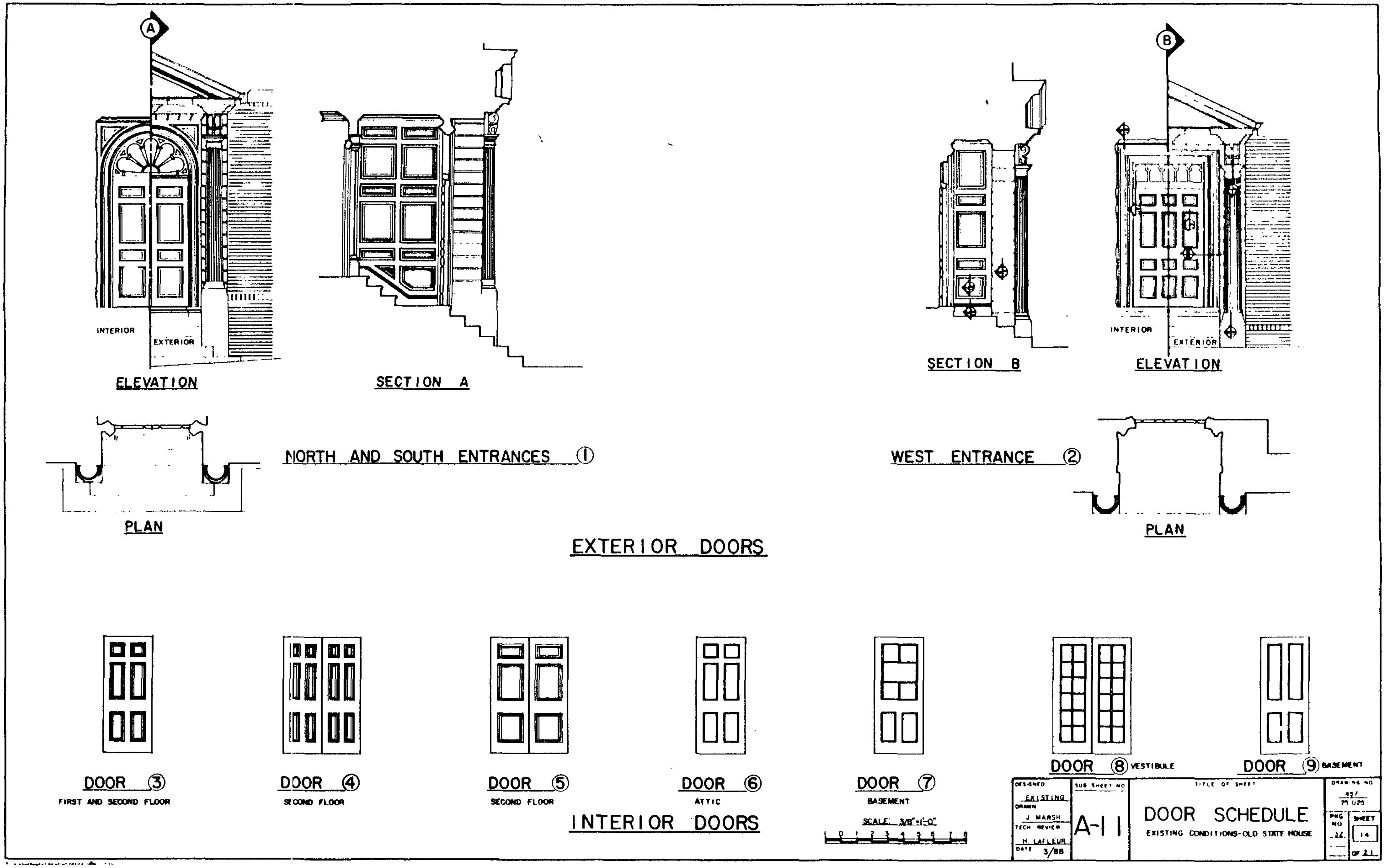
182m



DESIGNED EXISTING DRAWN J. MARSH TECH REVIEW H. LAFLEUR DATE 3/88	SUB SHEET NO A-10	TITLE OF SHEET WINDOW SCHEDULE EXISTING CONDITIONS-OLD STATE HOUSE	DRAWING NO 457/25 025 PKG NO 132 SHEET 13 OF 21

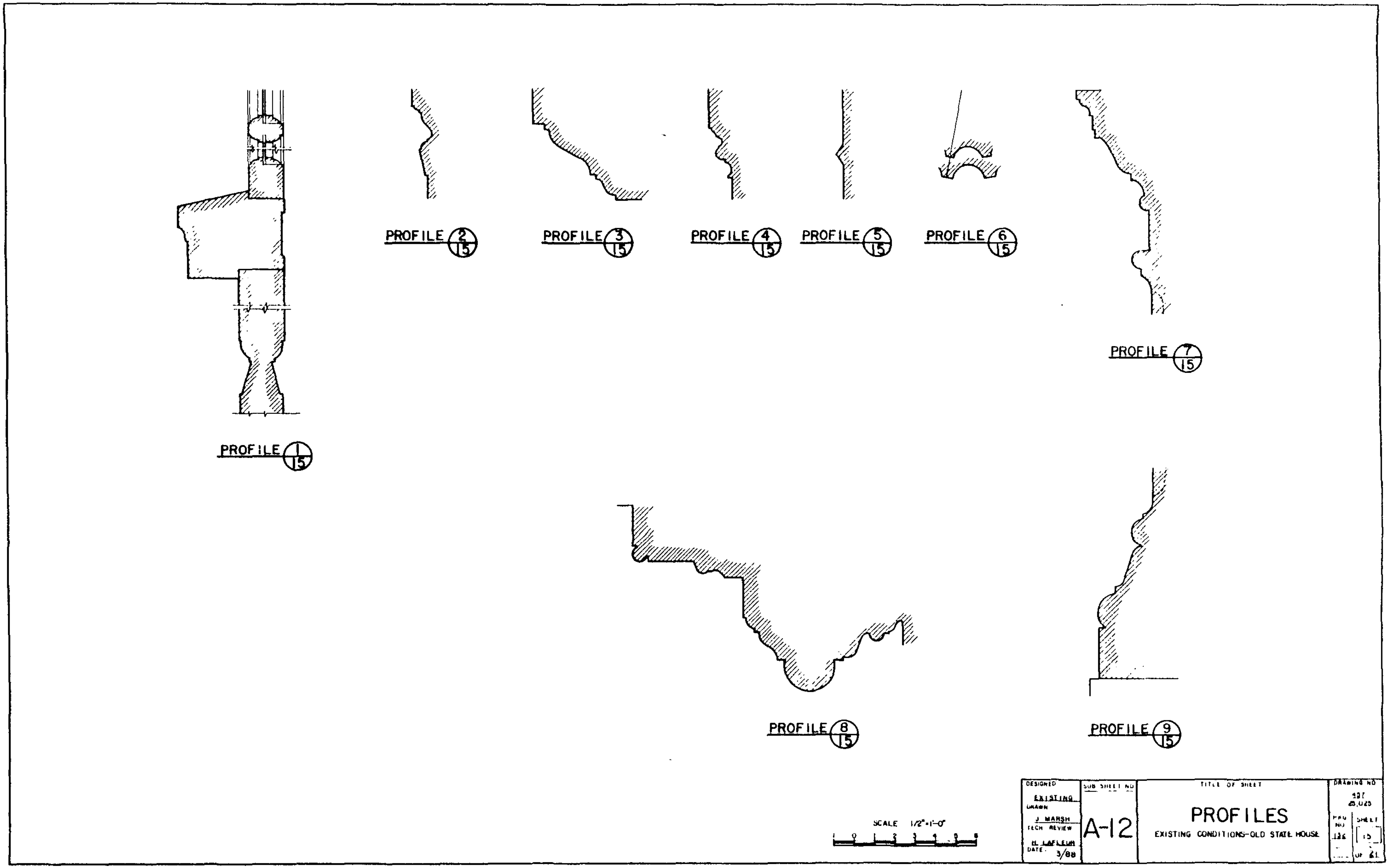
HSR DRAWINGS, EXISTING CONDITIONS, SHEET 14

182n



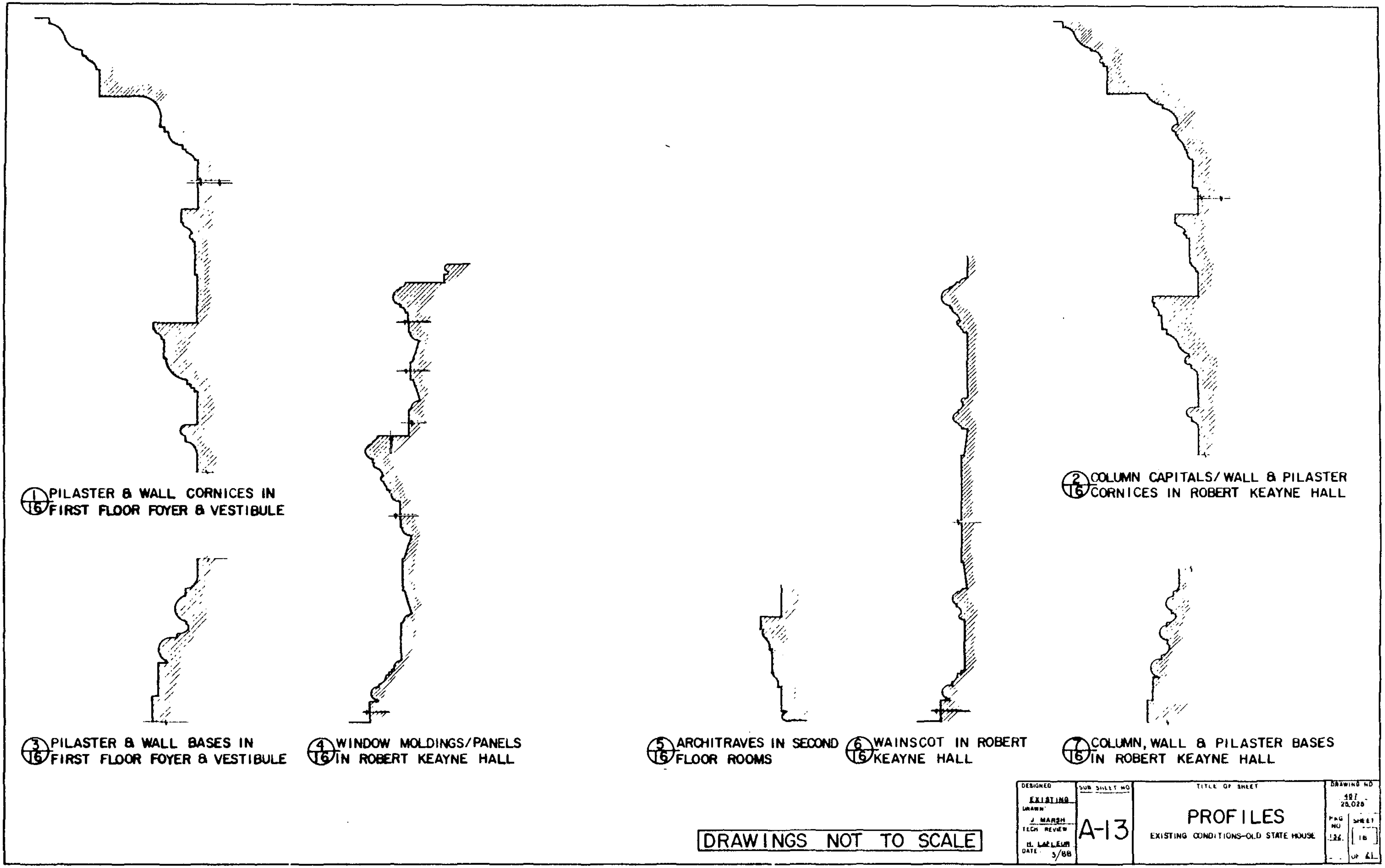
HSR DRAWINGS, EXISTING CONDITIONS, SHEET 15

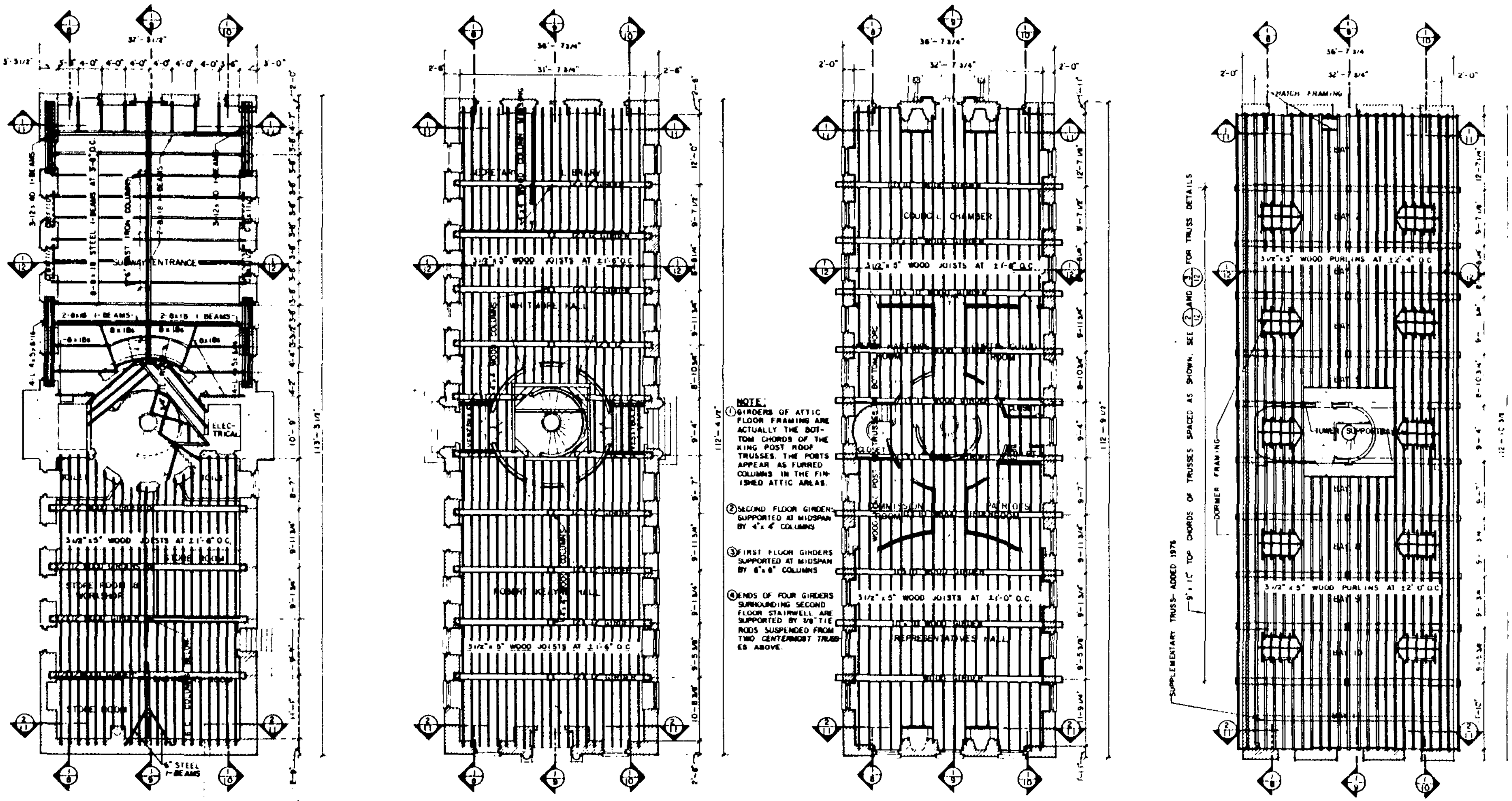
1820



HSR DRAWINGS, EXISTING CONDITIONS, SHEET 16

182p





FIRST FLOOR FRAMING PLAN

SECOND FLOOR FRAMING PLAN

ATTIC FLOOR FRAMING PLAN

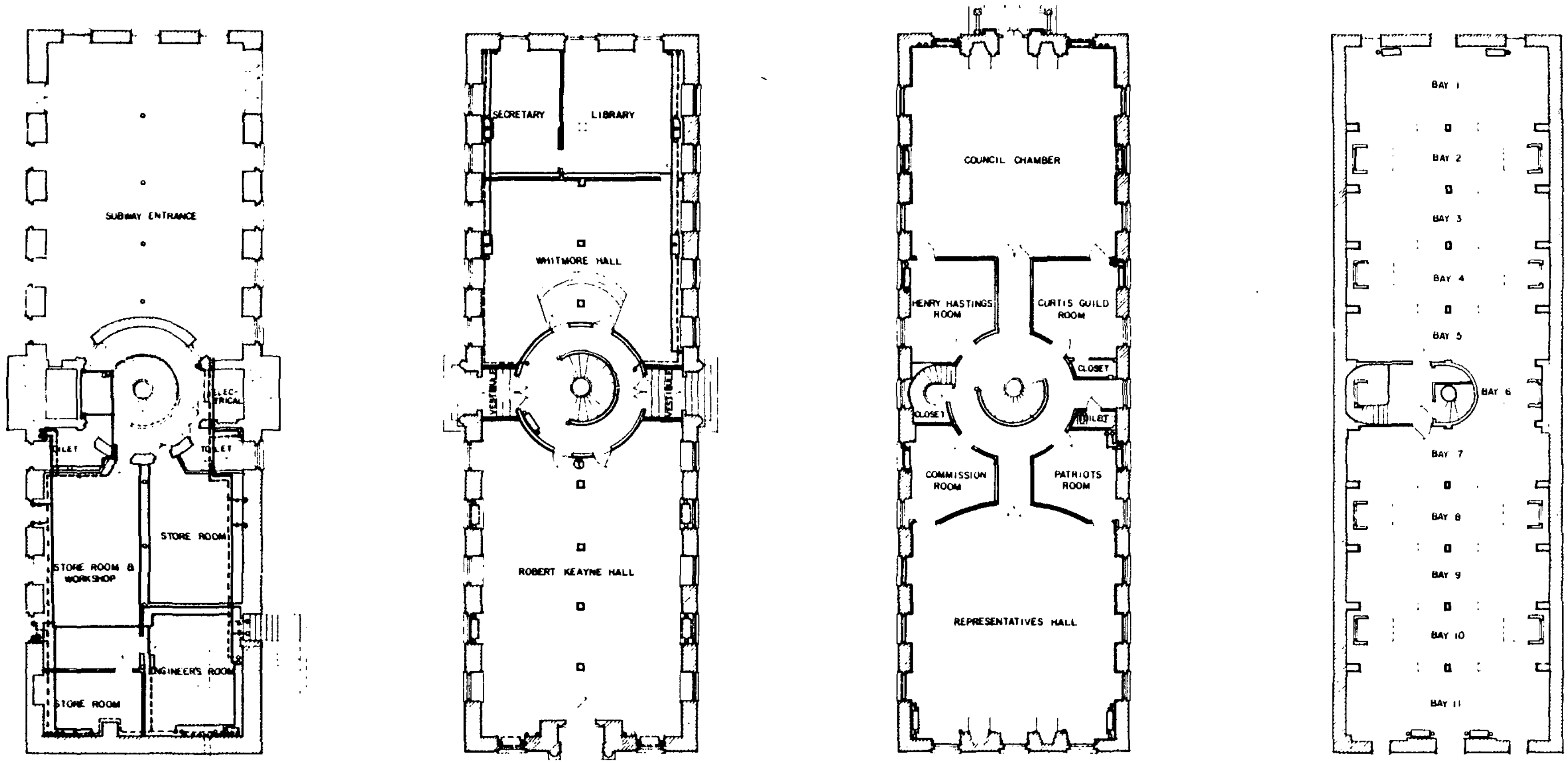
ROOF FRAMING PLAN

SCALE 1/8"=1'-0"

DESIGNED EXISTING DRAWN J. MARSH TECH REVIEW H. LAFLEUR DATE 3/88	SUB SHEET NO S-1	TITLE OF SHEET FRAMING PLANS EXISTING CONDITIONS-OLD STATE HOUSE	DRAWING NO 407 26,028 PKG NO 134 SHEET 17 OF 21

HSR DRAWINGS, EXISTING CONDITIONS, SHEET 18

182r



BASEMENT FLOOR PLAN

FIRST FLOOR PLAN

SECOND FLOOR PLAN

ATTIC FLOOR PLAN

LEGEND

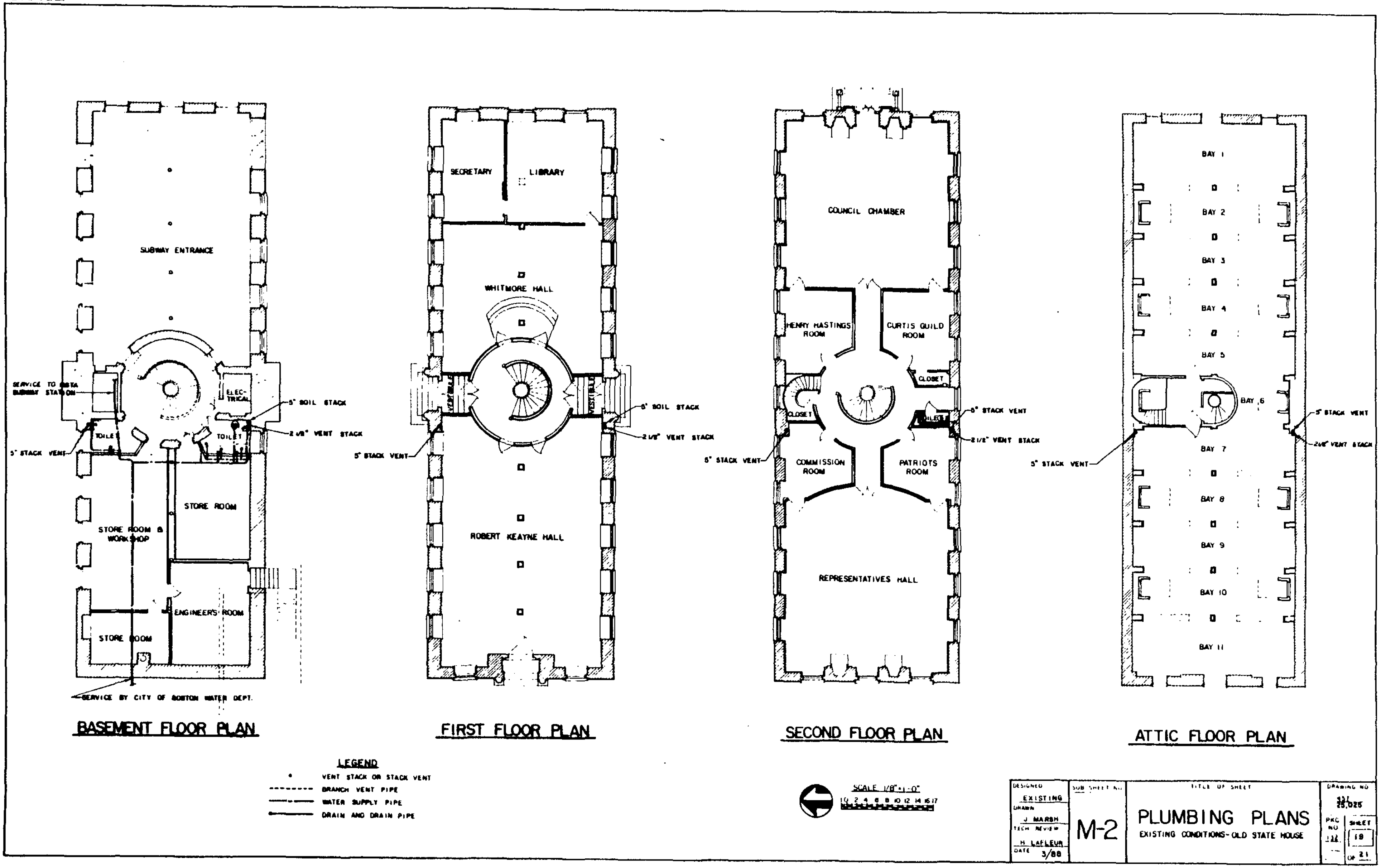
STEAM SUPPLY PIPE	RADIATOR (EXPOSED)
STEAM RETURN PIPE	RADIATOR (ENCLOSED)
ELBOW TURNED UP	ELBOW TURNED DOWN
THERMOSTAT	VALVE

SCALE 1/8" = 1'-0"

DESIGNED	EXISTING
DRAWN	J. MARSH
TECH REVIEW	H. LAFLEUR
DATE	3/88
SUB SHEET NO	M-1
TITLE OF SHEET	HEATING PLANS EXISTING CONDITIONS—OLD STATE HOUSE
DRAWING NO	431/25,025
PKG NO	132
SHEET	18 OF 21

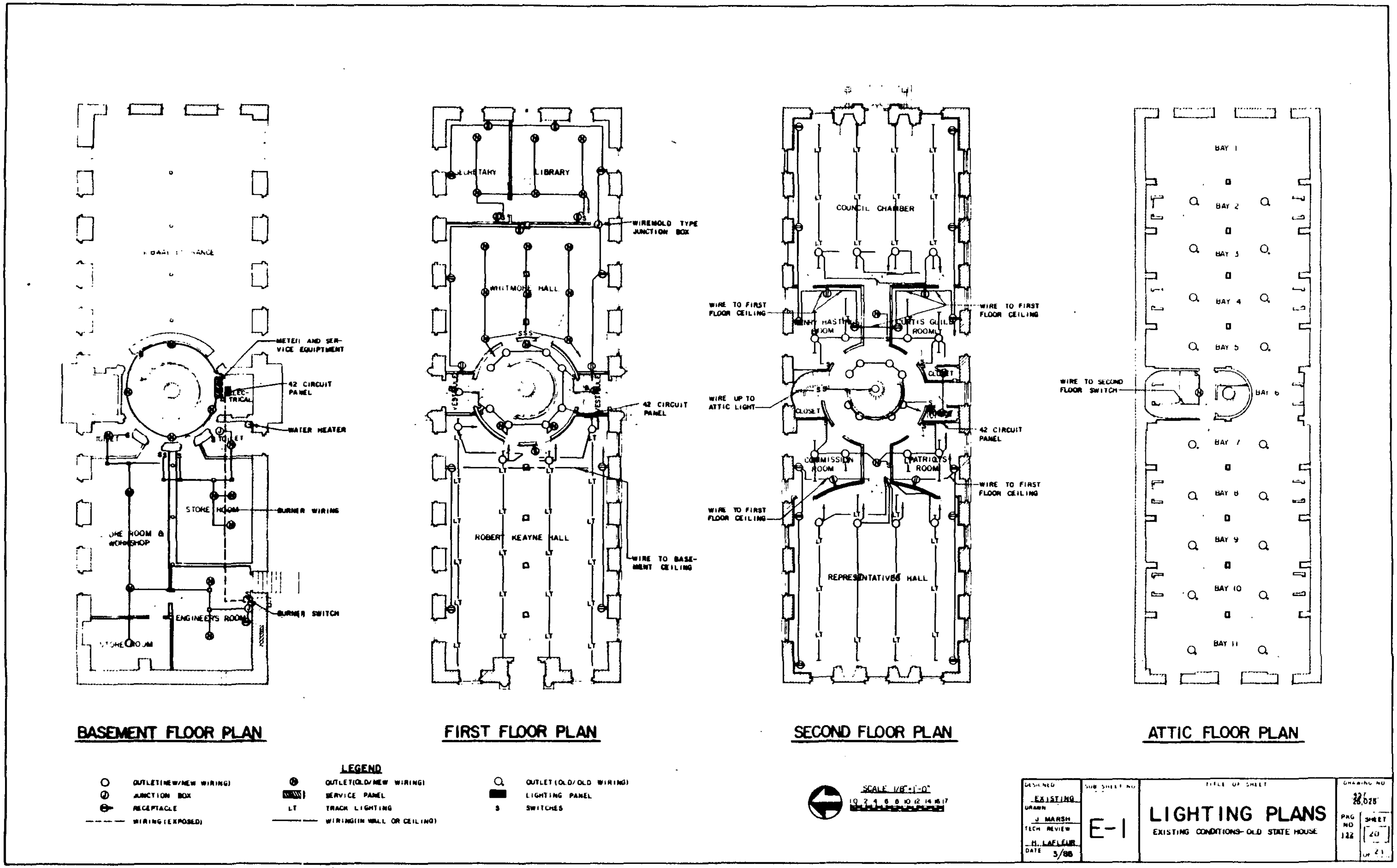
HSR DRAWINGS, EXISTING CONDITIONS, SHEET 19

1828



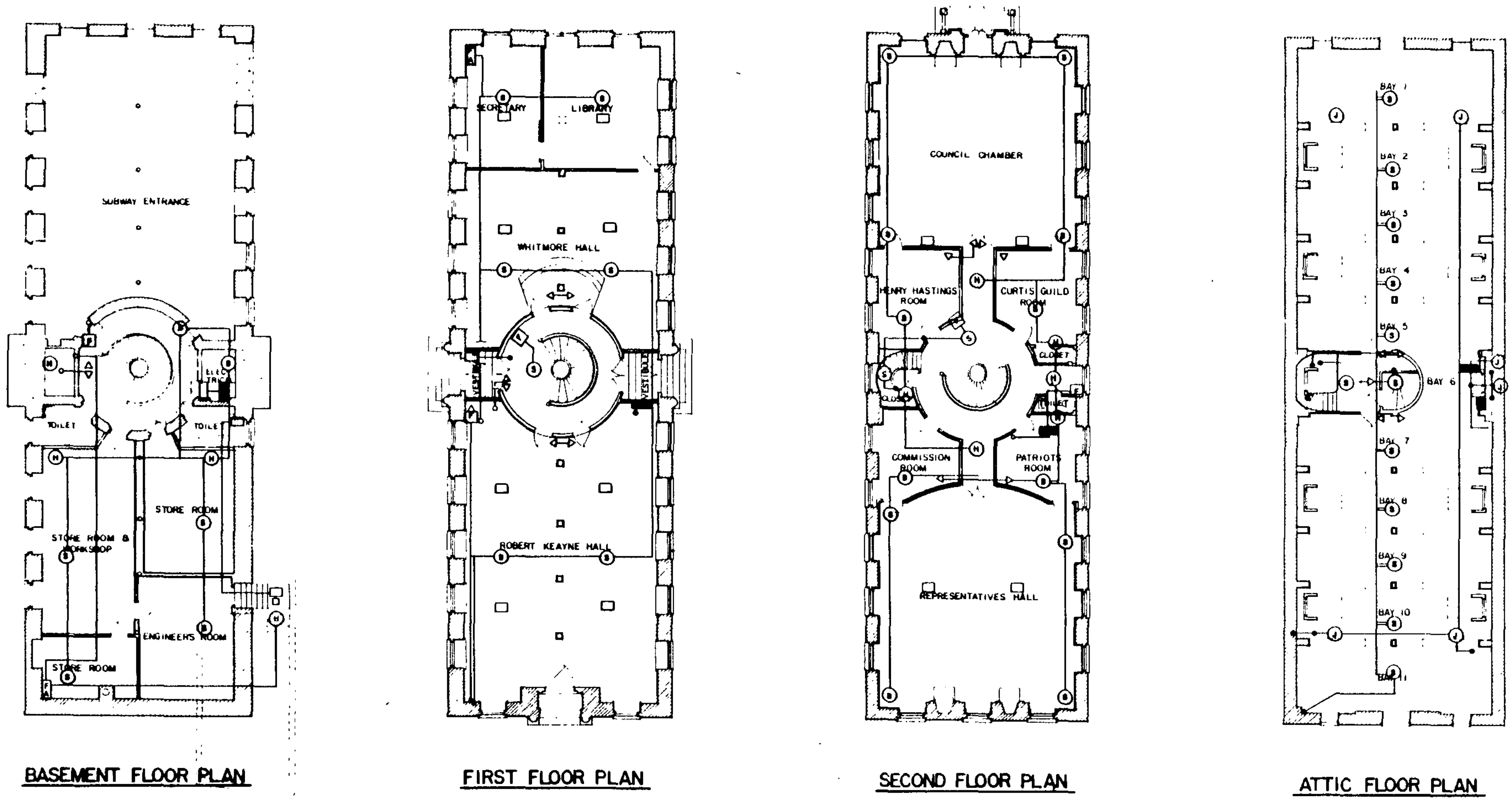
HSR DRAWINGS, EXISTING CONDITIONS, SHEET 20

182t



HSR DRAWINGS, EXISTING CONDITIONS, SHEET 21

182u



LEGEND

- F — MANUAL FIRE ALARMS
- F▷ — FIRE ALARM HORN & LIGHT
- △ — FIRE ALARM HORNS
- ● — WIRES DOWN
- (H) — HEAT DETECTORS
- —— — WIRING (Location Conjectured)
- ▭ — MOTION DETECTORS
- F/A — FIRE ALARM CONTROL PANEL
- (S) — SMOKE DETECTORS
- ■ — ALARM PANELS (AREA)
- ○ — WIRES UP
- □ — FUSED SWITCH

SCALE 1/8"=1'-0"

DESIGNED	SUB SHEET NO	TITLE OF SHEET	DRAWING NO
EXISTING DRAWN J. MARSH TECH REVIEW H. LAFLEUR DATE 3/88	E-2	FIRE & INTRUSION EXISTING CONDITIONS-OLD STATE HOUSE	437 85,085 PKG NO 132 SHEET 21 OF 21

J. CODE ANALYSIS

1. General: The Old State House is currently occupied by the Bostonian Society and is predominantly used as a museum exhibiting artifacts from the history of Boston, Massachusetts. Based on its predominant use with incidental office, sales, and curatorial storage spaces, the structure is classified as an "Assembly Occupancy" under the auspices of the "Life Safety Code" (LSC), and the "Commonwealth of Massachusetts--State Building Code" (780 CMR) which also classifies it as TYPE 3b Construction (Exterior Masonry Walls--Ordinary protected). This structure, with its load-bearing brick masonry walls and heavy timber framing, is presumed to have a 2-hour exterior fire rating with interior partition walls, and all doors and windows of less than 1-hour fire-rated construction.

Under the LSC, and 780 CMR, the structure must comply with pertinent provisions of Chapter 9, "Existing Assembly Occupancy," and Section 22, "Repair, Alteration, Addition, and Change of Use of Existing Buildings," respectively. In addition, the structure must comply with other local and national codes to include "Specifications for Making Buildings Accessible to and Usable by Physically Handicapped People" (ANSI A117.1), and the National Plumbing Code. NPS-28 and the Secretary of the Interior's Standards for Rehabilitation and Guidelines for Rehabilitating Historic Buildings will also be consulted for compliance when designing for the structure. Although compliance with the guidelines may be difficult to ignore for a structure of this caliber (Category A - "must be preserved", List of Classified Structures), compliance with the provisions in the codes can be waived when found impractical because of structural or construction difficulties, or regulatory conflicts. Waivers or "variances," in either case, must be granted by the "Authority having Jurisdiction" (Building Department, city of Boston). Furthermore, if the building can qualify as a "Totally Preserved Building" under 780 CMR, Section 436.3, it will be exempt from most of the requirements of the codes. Nevertheless, in the interest of the health, safety, and welfare of the public, we will attempt to meet code whenever possible.

In the discussions that follow, code requirements (exits, occupancy loads, fire detection and suppression, etc.) primarily impacting the building, collections, and the public are addressed and cited with possible solutions. These and more specific code requirements will be reexamined in more detail by the A/E during the Comprehensive Design Phase of this project.

2. <u>Exitways and Occupancy loads</u>: Code provides for a building and its occupants:

a) General Code Requirements

(1) Adequate exits without dependence on any single safeguard.

(2) Sufficient construction that will provide structural integrity during a fire while occupants are exiting.

(3) Exits designed to the size, shape, and nature of the occupancy.

(4) Assurance that exits are clear, unobstructed, and unlocked.

(5) Assurance that exits and routes of escape are clearly marked so that there is no confusion in reaching an exit.

(6) Adequate lighting.

(7) Assurance for early warning of fire.

(8) Back-up or redundant exit arrangements.

(9) Assurance of suitable enclosure of vertical openings.

(10) Allowances for those design criteria that go beyond the provisions of the code and are tailored to the normal use and needs of the occupancy in question.

b) Code Issues: In the Old State House, most of these provisions have been or can be met with minor alterations to the building's historic fabric. However, to meet or comply with other provisions of the code, the structure will be heavily impacted. For example, adequately-sized and a sufficient number of exits are provided for most of the building's rooms, but there is only one existing rotunda, when there should be at least two (780 CMR, Section 2203.7) serving each floor of the building. Not only does the central staircase or rotunda provide the only means of egress from one floor to another, but the wood doors to the stair enclosure are not self-closing and tight fitting and will not meet code (780 CMR, Section 2203.12) unless they are substantially altered. This and the problem of the single exitway are two of the most difficult code problems at this time, since under NPS-28 and due to the limited space in the building the NPS is reluctant to add another exitway to the building or alter the doors in the enclosures. These are only a few of the code issues, however; other code issues of the building are as follows.

3. <u>Attic</u>: The attic is basically the third floor of the building and is currently used for curatorial storage, incidental to the assembly or museum exhibit spaces below. Although the attic does not function as an assembly space, code (LSC 4-1.10) requires that it be evaluated as one, due to its proximity and relationship to the predominant assembly occupancy. However, with fixed storage shelving, knee walls, and sloping

ceilings consuming most of the occupiable floor area, little assembly floor space remains. Out of a gross floor area of 2,947 square feet, approximately 500 square feet (main and branch aisles between shelving) are available for assembly use. Therefore, the occupancy load (LSC 9-1.7.1 and 780 CMR, Section 606.0) is computed as follows:

> Occupancy load equals net square feet divided by number of occupants divided by square feet equals 500 divided by 15 equals 35 persons.

Two 2-feet 6-inch wide wood doors form the exits from the attic onto a landing and a spiral staircase providing the only means of egress from this level. Under code (LSC-5-3.2 and 780 CMR, Section 608.3) the doors provide 2-1/2 units of exit width and theoretically can serve as many as 250 persons (i.e., 2-1/2 units x 100 persons/unit = 250 persons). With the exceptions that they do not swing in the proper direction and are not fire rated, these exits are more than sufficient to serve the 35 occupants that the attic will accommodate. However, neither the doors nor the partitions that house them are fire rated.

As a part of the egress route, the landing is broad enough to accommodate the attic occupants but the stairs are inadequate. Although code permits winding or circular stairs to form a part of the "means of egress" in assembly areas, the stairs' dimensions are short of those required by code, and propose a danger to occupants using them. It is unfortunate that this problem exists because the stairs are a part of the historic building fabric and the NPS would like to preserve them at any cost. Our appeal for the stairs' preservation is not limited to their relationship to other building fabric, but is also based on the actual use of the stairs. Although the attic's occupancy load is 35, this space and its stairs, in reality, will probably serve no more than one to five persons at a time since they are to be used only by the museum staff when servicing or storing exhibits. The attic space is off-limits to the general public which reduces the seriousness of the safety issues surrounding the stairs. Nevertheless, persons entering and leaving the attic should still take caution of the stairs and the danger that the they propose.

Moreover, as a storage space for exhibition materials not on display, code (LSC: 9-4.3.3) requires that the attic be provided with a 1-hour separation from the adjacent assembly areas of the building. In addition, code requires that a space like the attic be protected by an automatic sprinkler system which, in this case, should be limited to a halon system due to the sensitive nature of the collections in storage.

Due to the nature of the loosely constructed floors, ceilings, walls, and doors of the attic, it is conceivable that they do not provide the 1-hour fire separation required by code. However, the appropriate fire separation can be achieved with alterations which will result in major impact on the historic fabric in several areas.

Like the finishes that must be altered or removed, structural members such as joists and trusses may have to be strengthened during the alterations should it be necessary for them to support the added weight of new materials. Any action taken to provide the 1-hour fire rating in the attic is anticipated to be greater than the previous alterations to provide the current storage shelving, wiring, or the strengthening of the two central trusses. Proposed actions are an outgrowth of the problems in the existing construction and other work deemed necessary to correct these problems. A description of the existing construction and the actions are as follows:

a) Floor/Ceiling Below Attic Space: The assembly is composed of 1-inch by 6-inch by 8-inch wood finish flooring over 1-inch by 6-inch by 8-inch wood subflooring. These are nailed to 3-inch by 5-inch joists at 18 to 20 inches on center, and are supported by 10-inch by 10-inch girders. The girders are actually the bottom chords of the roof trusses spaced 10 to 12 feet on center, and bear directly on the unreinforced brick masonry walls. Wood scabs suspended from the floor joists support the ceiling framing which hangs just inches below the bottom of the girders. The ceiling framing consists of 2-inch by 4-inch wood joists supporting wood and metal lath, which in turn supports a finish ceiling consisting of two or three coats of lime or cement plaster.

The existing assembly is of nonairtight construction since there are openings in the flooring and the ceiling. When compared to code approved fire-rated assemblies, these have little or no fire rating at all. Consequently, actions must be taken to ascertain the fire rating of the ceiling and acquire a 1-hour fire rating in the floor/ceiling assembly. Steps in acquiring the 1-hour fire rating are contained in the statements that follow.

(1) Provide an airtight assembly by altering the existing flooring system. Begin by temporarily removing the tongue-in-groove finish flooring and storing it for reuse. The subfloor is then covered with a .010-inch thick layer of rosin-sized building paper. The tongue-in-groove finish flooring is then installed, making sure that all openings in it are covered up.

Should the ceiling below need an improved fire rating, this can be accomplished by applying an additional 1/4-inch thick coat of gypsum or cement plaster over the existing ceiling plasters. This could be sprayed on or troweled on from above with both the subfloor and finish floor removed, or applied directly to the face of the plaster ceiling from below. The problem with the latter technique is that the return or the cornice to ceiling profile in the second-floor rooms would be altered, along with its historic appearance. Lath connections may have to be strengthened or supplemented to support the extra weight added by the new plaster.

(2) An easier but more impacting way to acquire the 1-hour fire rating in the floor/ceiling assembly would be to construct a 2-inch thick concrete slab, reinforced with wire mesh, directly atop the attic floor; this is done after protecting the floor with the application of a building felt or vapor barrier. Although the installation is accomplished without disturbing the existing floor, the slab causes other problems since it changes the original elevations of the floor. As a result, doors in the attic will have to be cut shorter or have their swings reversed if they are to remain operable. The weight of the concrete floor poses another problem because it adds weight to the floor/ceiling assembly, floor joists, and girders; perhaps all of the trusses will have to be strengthened.

b) Partition Walls: Both sides of these walls are constructed of three coats of lime plaster on wood lath, or three coats of cement plaster on metal lath in areas that were repaired after the 1921 fire. The lath and plaster cover 2-inch by 4-inch wood wall framing. Fire ratings of the wall assemblies should be checked by the Building Official. Should the assemblies be found unsuitable for the required protection, a method similar to the one employed for the ceiling can be used at the exterior faces of both sides of the walls. However, the 1/4-inch thick coat of plaster applied to both faces of the walls will change the wall-to-baseboard and wall-to-architrave profiles, just as the cornice-to-ceiling profiles were changed above. Nevertheless, if other alternatives for treating the walls are more drastic, we may have to live with the treatment described. The only alternative to altering the walls is to hope that they already provide the required fire rating or ignore their fire-rating deficiencies, and preserve their historic appearance. Although it may be conservative, the latter alternative can only succeed in endangering the lives of the public.

c) Doors: Door assemblies in the walls are less than adequate for the 1-hour fire-rating requirement. In addition, they do not swing in the proper direction. There is no way to make these doors conform to code without changing completely their historic appearance, changing the appearance of the area around them, or replacing them. To accomplish the 1-hour fire-rating requirement, the doors may be covered with a fire-rated material (Kalamein doors), or the area surrounding the doors can be enclosed in a fire-rated vestibule equipped with an operable fire-rated door. The vestibule takes up a lot of space and should be considered as a last alternative. Consequently, neither the latter nor the former alternative is preferred. However, since the attic has already been substantially altered, there is more freedom to incorporate contemporary design here than in any other areas of the building.

d) Ceilings: To seal the attic completely in 1-hour fire-rated materials, and to help protect the roof, the attic ceiling, if need be, should also receive treatment to provide it with a 1-hour fire rating. This can be accomplished by spraying an additional 1/4-inch coat of plaster from above on the lath and plaster of the existing ceiling. Connections holding the lath to the ceiling joists may have to be strengthened or supplemented to support the extra weight.

Should the attic continue in its current storage capacity, it is wise to carry out the recommendations that will give it a 1-hour fire rating. In addition, its fire detection and suppression and fire alarm systems should be checked out or upgraded. While it may only be necessary to check out and assure the proper operation of the existing fire alarms and "Rate of Rise" smoke detectors, the manual fire suppression system (water or chemical fire extinguishers) should be upgraded to an automatic fire suppression system.

Although the above recommendations are not the only changes the attic needs to make it a successful storage area, they are a good place to start. However, to complete the storage requirements, the attic must also have an environmental control system, or a combination of environmental control systems, installed that are conducive to the preservation of the space and the collections stored therein. Either system must provide year-around climate control to regulate the temperature, humidity, and air distribution levels in the space. The structural adequacy of the attic floors for storage should also be examined.

4. Second Floor: Unlike the attic floor above, the second floor is a bona-fide "assembly" space. It consists of two large rectangular rooms (Representatives Hall and Council Chamber) that are each bordered by two anterooms, a corridor, rest room, and closet encircling the central staircase which leads to the floors below (see HSR Drawings, Sheet 4, Second-Floor Plan). Egress from the larger second-floor rooms to the staircase is gained via the anterooms or corridors.

To the east of the staircase is the Council Chamber adjoining one of the corridors. Both areas are flanked by two of the anterooms (Henry Hastings and Curtis Guild room). While the corridor provides direct egress from the Council Chamber to the staircase through a double door exit, egress from the Council Chamber to the staircase via either anterooms require occupants to exit through two separate doors. Due concern is not so much for the number of exits an occupant must pass through, but for the potential confusion he may experience should he become disoriented while using these exits during a fire. Under the circumstances, the most direct route, or the door closest the staircase or exitway, should be clearly marked "EXIT" with code acceptable signage. This will help to assure the safety of the occupant until he reaches the staircase.

The double doors of the Council Chamber are each approximately 2-feet 6-inches wide and together form 2-1/2 units of exit width. Theoretically, these doors are sufficient to accommodate some 250 persons leaving the space. The corridor is 5-feet 8-inches wide and 12-feet 0-inches long. It also has the capacity to serve that number of persons. Although each single door to the anterooms serves only half the number of the persons above, either is adequate, but, neither the exit nor its enclosure (staircase's partition) are fire rated. Nonetheless, since code (780 CMR, Section 2203.1) does not require enclosures of stairways to be fire-rated if the use of an occupancy group is to continue, no code problem is perceivable here.

The discussions above deal with the occupancy loads that the exits will accommodate, however, the occupancy load of the space is defined in the discussion that follows. These loads are nominal and are not actual since circulation and storage are not yet deducted.

The Council Chamber is primarily used for exhibits and for the occasional seating of small groups during lectures and presentations. The room covers an area of approximately 1,072 square feet, of which some 50 square feet are allotted to fixed exhibits. The seating for lectures and presentations is not fixed. In a situation such as this, code permits two separate allowable square feet areas per person for computing the occupancy load of a space based on the function of that space at any given time. Based on the net available area and the code allowable, 15 and 7 square feet per person for exhibits and seating respectively, the occupancy loads become 168 and 68 persons respectively. However, since this nor any other room of the building fully complies with code, the smaller number (68 persons) should be taken and posted as the rooms occupancy load.

The Curtis Guild and Henry Hastings Anterooms that border the Council Chamber and corridor are also assembly spaces. The occupancy loads of these rooms, however, are substantially lower than that of the latter space. Each anteroom measures approximately 244 square feet, and each has an occupancy load of 15 persons. Although the rooms share problems similar to those in other areas of the building, the problem of egress stands out most. Recommendations for the problems evolving around the confusion caused by exits have been made in the above discussions on the Council Chamber.

At the east end of the second floor, the other two anterooms (Commission and Patriots Room) border a third room (Representatives Hall) and a central corridor. The arrangement and dimensions of the rooms at this end are somewhat identical to the arrangement and size of the rooms at the west end. These rooms and those at the west end have similar problems, and the same occupancy loads.

5. <u>Central Staircase (Rotunda)</u>: The rotunda, or central staircase, of the Old State House lies directly beneath the tower. This area, with the exception of the first floor, contains the only access and discharge route serving all floors of the building. Circular wood-frame and plaster partition walls on the first and second floors, and a plastered circular brick wall in the basement, form the enclosure to this staircase. Housed within the central staircase are the circular wood landings of the first and second floors and the circular concrete landing in the basement. Two-sectioned circular wood stairs tie all the landings together.

Again, the central staircase alone does not meet the requirements for the "number of exits," since 780 CMR, Section 2203.7 states that any existing building shall provide at least two means of egress serving every story which are acceptable to the Building Official. In addition, most of the staircase's enclosure is not fire-rated. While this enclosure is unsuitable as 1-hour fire-rated separation construction for the means of egress under LSC-5-1.3, it has no bearing on the structure from the point of view in 780 CMR, Section 2203.12 which does not require a minimum fire resistance rating for the enclosure of a stairway in an existing assembly building.

Moreover, the stairs themselves do not qualify as fire stairs, nor as a means of egress under code. Although codes permits the use of circular stairs as a means of egress, the existing circular stairs of the rotunda fall short of code requirements. Codes (LSC 5-2.2.2.3 and 780 CMR, Section 616.1) require that the minimum tread depth of circular stairs be at least 10 inches, and the smallest or interior radius be not less than twice the stairs' width. The existing stairs have a 6- to 8-inch minimum tread depth and its smallest or interior radius is 1 foot 6 inches in a 4-foot wide stair. Obviously, its dimensions are far less than the minimum required by code. Consequently, the only way to meet code with these stairs is to demolish and reconstruct them. However, demolishing and reconstructing these historic stairs is not recommended.

There are other alternatives, but none come without its their problems. For example, we can construct two new means of egress in the building, but these will alter the historic character of the spaces, destroy historic fabric, and also require the use of building space that can not be spared. The other alternative is to have the building declared a "Totally Preserved Building" which will exempt it from most of the code requirements and definitely limit the occupancy load. There can be problems in a building of this nature if the code issues that apply to the structure and the occupancy load reduction for the structure are not initiated and completed or enforced.

The code insert (780 CMR, Section 436.0) that follows reviews "Totally Preserved Buildings" in detail, and should be considered if we are to overcome some of the problems associated with code:

SECTION 436.0 HISTORIC BUILDINGS

436.1 Scope: The provisions of Section 436.0 shall govern all buildings and structures in the Commonwealth which are legally designated as historic buildings. This section shall preempt all other regulations of this code governing the reconstruction, alterations, change of use and occupancy, repairs, maintenance, and additions for the conformity of historic buildings and structures to this code, with the exception of Section 126.0 for appeals, or unless otherwise specified (see Appendix U).

436.2 Definitions:

Historic buildings: Any individual building or structure, but excluding districts, so designated by the National Register of Historic Places or certified by the Massachusetts Historic Commission and ratified by the Massachusetts Building Code Commission as listed in Appendix U. Historic buildings shall be further defined as totally or partially preserved buildings.

Partially Preserved Buildings: Any building or structure designated as a historic building by the State Building Code

Commission or listed in the National Register of Historic Places and not designated as a totally preserved building in Appendix U.

Restoration: Restoration is the process of accurately reconstructing the form and details of a building or structure or portion thereof as it appeared at a particular period or periods of time by means of removal of later work and/or the replacement of missing original work.

Totally Preserved Buildings: A totally preserved building is a historic building or structure. The principal use of such a building or structure must be as an exhibit of the building or structure itself which is open to the public not less than twelve (12) days per year, although additional uses, original or ancillary to the principal use, shall be permitted within the same building up to maximum of twenty-five (25) per cent of the gross floor area. Totally preserved buildings shall be those listed in Appendix U.

436.3 Totally Preserved Buildings

436.3.1 State Building Code Exceptions: A totally preserved building shall be subject to the following exceptions:

1. Repairs, maintenance and restoration shall be allowed without conformity to this code if the provisions of Section 436.4 have been fully complied with.

2. In case of fire or other casualty to a totally preserved building, it may be rebuilt, in total or in part, using such techniques and materials as are necessary to restore it to its original condition and use group.

3. If a historic building or structure, as a result of proposed work, would become eligible for certification as a totally preserved building and the Massachusetts Historical Commission so certifies by affidavit and it is submitted to the Building Official with the permit application, then the Building Official shall allow the work to proceed under the provisions of this section.

436.4 Mandatory Safety Requirements: All totally preserved buildings shall comply to the following requirements:

436.4.1 Fire Protection Equipment: Fire protection equipment shall be provided according to the following requirements.

1. Manual Fire Extinguishing Equipment: All use groups, other than residential R-3, shall have approved

manual fire extinguishing equipment, as determined by the Fire Official.

2. Automatic Fire Warning System: All residential buildings in use groups R-1, R-2, and R-3 shall conform to the requirements of Section 1216.3.2 of this code. All other use groups shall comply with Items a and b below:

a) Locations: Provide one (1) smoke detector, but not less than one, for every twelve hundred (1,200) square feet of floor area per level. In addition, all lobbies, common corridors, hallways and exitway access and discharge routes shall be provided with approved smoke detectors with not more than thirty (30) foot spacing between detectors. All required smoke detectors shall have an alarm audible throughout the structure or building.

b) Single Station and Multiple Station Smoke Detection Devices: Smoke detectors of single station and multiple station types shall meet the requirements of U.L. 217 and be listed or approved by a nationally-recognized fire-testing laboratory.

3. Manual Pull Stations: A manual fire alarm pull station shall be provided in the natural path of egress in all use groups except R-3. Manual pull stations shall be

connected to the building fire warning system in conformance with (NFPA 72A) as listed in Appendix B of the fire code.

436.4.2 Exit Signs and Emergency Lights: Approved exit signs and emergency lighting, where designated by the local Building Official, shall be provided in compliance with Sections 623.0 and 624.0 of this code.

Exception: All totally preserved buildings need not comply with Sections 623.0 and 624.0 if not occupied after daylight hours, except that paths of egress shall have exit signs.

436.4.3 Maximum Occupancy: Occupancy shall be limited by the actual structural floor load capacity as certified by a qualified Massachusetts registered professional engineer or architect or as per Section 606.0, whichever is less. Said floor load shall be posted as per the procedures set forth in Sections 119.0, 120.0 and 705.0. The owner shall submit evidence of this certification and related computations to the Building Official upon request.

436.4.4 Limited Egress: Where one or more floors of a totally preserved building are limited to one (1) means of egress, the occupancy load shall be computed as follows:

1. Floors Below the First Story: Not more than one (1) occupant per one hundred (100) square feet of gross floor area with a maximum occupancy of forty-nine (49).

2. First Story: Not more than one (1) occupant per fifty (50) square feet of gross floor area.

3. Second Story and Above: Not more then one (1) occupant per one hundred (100) square feet of gross floor area, or thirty (30) occupants per unit of egress width, whichever condition results in the lesser occupancy load.

436.4.5 Inspections: The Building Official and Fire Official shall inspect all totally preserved buildings not less frequently than once every year in order to determine that the building or structure continues to conform to Section 436.4. A qualified Massachusetts registered professional engineer or architect shall certify every five (5) years thereafter as to the exact floor load capacity of the building or structure. The Building Official shall certify all totally preserved buildings not less frequently than once every year. Fees shall be established at $25 per building per inspection.

436.5 Historic Buildings Not Qualified as Totally Preserved

436.5.1 Applicability: This section and Article 22 shall apply to all historic buildings which are not defined as totally preserved buildings.

436.5.2 Continuation of Use and Occupancy: The legal use and occupancy of any partially preserved building may be continued without change or further compliance to this code. The provisions of Section 436.4 shall be required for historic buildings accessible to the public on more than fifty (50) days per year.

436.5.3 Inspection, Certification and Fees: The building inspector shall inspect all partially preserved buildings not less frequently than once a year in order to determine that the building or structure continues to conform to Sections 436.5 and/or 436.4. If in conformance, then the inspector shall issue a certification. Fees shall be in conformance with Table 108.

436.5.4 Fire Damage: If a building or structure is damaged from fire or other casualty, it may be restored to its original condition using techniques and methods consistent with its original construction, or it shall meet the requirements of this code provided these requirements do not compromise the features for which the building was considered historic when listed in Appendix U of this code or the National Register of Historic Places.

436.5.5 Repairs and Maintenance: See Article 22.

436.5.6 Change in Occupancy: See Article 22.

436.5.7 New Systems: See Article 22.

436. 5.8 Lesser and Equal Hazard: See Article 22.

436.5.9 Greater Hazard: See Article 22.

6. First Floor: The first floor, like the second floor, houses assembly areas. These areas consist of Keayne Hall, and Whitmore Hall which is currently divided into three rooms.

Keayne Hall, the largest of any single one of the areas, is west of the central staircase and main exits to the exterior (North and South State Streets) "right of ways." The space has a gross area of 1,403 square feet that is currently used for exhibits. With 70 square feet of this space physically allocated to fixed exhibits and columns, a net area of 1,333 square feet remains to accommodate an 89-person occupancy load.

There are two exits leading from this space. The first is a double exit that leads into the central staircase, and from the staircase to the outdoor exits at the north and south elevations.

The second exit leads directly to the outdoors at the west elevation. The two doors of the first exit are each 3-feet wide, and are combined to form three units of exit width. The second door is 48 inches wide and alone forms two units of exit width. When combined, the two exits have the capacity to accommodate the passage of 500 persons (e.g., 5 units multiplied by 100 persons/unit equals 500 persons), although they are only expected to accommodate the 89-person occupancy load. However, code (LSC-9-1.7.2) allows for a density increase of 1 person per 5 square feet if aisles and necessary exits are provided. Under these conditions the occupancy load of Keayne Hall can be increased from 89 to 266 persons, as seen in the formula below.

> Occupancy load equals net square feet of building divided by allowable square feet per person equals 1,330 divided by 5 equals 266 persons.

Although this increase in occupancy load is well below that specified for the exit capacity, this load should still be lowered considering the potentially hazardous conditions imposed on the public by a structure not meeting building and life safety code requirements. By reducing the occupancy load, we can reduce the potential impact on human life and safety.

Partitions and doors which divide this space from the central staircase (staircase enclosure) do not provide the 1-hour fire rating required by code. This can be remedied, but not without extensively altering building fabric with additional materials and assemblies that meet the required fire rating. Several doors will have to be changed and the walls' construction may have to be altered. These are tasks that the NPS is reluctant to perform, since they most certainly will result in the permanent loss of historic building fabric, and the loss to the integrity of the historic scene.

Whitmore Hall is at the first floor's east end with its easternmost section converted to an office (old library) and temporary storage (secretary office). Its western section is a sales area. In reality, these areas are storage, light business, and office spaces but calculations for their occupancy loads are made as though they were "assembly areas" since they, like the attic, are only incidental to the predominant assembly use of the building. Consequently, the occupancy loads for the spaces above are as follows:

Secretary's Office	- 17
Old Library	- 27
Sales Area	- 55

These loads are based on respective floor areas of 252 square feet, 399 square feet, and 829 square feet, divided by an allowable floor area of 15 square feet per person for the assembly occupancy.

The secretary's office is in a remote corner of the building and, if ever occupied, its occupants must pass through the old library and sales area before gaining safe access to the central staircase and major exits to the streets. A clear and unobstructed path of travel should be provided through the adjacent spaces for the occupants' welfare. Although the 2-feet 6-inch wide door of the space provides 1 unit of exit width, which is sufficient to serve 100 persons, this exit is currently partially blocked by bookshelves and boxes. The obstructions decrease the capacity of the exit and retard the flow of occupant traffic.

Likewise, the exit from the old library is partially blocked by shelves and a desk in the sales area. Obviously, since the space is treated as an assembly area and must provide safe exit for its 27 occupants, as well as the 17 occupants of the library, its exits should also be cleared of obstructions that restrict safe travel.

Paths of safe travel must be clearly defined in the sales area where the two exits must provide safe passage for its 55 persons, as well as the 44 persons of the secretary's office and the library. Although calculations indicate that the exits have the capacity to accommodate as many as 300 persons, there is no way these exits can be totally utilized under the current arrangement of this space. The contents of the space are poorly arranged so that they block the paths of travel, and there is a floor level change above the steps at the approach to the exit. These obstructions, in themselves, reduce the exit capacity and consequently reduce the occupancy load of the space.

Under the circumstances, the occupancy load at this section of the structure should be limited to whatever capacity the "authority having jurisdiction" deems necessary to provide for the occupants' safety, health, and welfare. In addition, the partition assembly containing the doors of the space and enclosing the central staircase is of less than adequate fire rating. Furthermore, preservation demands restrict our ability to alter the space to provide for total fire protection.

7. Basement Floor: There are a number of rooms in the basement which have a service or utility function. There are two toilets, an electrical room, three storerooms, and a workshop. The central staircase, which has concrete block and brick walls at this level, fronts the basement spaces on the east. One of the current storerooms still functions in its historical capacity, while another room was once the old engineer's room. A third room historically used as a storeroom is now the workshop.

Each space is divided from the others by asbestos painted partitions and wood doors that provide egress for the occupants. Occupancy loads for these areas are computed on the basis of 15 square feet per occupant since the areas are only incidental to the assembly occupancy classification, which is the predominant building use. Consequently, the occupancy loads of the basement spaces are as follows:

SPACE	AREAS (SQUARE FEET)	OCCUPANCY LOADS (PERSONS)
Storeroom No. 1	168	11
Storeroom No. 2	300	20
Storeroom No. 3	322	21
Work Shop	630	42
Toilet No. 1	-	N/A
Toilet No. 2	-	N/A
Electrical Room	-	N/A

However, at this time, with most of the basement serving as a service or utility space, it is unlikely that we will ever see the specified occupancy loads. Nonetheless, it is to our benefit to know what to expect should the use of the spaces ever change.

The doors from the old engineer's room and its adjacent storage room measure 2 feet 10 inches and 2 feet 8 inches, respectively. Together, these doors form three units of exit width and provide for the passage of some 300 persons. The persons must then pass through the workshop to the central staircase on their way to safety.

The workshops' door measure 3 feet and forms another 1-1/2 units of exit width, providing for the passage of another 150 persons.

This door must provide safe passage for occupants in the workshop as well as for those of the engineer's room and the adjacent storage room. If we base this door's exit capacity on units of exit width alone, the door is obviously too small to handle the occupants of the workshop and those of the storage and engineer's room. However, if we base the door's capacity on occupancy load and lower the occupancy loads of the rooms emptying into it, the door size will be sufficient. The sufficiency of the door must also allow for a projected two to three additional persons who will be coming from the subbasement through the engineer's room.

With the "rough occupancy loads" of the attic at 35, the second floor at 196, the first floor at 188, and the basement at 94, the total rough occupancy load of the building becomes 513. However, to establish the "true occupancy load" of the building, a diagram showing aisles, means of egress, and seating should be submitted to the Building Official who shall be responsible for making that determination. He shall also determine whether the existing means of egress are adequate. All submissions to the Building Official should take place during the Comprehensive Design Phase of this project.

8. <u>Handicapped Access</u>: The building in its current configuration does not lend itself to access by the physically handicapped. Entrances are stepped above the ground and cannot be independently accessed by persons in wheelchairs or on crutches without the assistance of the current tenants. When

inside the building, there are abrupt floor changes that prohibit handicapped access, and there is no access to the upper floors. Neither of the three toilets in the building is accessible to or equipped for handicapped usage.

Under these and similar circumstances, the "Uniform Federal Accessibility Standards" (UFAS) mandates that physically handicapped persons have ready access to, and use of, the Old State House and other buildings in accordance with the Architectural Barriers Act, 42 U.S.C. 4151-4157. These standards are based on the American National Standards Institute Specifications for making Buildings and Facilities Accessible and Usable by Physically Handicapped People (ANSI A117.1).

Under the standards listed above, we shall perform the following at the Old State House:

a) Make the first floor accessible to all handicapped persons. Current thinking is to ramp up to the west entrance to permit handicapped access into the building. Once in the building, provisions will be made for handicapped access where the floor level changes at the east end of the first floor.

b) Provide for handicapped experience to the upper floors (2nd, 3rd) by use of administrative solutions (slides, film, etc.) since limited floor space may prohibit the installation of elevators, lifts, etc., for access to these floors. However, if an elevator is desired for handicapped access to the second or basement floor, the best place to locate it is west of the rotunda near the existing wall (see Preliminary Study Drawings Leading to Architectural/Engineering Recommendations, Sheet 6). It should be noted that some available building space will be lost, and the building fabric and the historic scene will be impacted. Therefore, the installation of an elevator is not recommended. However, this installation remains a management decision.

c) Provide rest rooms which are accessible to the handicapped. While this may not occur at the Old State House, rest rooms are provided at 15 State Street across the street from the building. Site work may have to take place on the brick pavement so that wheelchair maneuvering is not restricted.

9. Fire Detection and Suppression Systems: In Section b above, the discussion indicates that the doors, interior partitions, ceilings, and means of egress are unacceptable under the life safety and building codes. However, we as preservationists, have elected not to alter these building component's in areas of high visibility (first and second floors) due to the visual impact on the historic fabric and scene. Under the circumstances, it may be that the building's interiors are never brought up to code, although there are a number of ways to reduce their impact on the life, health, and safety of the public by overcoming the high incidence of combustion during a fire.

Begin by examining the building's fire detection and suppression systems, to see if they are functioning properly and if they are adequate for the task they must perform. Next, reexamine the building area and occupancy load.

The building is currently protected by "Rate of Rise" heat detectors and alarms which ring at the city of Boston's fire department, and a series of manual water or chemical-base fire extinguishers. The smoke detectors and alarms are wall or ceiling mounted and are adequate for the services they provide; however, some are broken or disconnected, leaving the areas of their location unprotected. Fire extinguishers are mounted on the walls in inconspicuous places such as the closets and pantries. The extinguishers should be checked for proper operation. The number of extinguishers is adequate for the area they protect. Code requires that there be at least one fire extinguisher for every 3,000 to 4,500 square feet of floor area. Since there is an average of two extinguishers per floor, the Old State House's current fire extinguishers serve no more than 2,000 square feet of area each. To increase fire protection, the number of chemical extinguishers can be increased in slightly hazardous areas such as the attic and workshop, or an alternative manual or automatic sprinkler system can be installed.

The manual fire suppression system under consideration is a system of standpipes. The pipes and their hoses may be housed in the closets or pantries surrounding the central staircase of the building and can be supplied by piping hooked up to the city water supply. Interfaces with the city of Boston's water department will be required at this point. A siamese connection may also be provided at the exterior of the building for use by the fire department. Although this system (the siamese connection and standpipes) is intrusive or impacts the structure, it is far less intrusive than an automatic sprinkler system.

An approved automatic sprinkler system is required by code (LSC-9-3.5. and 780) in assembly occupancies used for exhibition or display purposes only when the display area exceeds 15,000 square feet. Although desirable for the Old State House, such a system is not required since the total floor area of the building is only 14,000 square feet. However, if a system of this type is selected in order to reduce the impact on the public or collections, we must consider its impact on the building as well. The installation of an automatic sprinkler system will require extensive alterations to the historic building fabric, as well as visual intrusion on the historic scene. If the sprinkler system is left exposed its piping and heads will be visible along the ceiling of each room, which may be less of a impact on the structure than the current track lighting installed there. Risers from the system will run along the walls. If the sprinkler system is concealed, the only part of the system to remain visible is the heads. Horizontal runs and riser piping would be concealed in the walls and ceilings. Hookups to the city's water supply will also be required. These alterations however, are considered far less intrusive than altering the existing stairs, adding another staircase, or replacing doors and wall assemblies in the building. Moreover, the intrusion by this system is such a small price to pay for public safety and protection of the building during a fire. Nevertheless the decision is left up to the "authority having jurisdiction," whose decision on this or any issue of the code is final.

10. Other Code Issues: As the structure develops into a product of preservation/restoration and adaptive use, other code issues will be continually addressed. The following are included:

a) Structural Adequacy

b) Adequacy of Electrical System

c) Adequacy of the Plumbing Facilities, etc.

The structural integrity of the building has in the past been questioned, but it will undergo a complete study as a part of this report. Recommendations for its repair or stabilization will be made to conform to the requirements of the Commonwealth of Massachusetts State Building Code, Fourth Edition, and Preservation Standards outlined in NPS-28. Other codes and guidelines will also be consulted.

The electrical system must also be reexamined and made to conform to code, if necessary. After a field inspection of the system by DSC Electrical Engineer Ray Johanningsmeier, he reported that the current system was one utilizing armored cable (BX) wiring; a wiring not allowed in places of assembly without exceptions made by the local building authorities. This system, and any proposed system of wiring (i.e., attic), should be checked for compliance with the local codes.

Plumbing facilities at the Old State House are inadequate for serving the number of occupants or visitors (occupancy load). The National Plumbing Code requires the following fixtures:

URINALS	MEN	WOMEN
	If urinals are used, one other base water closet should be provided than the number specified	

LABORATORIES	3 for every 36 to 60 men	3 for every 36 to 60 women
DRINKING FOUNDATIONS	1 for every 75 persons	1 for every 75 persons
WATER CLOSETS	3 for every 36 to 55 men	1 for every 36 to 55 women

The building does not come close to these requirements and is too small to give up the space to acquire them. Therefore, the rest rooms at 15 State Street should be kept open to serve the general public as well as handicapped visitors. Should this not be possible because of a change in use of the visitor contact space at 15 State Street, then adequate rest rooms must be provided at the Old State House. The basement is best suited for the installation of rest rooms, but must be made accessible by the use of elevators.

K. ENERGY CONSERVATION ANALYSIS: In considering energy conservation at the Old State House, we must utilize the basic design of the structure and its elements to work as they were intended. The inherent qualities of the structure's design, if correctly used, will enable us to reduce the degree of retrofitting the structure, and likewise save on the initial and operating costs of energy during its lifetime.

For example, since advantage was taken of the natural light provided through the windows at the Old State House, the comparative amount of electrical energy required to provide lighting and power circuitry services to similar size buildings with fewer windows has been substantially reduced. It is obvious that these windows were not only sized to ventilate the building, but also to admit the maximum quantity of light into each of its spaces. Since most of the spaces are illuminated by sunlight, the need for artificial or electrical lighting has been minimized, and to some extent is only supplementary. The supplementary lighting is currently used to provide accent lighting for exhibits, paintings, and special tasks, and to illuminate the building during inclement weather when natural light is scarce. Moreover, the provision of a large number of receptacles along the walls is ingenious since they can be used to accommodate additional "task lighting" and serve portable appliances and machinery as needed. Any intrusion on the historic fabric of the structure by "area lighting" has been minimized by these efforts.

ASHRAE has established a procedure for determining a "lighting power budget" which has been adopted in some areas as a mechanism for determining how much electrical energy will be allowed for electrical purposes in new buildings. Although the Old State

House is not a new building, we plan to rewire the attic for electricity, possibly modify the electrical lighting and receptacles on the other floors to accommodate new and existing exhibits, and possibly install full environmental controls in the structure. As a result, consideration should be given to using this procedure as a guide. The lighting power budget is intended only as a mechanism for encouraging energy conservation in lighting and is not a design tool. Once the budget has been established, the designer is free to design the attic and other lighting within the budget and for the circumstances. After the lighting design is complete and in use, much can be done to conserve energy while staying within the lighting power budget. For example, all elements of the structure that affect light need to be kept clean. Luminaries, diffusers, lenses, window glass, and wall surfaces tend to collect dust, which reduces their light controlling efficiency. Furthermore, the walls and ceiling especially should be of a light color so that they reflect the maximum percentage of the illumination level.

In addition to conserving electrical energy, the windows of this structure can help to conserve mechanical energy as well. They provide ventilation when open, and when closed they help keep out the adverse weather elements. These windows will also help to back up the environmental control system in use. The windows of the attic dormers were designed to allow air to enter the structure in the summer. Should an attic fan be installed, it and the open windows will circulate the air and therefore help keep the building cool during the summer as long as the doors to the attic and staircase remain open. Fans, along with the attic's and other windows of the building, may eliminate the need for summer air conditioning and likewise conserve energy at this time. During the winter season, if the windows are properly weatherstripped and caulked, they will help to conserve energy by reducing infiltration of heat to the outdoors and will thereby lessen the strains on the heating system. Double glazing or operable interior storm windows may also be installed at the windows to help reduce energy loss in the space. Although, if installed, these features will be a great asset to the existing heating system or an HVAC system, care must be taken to reduce the visual impact of double glazing or interior storm shutters on the historic appearance of the building.

Aside from the windows, other components of the structure play an important role in conserving energy. Some of these components are the roof and its overhang, doors and vestibules, and the buildings walls.

The roof, if properly insulated, helps to keep the sun's rays from entering the structure in the summer, and during the winter it keeps it from leaving. Consequently, an insulated roof can reduce the heating and cooling loads of the building. Roof overhang likewise helps to shade the building. Doors and the vestibules, like the windows, also provide good insulation when properly caulked or weatherstripped.

The massive walls of the building play an important part in conserving energy. These 24- to 36-inch brick walls help to store the sun's heat during the day and release it into the structure's interiors during the night and early morning when it is needed. This aids in reducing the start-up time of the heating equipment and the time it takes to first heat the structure during the day.

Although the inherent building features of the Old State House are essential in helping to conserve energy, they cannot work alone. There must also be an efficient and practical environmental control (heating or cooling) system that is also sensitive to the structure's historic fabric.

Currently, the steam heating system is not operating efficiently and is causing damage to the building and its collections. Because of vagaries in piping and controls, much of the energy (steam heat) provided by the boiler is wasted as the basement and parts of the first floor are chronically overheated. For the same reasons, second-floor spaces are poorly heated and, as a consequence of this poor distribution, the wall finishes and the exhibits in both areas show signs of deterioration.

Due to the problems of the heating system at this time, it should at least be repaired, updated, or even replaced with a more efficient system. The pros and cons of the existing heating system and alternative environmental control systems are discussed in Section E (Mechanical) of this report.

L. STRUCTURAL ENGINEERING REPORT WITH VIBRATION AND NOISE STUDY

1. Introduction

a) Description of Construction: Floors are joist and beam construction supported on the brick walls and on interior wood or cast iron columns. The Old State House is a timber-framed building with brick walls.

The roof and attic floors are carried by heavy timber trusses which span the entire width of the building producing a column-free second-floor space.

Most of the structure in the roof and attic appears to be from the reconstruction of 1748, after the interior of the original building was destroyed by fire.

From an engineering viewpoint, the building has no particular structural distinction. The roof trusses are interesting in form and detail, as is the central staircase, but the structure is essentially ordinary in nature, representing no more than a workmanlike design characteristic of the locally available materials and technology of its time.

The lumber with which the building is framed appears to be of excellent quality, consistent with the availability of good dense first-growth trees abundant at the time of construction. Lumber dimensions and shapes are characteristic of those used when wood was plentiful but cutting relatively difficult, being much more of a square profile than our modern dictates of structural efficiency encourage. In common with many old buildings, the floors are less strong and less stiff than we consider appropriate today.

The walls are solid brick and are relatively massive; judging by the apparent lack of formal connections between floors and wall, they were intended to achieve stability by their weight and thickness alone. That the walls are considerably out of plumb suggests a fallacy in this concept, notwithstanding the possibility that the underpinnings of the subway builders at various times may also have contributed to this fault.

The major roof trusses are interesting in their use of double-diagonal compression chords, and in incorporation of steel straps for making tension connections. It is not apparent whether the straps are original or a retrofit, but it is noteworthy that a modern wood truss would employ the same concepts.

The central staircase is impressive architecturally and was probably always overly flexible, having originally only the stringers to carry its span. Its structure would have been more at home in a domestic, rather than public, environment. Its longevity is more likely due to the common sense of users over the years who, observing its shakiness, probably proceeded one step at a time. The 1976 strengthening has much improved the stiffness of the stairs.

In examining the building using modern analytical techniques, many conditions exist which "do not work." There are also conditions existing which are considered unacceptable in later practice. Yet the building has stood for 275 years; an obvious dilemma.

The following pages give detailed observations and structural recommendations.

b) Existing Documentation: The existing floor framing for the Old State House is shown on Drawing S-1 of the HSR drawings prepared by the NPS. The layout and size of the beams and girders shown on this drawing were previously determined by field measurement. Additional information is available from sketches made during the 1974 renovations which show the framing at the first- and second-floor stair landings and the member sizes of the trusses under the tower. These sketches are shown on Drawings 54 through 65 of Appendix A.

The framing of the subway structure supporting the Old State House is shown on the original 1902 and 1907 drawings. These drawings also show the steel floor framing of the first floor at the library and Whitmore Hall. This information is also shown, in part, on the HSR drawings.

c) Recent Structural Work: A modest renovation of the building was undertaken in 1974 and is described in the drawings prepared by the architect at Stahl-Bennett, Inc., with LeMessurier Associates as structural engineers. The structural work undertaken at this time was comprised of reinforcing the two trusses under the tower with steel angles, strengthening a supplementary roof truss, reinforcing the stairs and stair landings, and adding ties between the east wall and the roof. This work is described on the drawings.

Renovation of the State Street Station was undertaken in 1976 and is described in the drawings by architects Wallace, Floyd, Ellenweig, Moore, Inc., with Simpson, Gumpertz and Heger, Inc., as structural engineers. The structural work was required to install a new escalator and elevator, and entailed modification and underpinning of columns under the west end of the south wall of the Old State House.

Cracks in the north wall near the northeast corner have been patched within the last 3 years by NPS personnel.

d) Investigations: The following survey work was conducted at the building during the months of September and November 1987.

(1) Floor elevations were taken throughout the building, generally at each column line at the exterior wall, at the columns and at the midspan of the supporting girder below. These elevations were referenced to the Boston City Base. These floor elevations are shown on Illustrations 31, 32, 33, and 34.

(2) The exterior walls were surveyed for plumbness. Measurements were taken at various locations along the walls as shown on Illustrations 35 through 39. The locations shown were chosen so that measurements taken in 1984 by D. Baugh and Associates could be duplicated. Levels were also taken along the top of the water table at the first floor. This information is shown on Illustrations 40 and 41.

(3) The side walls of the window openings were checked using a spirit level and were found to be reasonably plumb.

(4) Typical member sizes of the timber roof trusses were measured in the upper attic and checked at one location in the lower attic where one side of a typical truss has been exposed. The truss-to-wall bearing condition is visible at this location. The floor framing of the lower attic floor was

sized where the floor had been removed when the trusses supporting the tower were reinforced. The size of the second-floor framing was measured at the openings cut in the ceiling of the second floor over the secretary's office and the library. The size of the first-floor framing was measured and the condition of the timbers was checked at openings cut in the ceiling of the engineering room.

The exterior walls, the areaway under the sidewalk at the west end of the south wall, the boiler room, central staircase, tower, and the subway structure were inspected during several walk-through tours.

Vibration measurements were carried out by BBN Laboratories, Incorporated (BBN).

2. Foundations

a) Existing Conditions: The Old State House is entirely supported by the MBTA State Street Subway Station. Initial underpinnings were carried out for construction of the East Boston Tunnel located, under the northern half of the building. No detail drawings are available of the tunnel structure, but drawings of later construction show that the tunnel roof directly supports the basement floor. The reconstruction of the eastern half of the first floor of the building was carried out during this time and drawings are available showing the steel framing.

Construction of the Washington Street Tunnel and associated station work was subsequently carried out, and this completed the underpinning of the building with subway structure. Drawings of this work from the MBTA archives show the tunnel and station to primarily comprise steel beams, trusses, and columns encased in concrete. The tunnels and station are soil supported, the bottom of the slabs varying between about 25 feet to 45 feet below grade. Soil conditions are not known.

Drawings of the East Boston Tunnel work are dated 1902 and Washington Street tunnel work are dated 1907.

A renovation of the State Street Station was carried out in 1976 and is described on drawings by Wallace, Floyd, Ellenweig, Moore, Inc., as Architects and Simpson, Gumpertz and Heger as structural engineers. The structural work affecting foundations comprised the following:

(1) Removal of a 30-foot length of existing wall directly under the west end of the south wall of the building.

(2) Extension downwards by 8 feet, and

provision of a new footing for a column (S-13) located under the south wall of the building about 65 feet from the west end.

(3) Underpinning of two columns (S-16 and S-17) located under the south wall of the building 23 feet and 12 feet from the west end, for installation of a new elevator.

(4) Removal of three columns (S-24, S-26 and S-16.5) and provision of four new beams as replacement support under the basement floor, spanning between the East Boston Tunnel wall and columns under the building's south wall. This work occurs in an area from 20 feet to 30 feet east of the west wall of the building, and from the south wall to about 20 feet northwards.

That the various underpinning work has not seriously impacted the Old State House is evidenced by the elevations taken of the water table feature at the exterior walls given on Illustrations 40 and 41. This shows essentially level conditions, the maximum discrepancy in elevation of the four corners of the building being only 3/8 inch with the maximum deviation of high and low points being 1-1/2 inches.

Any movement of the ground due to the original tunnel construction has long since past. Significant movements of the ground due to the 1976 work would are unlikely since changes in soil pressures are slight. If any movement due to the underpinning operations occurred, these have now past with no future movement expected. The possibility of foundation movement causing cracking at the corners of the building is dealt with later in this report.

b) Buildings Erected Recently: During the past 15 years or so, several major buildings have been erected close to the Old State House as noted below.

(1) Sixty State Street about 200 feet to the northeast having 40 floors above grade.

(2) Bank of New England about 100 feet to the north having 35 floors above grade.

(3) Exchange Place about 200 feet to the east having 40 floors above grade.

(4) One Boston Place about 100 feet to the west having 40 floors above grade.

(5) Devonshire Place about 200 feet to the south having 40 floors above grade.

c) Effects of Constructions: Such major construction can cause ground movement due to a variety of factors.

(1) The weight of the building.

(2) Changes in the water table from pumping to keep basements dry or during construction.

(3) Horizontal ground movement towards the basement excavation.

We know of no documented reports of any such effects, however, but we cannot rule out the possibility that such construction related ground movement may have contributed to cracking in the exterior walls.

The MBTA has not kept records of any tunnel movement over the years. The subway structure under the Old State House provides, in effect, a "deep" foundation for the building. It is of note that a deep foundation is far less affected by the construction of adjacent buildings than would have been the case with the original shallow footings of the building.

Because there is evidence of recent cracking of the Old State House walls at the southwest and northeast corners of the building, particular attention has been paid to the foundations in these areas.

Subway Column S-18 supports the southwest corner below the basement floor, passing through the boiler room down to the Orange Line platform and foundation some 35 feet below. The column in the boiler room is exposed steel and is somewhat rusty, but not deteriorated. The column within the subway space is behind a tiled concrete masonry unit (CMU) wall and cannot be seen. The wall however, contains a vertical crack at the corner adjacent to the column, suggesting that recent movement of the structure might have occurred (Illustrations 52 and 53). There are also some very minor hairline diagonal cracks in the tiled wall to the east of the column. The MBTA has been asked to open up the column for inspection, but this has not been done yet. Cracks also occur in the basement walls near the boiler room steps and near Column S-17, which is located under the south wall about 16 feet from the west end, together with cracks in the support beam for this wall. These are shown on Illustration 12 and appear sympathetic with the above grade wall cracks.

Cracks also exist in the concrete surrounds of a steel column which is located at the end of the station platform at the East Boston Tunnel (Blue Line), and which supports the northeast corner of the Old State House. The cracks are predominantly vertical, and the MBTA has been asked to investigate these as well. The MBTA has also been asked to monitor the elevation of these columns using surveying instruments and relating to a bench mark in the tunnel about 400 feet from the building. Such surveying will not pick up very small movement, but will identify movement greater than about 1/8 inch.

Some small parts of the foundation walls, which are exposed in the boiler room, consist of a rubble wall which appears weak due to the loss of cementitious material. The bearing stresses on these walls are extremely low and no structural failure is indicated. The walls should, however, be repaired to avoid future deterioration.

Moisture damage has occurred to the plaster at the bottom of the circular brick walls in the basement which surround the central stairs. This appears as a rising damp condition. Old State House employees report that this area has been flooded from time to time in the past, but this no longer occurs since sidewalk repairs were made. No structural distress is apparent.

A 6-foot wide by 5-foot high vault runs along the outside of the north wall under the sidewalk and extends about 35 feet from the northwest corner. This vault is accessible through a hatch in the wall of the basement storeroom. The walls and roof are reinforced concrete that appeared to be in good condition and no signs of water intrusion were found.

d) Recommendations

(1) Close liaison should be kept with the MBTA regarding their investigation of conditions at columns at the southwest and northeast corners of the building, and in their level surveys.

(2) Cracks in the walls in the boiler room should be repaired by patching. This should be done after repairs are made to the MBTA columns, if the columns are found to be defective or settling.

(3) Deteriorated rubble walls in the boiler room should be stabilized.

(4) The rising damp conditions at the circular walls in the basement around the central stairs should be treated.

(5) Spalled concrete at the boiler room walls and roof should be patched.

3. Floors

a) Existing Conditions: The first and second-floor structure generally comprise wood joists spanning east to west onto beams which span in the north and south direction between the exterior walls and a central row of wood or cast iron columns. Beam spacing is about 10 feet on center. This layout is illustrated on Drawing S-1. The first floor over the eastern half of the building from the central lobby to the east wall is a steel framed raised floor which was installed during subway construction. This floor forms the ceiling of the State Street Station subway entrance.

The basement floor is a framed concrete slab forming the roof of the subway station and tunnels.

The western portion of the first-floor and second-floor structure is hidden by plaster ceilings, therefore, ceilings have been opened up at various locations in order to examine the member sizes, spacing, species, condition of the wood, and connection details. The inspections revealed the typical original framing members which predominate, as described below, but also some larger and more modern joists randomly located. Layout of members given on Drawing S-1 should be considered only to represent the original beam structure, excluding any subsequent local modifications that may have occurred.

The original joists are typically 3-1/2 inches wide by 5 inches deep at 18 inches on center, the species being white pine or eastern spruce. Beams are typically 12 inches square with notches in the upper portion for joist support. The spans at the east and west end of the building are 12 feet 7 inches and 11 feet 10 inches, which is longer than the typical interior spans of approximately 9 feet 0 inches. At the first floor at the west end, the joists of the end span were seen to be 4 inches by 6 inches at 22 inches on center. The joists for the even longer span at the second floor at the east end are the typical 3-1/2-inch by 5-inch dimension, however.

Bearing of joists on the beams of 1-3/4 to 2 inches was observed at inspection openings cut in the ceiling of the basement in the engineer's room and in the ceiling of the first floor in the library and secretary's office. No nailing or other positive connection was observed. Bearing of joists on the exterior east wall was inspected through a floor access panel in the corner at the northeast corner of the second floor. The joists bear directly on brickwork with no sill member or anchor apparent. Bearing dimension is quite random, averaging about 2 inches. No rot was observed at these points of inspection.

Bearing of a beam on the exterior south wall was observed through an inspection opening cut in the ceiling of the basement in the engineer's room. The depth of bearing is 7 inches, and no anchor between beam and masonry wall was observed. The beam had been mortared solidly into the wall, with no attempt to leave an air gap. Mortar was removed to observe the condition of the beam end. Some dry rot was present at the bottom of the beam at the bearing, penetrating approximately 1/4 inch into the wood from the bottom. The beam end was dry and otherwise sound, and no spread of rot along the beam has occurred.

A column previously existed in the center of the building in the library room about 12 feet in from the east wall, but this was removed sometime in the past. The main floor beam, which is apparently a single member extending the full distance between the north and south walls, surprisingly survived this removal probably by resting partially on a partition. Temporary shoring has been installed and this is adequate until a permanent column can be reinstalled.

Wood flooring primarily comprises a 1-inch hardwood finish floor plus one layer of 1-inch boards spanning north-south onto the joists as subfloor. However, in the Council Chamber the finish floor is covered over by another 1-inch finish floor.

No significant obvious sagging or obvious deflection of the floors that would suggest any structural distress is apparent. The floors all feel firm to the foot. The floors however, are by no means level. The second floor varies from a high point at the southwest corner of 43.93 feet to a low point of 43.49 feet at the entrance to the Council Chamber, a difference of 5-1/4 inches. A study of the floor elevations reveals no obvious uniform slope or dip to the floors, but rather a random pattern of rise across the floor is shown. The other floors show a similar random pattern of elevation change, but the differentials are smaller. The attic has a 2-3/8-inch difference, the first floor 1-5/8 inch, and the basement 3 inches. The elevations of points on one floor are not a constant dimension from corresponding points on the floor above and below. Reasons for this lack of consistency are not known. Elevations at the east half on the first floor where a new steel framed floor was added during subway construction are very consistent, indicating that settlement is not the cause of the floor unevenness. Floor elevations are given on Illustrations 31, 32, 33, and 34.

One pattern of consistent unevenness is apparent and explains hairline cracking in plaster walls at the second floor in the rooms around the central stairs. The walls around the central stairs are load-bearing and are continuous down to the basement, whereas walls at the west end of the Council Chamber and east end of the Representatives Hall are nonload-bearing partitions resting on the floor. The direction of shear cracking in the plaster suggests a downward movement of the floor-supported partitions relative to the circular bearing walls. Such movement is verified by the floor elevations recorded. Movement may have been caused by wood creep, shrinkage and elastic deflections. It is unlikely that any further significant movement will occur, other than that caused by seasonal or humidity changes in the wood or any permanent change in live loading. The cracks should be patched, but since these will remain as a weak point in the plaster, the cracks may reoccur.

Some strengthening of the first floor and second floor at the lobby around the central stairs was carried out in 1974 under the direction of LeMessurier Associates. Floors were strengthened by adding new steel and wood beams and joists to give a live load capacity of 80 psf. Details are given on the drawings dated January 1974 by Stahl-Bennett, Inc., architects for the work.

The east and west walls of the building are considerably out of plumb and it can be expected that wall movement has significantly reduced the joist bearing dimensions. The bearing conditions must therefore be inspected.

It is recommended that mechanical anchorage be provided between the first and second floors and exterior walls. This requirement is addressed in detail in the section dealing with the exterior brick walls.

b) Load Capacity: In order to determine characteristic allowable stress design values for the wood, the joists and beams were examined in situ by Albert G.H. Dietz, Professor Emeritus of Building Engineering at the Massachusetts Institute of Technology.

Professor Dietz reported that the wood observed is of superior quality, being dense, straight grained, with a minimum of knots and defects, and is characteristic of first-growth lumber having a close spacing of growth rings. The following allowable basic stress values in pounds per square inch are considered appropriate and have been used to arrive at the allowable floor loading capacity.

	Beams	Joists
Bending stress Fb Single member	1,300	-
Repetitive member	-	1,650
Tension Ft Shear Fv	70	75
Compression perpendicular to grain $Fc_{\perp}$	405	405
Compression parallel to grain Fc	925	1,150
Young's Modulus E	1,300,000	1,500,000

The predominant joist size observed was 3-1/2 inches by 5 inches, and this was also the smallest size seen. Floor load capacity has therefore been calculated assuming this size exists throughout the first and second floors, except at the westernmost bay of the first floor where joist size was seen to be 4 inches by 6 inches.

The safe live load capacity of the wood framed sections of the first and second floors is 65 psf. At the second floor, the capacity varies throughout the floor. The basic capacity is 65 psf, except as noted below.

(1) Easternmost end bay - 55 psf.

(2) Bay supporting partition at east end of the Representatives Hall - 25 psf.

(3) Beam supporting partition at west end of Council Chamber - 50 psf.

If the joists noted in b above are strengthened, the floor capacity in this area will become 50 psf.

The 65 psf capacity is controlled by the bending and shear strength of the main beams. At a live load of 65 psf, the joist deflections are in the order of span/360, except for the westernmost bay of the second floor where deflections are span/250. At the easternmost end bay of the second floor, where live load capacity is 55 psf, the deflection is span/220 under this load. Common recommendations for floors supporting plastered ceilings are that live load deflections should not exceed span/360.

Live load capacity at the steel framed floor at the east half of the first floor is in excess of 100 psf.

Load capacity of the central row of 4-inch by 4-inch columns supporting the second floor is only slightly in excess of the existing dead loads. These columns must be strengthened or replaced. Cast iron columns supporting the first floor have adequate capacity.

Live load capacity of the first and second floors required by the Commonwealth of Massachusetts State Building Code is 100 psf based upon public occupancy in new construction. Chapter 436 of the code allows lower loads to be accepted in historic buildings, subject to posting of appropriate loading restrictions. If strengthening of floors is not done to provide 100 psf capacity, such restrictions will be necessary.

Floor capacity of the basement floor has not been checked because detailed drawings are not available of all areas of the subway structure which forms the floor. The form of construction suggests that live load capacity is well in excess of 100 psf.

c) Summary of Options and Recommendations

(1) Floor live load capacity of the wood framed western half of the first floor must be limited to 65 psf, unless strengthening of beams and joists is carried out.

(2) The joists supporting the partition at the east end of the Representatives Hall should be strengthened, but first their size should be checked to see whether larger than standard joists were provided. Floor live loading at the second

floor must then be limited to 50 psf unless strengthening of other beams and joists is carried out.

(3) Four-inch by 4-inch wood columns supporting the second floor are inadequate and must be strengthened or replaced to 6 inches by 6 inches. The missing column in the library must be reinstalled.

(4) Floors shall be opened up at the east and west walls for inspection of the joist bearing condition and installation of anchors. The ends of the beams spanning onto the north and south walls shall be opened up so that an air gap can be introduced around the beam, and for installation of anchors; any rot found must be dealt with. The installation of anchors is covered more fully under the exterior brick wall section of this report.

(5) The deflections under the maximum allowable live load at the easternmost and westernmost bays of the second floor are somewhat excessive for plaster ceilings. We do not, however, consider deflection control by itself sufficient reason for strengthening the floors, in view of the disruption to historic fabric that would occur.

4. Central Stairs

a) Existing Conditions: The central stairs extend from the basement to the second floor.

Between the first floor and second floor, the stairs are free spanning through an arc of approximately 300 degrees. The stair between the basement and first floor was originally also free spanning, but posts have been added as a central support. The stairs are comprised of curved wood side stringers with wood treads and risers, some internal diagonal bracing and, originally, a plaster soffit. The joints are glued, nailed, and screwed. The stringers originally acted as the principal strength providing members. Because the span between the first and second floors was so flexible, improvements were made under the direction of LeMessurier Associates in 1974, when the plaster ceiling was removed and replaced with a wood soffit comprising several thin layers of plywood. The thin plywood layers were warped to the required profile and glued and screwed to the bottom of the stringers. The structure was thereby transformed from one which relied primarily on the stringers for spanning strength, to a channel section comprising stringers and soffits, which provides much greater stiffness and strength. Torsional properties were also greatly improved since the structure is now a closed box formed by the stringers, soffits, treads and risers, which is the optimum form for torsional stiffness. The stairs now feel relatively firm to the feet but not rock solid. The stairs between basement and first floor were not altered since this has adequate strength and stiffness by virtue of the added posts.

b) Load Capacity: The required load capacity for full compliance with the Commonwealth of Massachusetts State Building Code is 100 psf. Such loading is applicable to places of egress in new construction. Chapter 436 of the code allows for a reduced load to be acceptable in historic buildings, subject to posting of such loading. The code requires a reduced occupancy load for floors where there is only one means of egress, as is the case for this building.

The load capacity of the stairs is not known and cannot be determined by calculation. We propose that a nondestructive load test be carried out on the stairs between the first and second floor to determine safe load capacity. It is our opinion that the stairs from first floor to basement have adequate strength by virtue of the added posts.

c) Recommendations: The stairs between the first and second floor should be load tested for the maximum anticipated live load multiplied by a safety factor of 1.5. It is estimated that, fully loaded, the stairs could accommodate one person per tread at the outside rail and one person on alternate treads at the inside rail. Assuming the average weight per person is 175 pounds, this is equivalent to 60 psf.

The test loads on the stairs should therefore be 260 pounds on each tread at the outside rail and 260 pounds on alternate treads at the inside rail. Temporary shoring should be provided under the stairs to avoid any damage should the stairs not be capable of carrying the test load. The shoring should be placed so it will not be in contact with the stairs during the test. The stair should be loaded and unloaded incrementally and the deflections and recovery monitored. The test should be discontinued if the deflection is excessive or the stairs do not recover.

NOTE: Since the writing of this report, the stairs have been tested. The results of this test are included in Appendix G.

5. <u>Vibration Studies</u>: Measurements of the vibrations of the building due to subway trains, street traffic, and people walking in the building have been carried out by BBN. The study was done to determine if vibrations have any effect on the long-term durability of the structure. The report of BBN is included in Appendix A.

a) Vibration Velocities: Wood as a structural material will not be affected by the type of vibrations measured. The wood itself is flexible and ductile and has high tensile strength. It is an extremely tough material that under impact conditions can carry many times the stresses normally allowed for sustained loading. Joints between wood members of the floors in this building are all simple bearing type connections that will not be affected by vibrations. Plaster ceilings carried by wood floors can be damaged by high vibrational velocities. The BBN report identifies the most applicable criteria for threshold of damage from floor vibrations to be a velocity of 0.8 inches per second, which is well above the maximum recorded value of 0.34 inches per second. The maximum recorded velocity on the stairs was 0.73 inches per second, close to the 0.8 threshold value, but the stair soffits are plywood, not plaster, and would be unaffected. It is worth noting from the BBN report that floor vibrations from foot falls were far in excess of vibrations from street or subway traffic. Since the floors do not feel any less firm to the foot than other wood framed buildings, common sense would indicate that no plaster cracking problems from vibrations can be expected.

Brick masonry, being a brittle material having low tensile strength, is susceptible to damage from vibrational effects if the tensile stresses produced exceed the modulus of rupture of the material. The most appropriate threshold of damage quoted by BBN is a velocity of 0.05 inches per second at foundations. This value is not exceeded by the foundation vibration measurements which show a maximum velocity of 0.018 inches per second. The foundation threshold value quoted is exceeded by measurements at locations on the north wall at the first floor and on the south wall at the second floor, but, as noted in the BBN report, no standards are available by which these wall vibrational velocities can be judged.

b) Vibrations Displacements: Calculations have been carried out to determine stresses in the wall based on the recorded vibration displacements. The wall has been modeled using the most conservative assumptions of deflected shape considered appropriate, which is as a fixed ended beam spanning vertically between floors, and subjected to the maximum horizontal displacement found. This displacement is extremely small at 0.28 mils (0.00028 inches) and the calculated maximum stress is only 8 psi. When combined with the vertical compression stresses from gravity on the wall, the resulting stress is always compressive.

The conclusion from the above analysis is that the normal vibrations from subway trains and street traffic have no effect on the building structure.

6. <u>Exterior Brick Walls</u>

a) Existing Conditions: The exterior walls consist of solid brick masonry varying in thickness between 24 and 36 inches. The walls are load-bearing and support floor and roof framing, but there are no mechanical anchors connecting the floor or roof to the walls.

The exterior face of the wall is exposed throughout and has been generally well maintained for its age with evidence of repairs, repointing, and rebuilding. The interior of the wall is entirely covered with plaster except for some sections in the basement and at the northeast corner at the second floor where the plaster is missing due to water damage. The exposed brick at this location shows reasonably sound and well bonded mortar, although it is soft by today's standards.

Elevations taken along the water table around the perimeter show conditions to be generally level but with local dipping and rising in a random pattern, the maximum deviation between low and high points being 1-1/2 inches on the south face and one inch on the north face. Elevations are given in Illustrations 40 and 41.

The walls are not plumb, the east and west end walls and the south wall having significant outward lean at the top, with the north wall having slight inward lean. Misalignment from the vertical is shown on Illustrations 35 through 39, based on survey data. The west wall is also noticeably bowed in plan above the second floor.

Tie rods exist at the east and west end walls of the building to anchor the walls back to the roof diaphragm. The rods pass through the walls with an S-shape plate on the outside and anchor to the top chord of the first truss in from the end. There are four rods at the east end and two rods at the west end. The lower rods at each end are of an unknown date. The upper rods at the east end were installed in 1974. The 1974 drawings by Stahl-Bennett, Inc., show that two upper rods were scheduled to be installed at the west end also, but these are not present.

Cracks exist in the south wall near the southwest corner in the outside face brickwork (Illustrations 56, 57, 58, 59, and 60), in inside face plaster (Illustrations 52 and 53), and between the wall and window frame. Cracks recently existed in the outside face of the north wall near the northeast corner but have been pointed within the last 3 years (Illustration 51). Cracks at the same location on the inside face plaster are still present (Illustration 51). Other cracks exist in the interior plaster at the second floor in the Patriots Room (Illustration 50). Interior cracks have had plaster smears installed to monitor crack movement; none has been seen to date. Crack monitors are to be installed on exterior cracks. The exterior cracking is shown on Illustrations 40 and 41. A crack in the exterior face brickwork also exists at the southeast corner (Illustrations 54 and 55).

Cracks were last surveyed by LeMessurier Associates in January 1978. The cracks now observed at the northeast and southwest corners, including those recently patched, are at exactly the same location as those seen in 1978. Since plaster repairs and repainting were carried out in 1975, it is obvious that movements have occurred since that date and probably since 1978 also.

The cracks at both the northeast and southwest corners are wide at the top of the wall and small or nonexistent at the bottom; maximum crack width is about 1/2 inch. This is characteristic of the wall panel between the corner and first window having rotated in plane, the top of the wall moving away from the center of the building. Such movement is characteristic of foundation settlement at the corner. Elevations taken of the water table also show a dip at the northeast and southwest corners, the difference in elevation between the corners and a point about 7 feet from each end being 5/8 inch at both the northeast and southwest locations. Refer to Illustrations 40 and 41. Other cracks in the exterior brickwork previously noted in 1978, but now patched (located at the second floor under the second window in from the west end on the south wall, under the second window in from the east end on the north wall), have been checked against the water table elevations now available. The direction of movement indicated by these cracks are all consistent with dips measured in the water table elevations. Thus, we conclude that the cracking is caused by vertical settlements due to foundation or subway structure movements.

The crack at the southeast corner is a vertical crack, about 9 inches in from the corner on the south wall, and extends from about 2 feet above the water table for a length of 4 feet. The crack is up to 1/2 inch wide. The direction of displacement is an outward movement or bowing of the face of the south wall relative to the corner. The crack passes through both mortar joints and bricks and is at an angle of about 45 degrees to the plane of the outside face. A similar vertical crack was recorded in the survey report of LeMessurier Associates in 1978, but at a higher elevation. The crack suggests a localized failure of the outside face of the wall. The crack probably does not extend through the wall, but this has not been positively determined. Three steel I-beams are buried in the wall to form the lintel over the opening into the subway station, the ends of the beams being close to the crack location; these were installed in the 1902 construction. In 1976, the entrance was modified and the opening lowered. The original lintels were retained and a new concrete slab spanning the opening was cast from which the head brickwork was suspended. It is not known if any disturbance from the 1976 construction contributed to the cracking. The type of movement, which is a localized bowing outwards of the outside face of the wall, could be caused by high stress concentrations, but is more likely caused by water penetration and freeze/thaw effects. Foundation movement is not suggested.

As noted in the foundation section of this report, cracks occur in the subway structure and in the boiler room which appear sympathetic with the wall cracks at the northeast and southwest corners.

b) Loads and Stresses: Stresses in the walls from gravity loads are small, averaging 60 psi at the ground under full dead plus live loads. Such stresses are well within the capacity of the brickwork. Bearing stresses under beam ends under full dead plus live load are considered satisfactory at about 100 psi and under roof trusses at about 80 psi.

Additional stresses are induced in the walls from gravity loads due to the lean of the walls. These are also quite small, about 10 psi.

The lack of positive ties between the walls and the floors suggests that the walls were intended to be self-supporting, relying on their weight and thickness to resist wind loads. Some restraint is provided by friction generated by the bearing of joists, beams, and roof trusses on the walls, and these forces have been considered in our analysis of the walls to resist the wind. The stability of the east and west walls is aided by their connection to the north and south walls. The walls tend to span in two directions, both vertically as a cantilever from the ground and horizontally between the side walls. Because of the long distance between end walls, the north and south walls have no horizontal span. These walls, therefore, cantilever from the ground but are also restrained somewhat at the roof and second floor by friction forces, as mentioned above. Friction forces at the second floor are insufficient to resist wind forces, but friction at the top of the wall due to the roof and attic weight is adequate. Wind forces delivered to the roof and attic floor diaphragm can only be resisted by three diaphragms spanning to the east and west end walls. This span is great, and the diaphragm stiffness developed by the sheathing and flooring boards is not high. Additionally, there is no mechanical connection between the diaphragms and the east and west walls to take the reaction from the span. The diaphragm resistance presently provided by the roof and attic floor is, therefore, questionable. Acting as a pure cantilever from the ground without benefit of roof and floor diaphragms, the north and south walls develop several times the tension stresses allowed for unreinforced masonry under wind loads. Wind loads acting on walls have been taken as 15 psf, the minimum required by the Commonwealth of Massachusetts State Building Code.

New construction in Massachusetts is required to be designed to resist seismic forces. The Commonwealth of Massachusetts State Building Code does not require existing buildings to comply with seismic regulations if no major structural alterations are made and there is no change in building use; historic buildings are also generally excepted. The type of structure which the Old State House represents, having a high mass and low ductility, has traditionally performed poorly in earthquakes. The lack of ties between floors and walls is also a serious detriment to good seismic performance.

c) Options and Recommendations: The cracks which exist in the exterior walls should be repaired, but there is little to be gained in repairing a crack which still has a tendency to move. In such a case the crack, or one close by, is likely to reopen. Long-term monitoring of the cracks should be carried out and repairs made only if no movement is shown, other than minor seasonal variations. If progressive movement is found, such as from foundation settlement or materials deterioration, then these faults should be remedied before repairs are done. It is noteworthy that cracks repaired in exterior brickwork at the northeast corner a few years ago have not opened, suggesting that conditions are dormant at this location. The opening up by the MBTA of columns at the northeast and southwest corners of the building may shed light on the causes of cracking of the walls at these locations. The crack at the southeast corner is considered dormant and should be repaired.

Because of the considerable thickness of the walls, repairing just the inside and outside faces of the cracks is not adequate since this leaves a weakened plane in the wall which would promote further cracking. The cracks should be repaired throughout the total thickness of the wall and it is recommend this be done by removing and replacing the bricks on each side of the crack, properly toothing bricks into the existing brickwork and ensuring good bond is achieved with the mortar. Existing bricks should be reused and mortar mix should be formulated as closely as possible to match the characteristics of the existing mortar.

An alternate method is to use injection techniques to close the cracks and bond the crack surfaces. Materials commonly used in injection repairs are epoxies which have good flow characteristics and high strength. Although such methods are commonplace for the repair of cracked concrete, their use in these brick walls may not be successful. Concrete cracks are usually well-defined throughout the width of the member, whereas the brickwork cracks probably meander about following the weakest mortar joint line. Also, it is likely that the walls are not completely solid, but contain pockets and voids where mortar was missed during the original construction. If these interconnect, it may never be possible to satisfactorily fill the crack without using excessive materials in filling the voids. If large quantities of epoxy are injected, the resulting wall will have different thermal expansion and stiffness properties than ungrouted portions which will lead to problems in the future. For these reasons, we do not recommend the use of crack repair by injection.

Because the walls are leaning, and because they have inadequate resistance to wind loads as freestanding elements, it is recommend that the floors at the first, second, and attic levels, and the roof be mechanically anchored to the walls. In this way, the diaphragm stiffness of the floors and roof will be mobilized to resist wall movements and forces, the walls being braced at each floor and at the roof. Seismic performances of the building will also be significantly improved.

Anchorage should be provided between each joist and roof rafter at the east and west end walls, and at each beam which bears on the north and south walls and the roof trusses. Consequently, the anchor will comprise a steel angle or plate bolted to the brick wall using adhesive type anchor bolts and a connection between the wood member and this steel attachment. Anchors are not required at the steel-framed floor at the east end of the ground floor over the subway entrance because adequate anchorage already exists, based on drawings of this construction.

Fire cuts should be installed in the wood or brick where these are not already present so as to allow free collapse of burning members in a fire without jeopardizing wall stability. The opening up of each joist, rafter, and beam bearing point for installation of anchors will afford the opportunity to inspect the condition of the wood and the bearing area, and will provide air gaps as recommended in other sections of this report.

Improvements to the diaphragm stiffness of the attic floor should be made as noted in the attic and roof section of this report.

7. <u>Roof and Attic</u>

a) Existing Conditions: The roof is framed by heavy timber trusses that span north-south over the full width of the building and are spaced approximately 10 feet apart. Layout, sizes, and details of these trusses are shown on Illustration 43. Roof purlins spanning east-west are supported on the top chord of the trusses and the bottom chord carries the attic floor joists.

The timber roof trusses show signs of damage from the fire of 1921 (Illustration 49). Some charring of the members is evident, but the cross-sectional area of the members has not been significantly reduced as a result, and the timber appears to be sound. Longitudinal splits parallel to the grain are evident in some of the top chords of the trusses. This splitting has been repaired in some locations by using lag bolts to tie the section together and to control further splitting. This repair was made during the 1974 renovation and a similar repair should be made to all members having large splits.

The diagonal chords of the truss are connected to the king post using mortise and tenon joints. Each top chord is secured to the king post by two 1/2-inch wooden pegs through each tenon, and the lower diagonals are secured by wooden wedges driven through the king post (Illustration 47). These wedges are loose in some locations and should be replaced. The king post has a 2-inch deep notch cut above these connections, the purpose of which is unknown (Illustration 46). The trusses in the east half of the building have steel straps across the faces of the king post between the upper and lower attics (Illustration 48). It is possible that the king post is discontinuous at the attic ceiling and that these straps are a tension connection joining the upper and lower sections, but this could not be confirmed. These straps do not occur in the west half of the building. The attic ceiling is supported by the truss collar beams that consist of two 2-inch by 6-inch members that span from the king post to the truss upper diagonal. These beams appear to be of a more modern vintage than the other truss members. The connections of these beams to the diagonals are inadequate.

The truss bearing at the eaves was examined at the south end of the third truss from the west end (Illustration 45). The upper and lower diagonal truss members are connected to the bottom chord using mortise and tenon joints. The joint of the upper diagonal is reinforced with a steel strap which ties back the diagonal chord to the bottom chord. The joint of the lower diagonal to the bottom chord was not tight. Shims should be driven into the space between the tenon of the upper face of the lower diagonal and the mortise in the bottom chord to ensure that the joint can transmit the horizontal thrust transmitted by the diagonal to the bottom chord of the truss.

The timber at the bearing showed some water stains but no deterioration has occurred.

There is no mechanical anchorage between the truss bearing observed and the exterior walls. The requirements for anchorage at this location are discussed in the section of the report dealing with the exterior brick walls.

The two trusses supporting the tower were reinforced in 1974. This reinforcing was made by bolting steel angles to each side of the timber members, and is fully described in the Stahl-Bennett renovation drawings. The second-floor stair landing beams are supported by new steel rods hung from these trusses. A supplementary truss adjacent to the west wall was also reinforced with additional timber members at this time and is also shown on these drawings.

The north side of the upper chord of the third truss from the west wall has also been reinforced with additional timber members bolted to each side of the original member, but this work is not shown on the renovation drawings (Illustration 44).

A portion of the collar beam at the attic ceiling level of the second truss from the east wall is missing on the south side. This member should be replaced.

The fire damaged roof sheathing has been repaired in some locations and now appears sound. The roof purlins are also fire damaged in the upper attic. The size reduction from charring is only significant at the second bay from the east wall where the typical 4-inch by 5-inch purlins have been reduced to approximately 3-1/2 inches by 3-1/2 inches. The top three roof joists on each side of the center line should be reinforced in this bay.

The attic floor is framed with 3-1/2-inch by 5-inch joists at 1 foot 8 inches on center, typically, as a minimum size with larger joists at some locations. The flooring is comprised of two layers of 1-inch boards spanning north-south onto the joists.

Tie rods exist at the east and west end walls of the building to anchor the walls back to the roof diaphragm. The rods pass through the walls with an S-shape plate on the outside and anchor to the top chord of the first truss in from the end. There are four rods at the east end and two rods at the west end. The lower rods at each end are of an unknown date, but the upper rods at the east end were installed in 1974. The 1974 drawings by Stahl-Bennett, Inc., show that the upper rods were scheduled to be installed at the west end, but these are not present.

There are no obvious signs of structural distress in the roof trusses and purlins on the attic floor and ceiling.

b) Load Capacity: The typical roof purlins were found to be adequate to carry the existing roof and a snow load of 18 psf as required by the Commonwealth of Massachusetts State Building Code.

The typical attic floor joists are adequate to carry a storage live load of 50 psf.

An analysis of a typical truss under dead loads, a roof snow load on the upper diagonal chord, and the attic floor storage live load on the bottom chord was made. This analysis shows that the truss members are adequate to carry these loads, but some of the truss connections are found to be overloaded.

The horizontal collar beam at the attic ceiling level is comprised of two 2-inch by 6-inch members nailed to each side of the king post and the upper diagonal. There is no connection to the lower diagonal. The 2-inch by 6-inch members are discontinuous at the king post and the connections are made using five nails into the king post and upper diagonal.

These nailed joints are inadequate to carry the loads. The truss was therefore reanalyzed, assuming these 2-inch by 6-inch members to be inactive. In this case, the upper and lower diagonal members were found to be overstressed due to the increase in bending that results when the strut action of the 2-inch by 6-inch members is eliminated. The 2-inch by 6-inch upper horizontal members of the truss must, therefore, be utilized by improving their connections.

Access to the connection of the 2-inch by 6-inch members to the upper diagonal is limited, so it is recommended that a new bolted connection be made to the lower diagonal. This will eliminate the difficulty of reinforcing the connection to the upper diagonal.

The connection of the lower diagonals to the king post is adequate as the full depth of the diagonals are let into the king post and the thrust is taken onto the wedges. Wedges must be tightened or replaced as noted earlier.

The connection of the upper diagonals to the king post is found to be inadequate in that the tension load that develops in the king post from the attic floor load is resisted only by the 1/2-inch diameter wooden pegs through the tenons of the diagonal chords. The truss was reanalyzed assuming that this joint was ineffective, but the lower diagonals then become overstressed due to the increase in axial load in these members. It will, therefore, be necessary to reinforce this joint.

The connection of the lower diagonal to the bottom chord of the truss is adequate to carry the imposed load as the horizontal thrust is carried in shear across the full width of the member.

The horizontal thrust of the upper diagonal is transferred to the bottom chord of the truss at the roof eaves through a 2-3/4-inch by 1-1/2-inch steel U strap. This strap is anchored to the bottom chord by a single 3/4-inch diameter through-bolt. The steel strap is adequate to carry the thrust, but the through-bolt is grossly inadequate to transmit the load to the bottom chord. The bearing stress under the strap at the upper diagonal is also high. The connection of the upper diagonal to the bottom chord of the truss should, therefore, be reinforced.

Because the walls acting on their own as freestanding cantilevers cannot take all of the wind forces imposed on the building, the floor and roof diaphragms must be mobilized to share in the job of wind resistance. As explained in the section of this report dealing with the brick walls, we propose to provide mechanical anchorage between the walls and floors and between the walls and trusses. The anchors will transmit wind forces from the walls into these diaphragms and thus locally brace the walls. Forces entering the diaphragm from the wind on the north and south walls will be transmitted by the diaphragm stiffness to the east and west walls which are capable of resisting these forces applied in their long direction. Wind applied to the east and west walls will be likewise transferred to north and south walls.

The attic floor will be the principal diaphragm carrying the highest forces because it is located at the top of the walls where wind forces are large due to the high exposed area of the roof and tower.

In order to carry the diaphragm shear, additional nailing is required to improve the connection of the two layers of flooring boards to each other, and to the joists and trusses. Alternatively, a plywood overlay could be used. To act as the tension and compression chords of the diaphragm, it is proposed that a continuous steel member be provided along the whole length of the north and south edges of the floor, attached to the floor by bolting. The brick walls will also tend to act as tension and compression chords to the extent that forces can be delivered from the floor diaphragm to the truss bottom chord, then to the wall. It is anticipated that about one half of the total wind will be carried by diaphragm action, and one half by the walls acting as cantilevers from the ground.

Wood that has been subjected to a fire can become embrittled and suffer a loss in strength. A potential strength loss in the 10 percent to 15 percent range is considered possible. Since the truss members are not subjected to dynamic loads, embrittlement is not a problem. Member stresses under load are not so high that the potential strength loss is significant.

Calculations which indicate truss strength deficiencies have been carried out using modern analysis techniques and allowable stress values. Basic stress values allowed are as given in the floor section of this report. It should be noted that these "inadequate" trusses have been performing satisfactorily for the past 275 years, which suggests that our modern concepts are overly conservative. The strengthening proposed will provide a positive increase in capacity while keeping the basic form of the old trusses intact.

c) Summary of Options and Recommendations

(1) Where large longitudinal splitting has occurred in truss chords, lag bolts should be installed across the split.

(2) The top three roof joists at the second bay from the east wall must be reinforced.

(3) The wedges in the connection of the lower diagonals to the king post of the truss must be replaced where they are loose.

(4) Timber wedges must be driven into the mortise of the bottom chord at the connection between the lower diagonal and the bottom chord of the trusses.

(5) The connection between the collar beam at the attic ceiling and the king post of the truss must be reinforced.

(6) The collar beam at the attic ceiling must be connected to the lower diagonal of the truss.

(7) The connection between the upper diagonal and the bottom chord of the trusses at the eaves must be reinforced.

(8) The bottom chord of the truss must be anchored to the exterior walls. (See Masonry of Exterior Walls.)

(9) The collar beam at the attic ceiling level must be replaced at the south side of the second truss from the east wall.

(10) The connection of trusses at eaves should be inspected for signs of deterioration or joint movement during the installation of mechanical anchors between the truss and walls, as described under the wall section of this report.

(11) New steel diaphragm chords should be bolted to the attic floor parallel to the north and south walls, and the diaphragm stiffness of the floor improved by renailing the floorboards or adding a new plywood floor.

8. Balcony: The structure of the small balcony on the second floor at the east end of the building is entirely hidden by the wood trim and the metal floor membrane. The structure has not been exposed, since to do so would require disruption to these finishes. It is recommend that, during renovation work, the condition of the balcony structure be determined.

9. Tower: The tower is a wood-framed structure comprising corner posts which carry the vertical loads, and

interior and/or exterior wood sheathing to carry the horizontal wind shears. The tower is carried on two of the main roof trusses which span the full width of the building onto the exterior north and south walls. These trusses were strengthened in 1974 under the direction of LeMessurier Associates because they were found to be severely overstressed by the weight of the tower.

The tower timbers are in good condition with no sign of rot or distress, and the tower appears vertical.

M. SUMMARY AND SUGGESTED PERIOD FOR RESTORATION: The Architectural Data Section, Volume I, Physical History, and the Historical Background component of this report demonstrate clearly to what extent the building's history is one of continual remodeling and restoration. To return the building to its appearance as of any early date would require extensive reconstruction of an almost wholly conjectural sort, particularly on the interior. Here, almost no material survives that predates 1882, and documentary evidence is extremely sketchy.

Given the extent to which the building was transformed three times in the Colonial Revival image, one must think of the Old State House as expressing the Colonial Revival period as eloquently and as significantly as it expresses any other. Clough's interiors of 1882 represent one of the earliest restorations in America, and are so unacademic as to be picturesque. This is especially true of the spiral staircase of Federal conception and Georgian detailing, and based on Greek Revival physical evidence. Chandler's Keayne Hall, and his complete revision of the trim of the exterior walls, illustrate the Colonial Revival at a later, less Victorian but still freely interpretive, stage; it also constitutes major work by the leading restoration architect of the period in New England. Perry, Shaw, and Hepburn's Council Chamber of 1943 provides the final chapter, of full-blown colonial academism executed by the nation's leading restorers of their day. (Their experience at Williamsburg may account for the sightly Virginian look of the fireplaces.)

All this work clearly merits preservation, leaving little opportunity for the would-be restorer of today to alter the building. The question, then, is whether to preserve to still later Colonial Revival manifestations of 1957: George Sherwood's sundial and the few other items applied at the same time, including the wood and LCC parapet copings and two new finials on the east balcony. Here, there is no way to avoid making a subjective judgment. If there is any doubt among those responsible for the building, preservation of all items is the safest course, leaving the decision to the future.

There is, however, a strong reason for considering a return of the east wall to its appearance just prior to 1957. Simon Willard's signed town clock survives in the attic, its works intact and portions of its face and surrounding decorations present as fragments. Indeed, the face may predate the present clock works (see Early Commercial Period, Volume I). Reportedly, there are only about a dozen Simon Willard town clocks in existence, of which only six or fewer are in their original locations. The importance of this clock thus far outweighs the importance of the reproduction sundial. It crowned the east facade for 13 decades, six times longer than the sundial. It survived both Clough's and Chandler's heavy restorations. It fits the space far better than the sundial. Most of all, it is a genuine 1830 clock, while the sundial is but a reproduction--and, in terms of its details, a highly conjectural reproduction at that. Missing elements of the clock would have to be reproduced, to be sure. But these elements are documented so precisely in photographs, measured drawings, and by fragments, that no guesswork would be involved.

It is the recommendation of this report to restore the clock, and to preserve all elements up through the Perry, Shaw, and Hepburn period. This would entail the preservation of the present rectangular steps on Chandler's south doorway, instead of the planned return to semi-circular steps not seen here since about 1800. The lower three steps on the north and south doorways definitely predate Chandler's doorways, as his drawings show them as existing material to remain. They probably date back to Rogers. They certainly form an integral part of Chandler's design.

All portions of Chandler's brick basement wall (on all four elevations) should be preserved.

In keeping with the policy of doing away with alterations post-dating 1943, the two broken down finials at the outer corners of the east balcony should be replaced with two more nearly matching the Chandler period ones against the brick wall. Likewise, whenever serious work is required on the parapets, all of George Sherwood's copper covered wooden copings, and all of the cement copings, should be replaced with brownstone copings laid over through wall flashings and fitted, like the surviving old ones, with halved joints. English "Red Hollington" brownstone would be a good choice of material, being of excellent quality and having a color close to the existing stones.

More important to the suggested period for restoration is the legislative mandate that the structure must be preserved and maintained, due to its "management category (Category A)" on the "List of Classified Structures (LCS)". Moreover, in keeping with the preservation spirit we will retain the existing building features, based on the "General Treatment and Use" under the "Standards for Historic and Prehistoric Structures (NPS-28, Chapter 2, page 3)".

With the evidence leading to the suggested period for restoration, and the latter two statements in mind, recommendations for treating the building will remain in compliance with the "Secretary of the Interior Standards for Rehabilitation and Guidelines for Rehabilitating Historic Buildings."

IV. PLANNING AND DESIGN REQUIREMENTS

At the Old State House, the proposed level of treatment and development represents a blend of preservation, restoration, and adaptive use of cultural resources and development, maintenance, and management of museum, interpretive, sales, and administrative facilities.

In the General Management Plan Volume 1, Boston National Historical Park, August 1980, the path or direction that the treatment and development of the structure will follow has been generally laid out. It considers visitor use and interpretation, and resource management requirements such as: preservation of the building, maintenance, management, and the collections. Direct excerpts from this guide for the treatment and development of the Old State House are as outlined below.

1. VISITOR USE AND INTERPRETATION: The Bostonian Society sales facility will continue to function on the first floor of the Old State House. The final location will be determined by consultation between the society and the NPS. The sales staff will provide backup information and orientation service.

The NPS will cooperate with the Bostonian Society in developing an exhibit on the first floor of the Old State House emphasizing the period and universal themes. This exhibit may include a wide variety of media, such as audiovisual for large groups and the physically impaired. Sufficient site theme material will need to be included to provide an adequate frame of reference for understanding.

The remainder of the building will continue to be used for the exhibition of the Bostonian Society collections. Some enrichment of the second-floor east room installation would be desirable, and the society will be free to request assistance from the NPS for revision or rehabilitation. Exhibits communicating the history of Boston should predominate, and the site themes would be most appropriate for those developments dealing with the Old State House itself. Every effort will be directed toward making future exhibits available for the enjoyment of all visitors. Access for the mobility impaired will be available through the existing street-level entrance at the west end of the first floor.

2. RESOURCE MANAGEMENT

a. Preservation of the Building: In preserving the fabric and design of the Old State House, the NPS will be maintaining a 19th- and early 20th-century interpretation of an 18th-century municipal building. After the American Revolution Centennial, the building was restored to what was presumed to be its prerevolutionary condition. Much license was used, with details incorporated from other structures (the Shirley-Eustis house, ca. 1747, Roxbury). The floor plan, then thought to be original, actually dated from 1830 renovations, and the interior functioned not as accurately restored and refurbished rooms, but as useful and elegant space of colonial design. Since the restoration, the Old State House has been administered as a patriotic shrine by the Bostonian Society.

In it present form, the exterior is interpretable as a close approximation of its appearance in the mid-1700s and will be retained and preserved for its own values. Fragments of original building fabric, interior and exterior, will be investigated so that these will not be damaged or altered in future work. The east half of the first floor will be given over to wholly contemporary design for exhibit space, and may include the Bostonian Society's sales area. Basement space not occupied by the MBTA station will also be rehabilitated for use by the Bostonian Society. The exhibits on the first floor may be enriched or expanded and will be compatible with the colonial revival interior. The appearance and use of the remainder of the building will remain the same.

The central staircase and attic trusses have been strengthened, and this program of structural repair should be completed. The east half of the first level, west half of the basement, and attic spaces are undesigned and poorly used. The latter two should be renovated for curatorial work space or limited museum storage, and the area over the MBTA entrance will be redesigned for exhibits.

It may be beneficial to limit traffic on the stairs and second floor, for their preservation. Monitoring will suggest what further reinforcement is necessary. The live load on the stairs and second floor, and the dead load in the attic, will need to be restricted at this time.

An adequate museum security system will be maintained by the park, and any upgrading of the present system deemed necessary will be carried out by the park.

Ultimately, it is considered desirable to present all principal rooms of the Old State House as an active and diverse exhibit museum. The interior design then becomes a backdrop implying a historical continuity to contemporary exhibits rather than presenting merely refinished period rooms.

b. Maintenance: The Old State House is maintained by the city of Boston, with the exception of the State

Street Station subway entrance, which will be maintained by the MBTA. The NPS will share responsibility for custodial maintenance with the Bostonian Society at this site, and the society will maintain its exhibits. A fire and intrusion detection system within the Old State House, controlled in the same manner as for the other principal sites of the Boston National Historical Park, will be maintained by the park. A fire suppression system for this site is appropriate and should be designed according to standard museum specifications.

The city of Boston, owner of the Old State House and lessor of its space to the Bostonian Society, will continue to assist in the security and maintenance of the building.

c. Management: The Bostonian Society will have authority to review and approve or reject all reports, recommendations, and design plans. It may itself accomplish some of the required studies, such as interpretive studies. It will retain all responsibility for site management, personal services, and onsite interpretation, and will approve all exhibitry. The society will keep the NPS informed about the condition of the building so that proper professional care can be provided.

d. <u>The Collections</u>: The collections and library of the Bostonian Society are extensive and directly related to the themes of the Boston National Historical Park. They are potentially invaluable to the park as a research facility and source of display objects for interpretation. The library has been moved to the visitors center at 15 State Street, where the Bostonian Society will continue to manage and maintain it. The NPS will provide curatorial or other professional assistance upon request.

Some objects from the Bostonian Society's collection not currently on exhibit can be stored in space redesigned for that purpose in the west half of the Old State House basement. Less sensitive objects can be stored temporarily in the Old State House attic. With the assistance of the NPS, the museum function and program of the Bostonian Society, for which American Association of Museums (AAM) standards exists, will be upgraded to meet those standards.

The park will actively seek a solution to the need for secure museum object storage as it relates to this and all other sites of the Boston National Historical Park. It is important to note that all collections should still be controlled by several owners when a parkwide storage facility is developed. Storage design must provide for this.

Since the writing, approval, and publication (August 1980) of the General Management Plan, the NPS, city of Boston, and the Bostonian Society have met to discuss, modify, and confirm a number of the interpretive and development issues above. In addition, the preservation and maintenance issues above have been reexamined and updated relative to any changes taking place over the years. Although the general direction that treatment and development of the Old State House will follow remain unchanged by later actions, specific parameters are being established in order to write a "Building Program."

For instance, in an attempt to set the foundation for a "Building Program" an October 1, 1986, memorandum from the Bostonian Society to the NPS outlines the programmatic uses of the Old State House. A copy of this memorandum is contained in the appendix. An outline of all specific treatment and development recommendations derived from later discussions, memorandums leading to the final "Building Program," and the reexamining of the preservation and maintenance issues are in the "Recommendations for Treatment" section of this report.

V. RECOMMENDATIONS FOR TREATMENT

In view of the continuing museum use of the Old State House, the requirements for preservation treatment, management goals, and occupancy type, are guided by NPS-28, the Secretary of the Interior's "Guidelines for Rehabilitating Historic Buildings," planning requirements, and the life safety, health, and building codes. Based on these documents and technical requirements, recommendations for the preservation, stabilization, restoration, and adaptive use of the structure are as follows:

A. PERFORM MASONRY REPAIRS

1. Repoint (spot point) brick masonry walls.

2. Clean brick masonry walls of efflorescence.

3. Clean all stone steps and repoint.

4. Reset stone steps at north elevation.

5. Reparge brick belt courses (patch pargeting).

6. Rebuild three brick masonry jack arches.

7. Refinish wood statues and scrolls at parapet walls.

8. Replace LCC covered wood copings on the parapets with brownstone copings.

B. PERFORM WOODWORK REPAIRS

1. Repair modillions of roof cornice at third stage of tower.

2. Refinish cornices at all three stages of tower roofs.

3. Refinish all walls and trim of towers to include: caulking, preparing wood surfaces for painting, painting, etc.

4. Refinish all wood balustrades and metal urns of the tower to include: preparing wood and metal surfaces for painting, painting, etc.

5. Refinish all windows of the tower.

6. Refinish the dormer windows and trim to include: pediments, cornices, etc.

7. Repair and replace the wood cornices of the brick portion of the building to include replacement of several sections of cornice, and preparing and painting cornice surfaces.

8. Refinish the wood windows of the brick portion of the building. Recaulk, and replace components as needed.

9. Refinish and refurbish the east balcony to include: rebuilding and replacing members, preparing surfaces and painting.

10. Refinish and refurbish the four entrances and surrounds (north, south, west, and surrounds of window of east balcony) to include: rebuilding and replacing members, preparing surfaces and painting.

11. Reset and reanchor the north entrance surrounds to the wall.

12. Install storm windows.

C. PERFORM ROOF REPAIRS

1. Replace broken roof slate.

2. Repair the leak in the metal roof at the tower.

3. Replace the roof flashing at the east and west parapet walls.

4. Reslope the gutters to permit proper drainage. Repair sections of gutter, if necessary.

5. Unplug the clogged downspouts to permit proper drainage. Repair or reset gutters, if necessary.

6. Repair the flashing at the central dormer of the north elevation.

7. Straighten the metal roofs of the tower's stages.

8. Repair the hatch door of the slate roof.

D. PERFORM STRUCTURAL REPAIRS

1. Foundations

a) FDN/1: Monitor the MBTA investigations of two columns and the survey of levels within the State Street Station to determine if foundation conditions are stable.

b) FDN/2: Repair and the patch cracks in the walls in the boiler room.

c) FDN/3: Stabilize and repair the deteriorated rubble walls in the boiler room.

d) FDN/4: Patch and repair the walls at the central stairs in the basement to eliminate plaster deterioration due to moisture.

e) FDN/5: Patch and repair the spalled concrete structure at the boiler room walls and roof.

2. Floors

a) FL/1: Limit the floor live load capacity in the western half of the first floor to 65 psf.

b) FL/2: Check the joists under the partition at the east end of Representatives Hall. If joists are undersized, strengthen them to support the floor live load of 50 psf. Limit floor live load of second floor to a uniform load of 50 psf.

c) FL/3: Strengthen or replace 4-inch by 4-inch wood columns supporting the second floor with 6-inch by 6-inch columns or the equivalent. Replace the missing column in the library.

d) FL/4: Inspect the joist's bearing condition at the east and west walls, and install anchors between the joists and masonry bearing walls. Similarly, inspect beam bearing conditions at the north and south walls, install anchors and open the wall for air gap between masonry and wood. Repair any rot found at the joist and beam bearings. Fire cut (or remove one course of masonry from above) each wood member at the masonry supports.

e) FL/5: Accept greater than normal deflections in the floor joists at end bays at the east and west.

3. <u>Central Stairs</u>

a) CS/1: Load test the stairs between the first and second floors for the maximum anticipated load and a safety factor of 1.5. This test is equivalent to a loading of 90 psf. Perform the test during the low period in Old State House visitation: February, 1988.

4. <u>Vibration Studies</u>

a) VS/1: Testing and analysis of the Old State House indicates that the structure has not been affected by vibrations caused by the subway trains or adjacent street traffic. In comparison to existing relevant criteria, the velocity of movement of building fabric is below the limits which can be expected to cause damage, and the stresses within building materials are within a range in which no damage is expected to occur.

5. <u>Exterior Brick Walls</u>

a) EBW/1: Establish a long-term monitoring program of cracks in exterior masonry walls. If progressive movement is found, repair the foundation settlement or materials deterioration before repairing the cracks.

b) EBW/2: Repair the cracks in exterior masonry which are dormant and stable. Repair the cracks by removing the bricks and rebuilding the entire thickness of the wall for a width of several bricks on either side of the cracks. Reuse existing bricks and use mortar as similar to the original as possible.

c) EBW/3: The alternative repair of cracks by means of injection of epoxy material for the purpose of tying the two sides of the crack together in a monolithic whole is not recommended. The use of such a grouting technique would lead to problems of the resulting patched area having characteristics different from the remaining original masonry.

d) EBW/4: Anchor the floors at the first, second, attic, and roof levels to the exterior masonry walls with mechanical anchors in order to improve the resistance of the masonry walls to wind and seismic forces. Inspect the existing bearing conditions of wood members onto masonry supports during this process.

e) EBW/5: Install fire cuts in wood members or, alternatively, remove masonry above each member at its support to allow free collapse of burning members in a fire without jeopardizing the wall stability. Inspect, at this time, the bearing condition of each wood member and provide air gaps, if none exists.

6. Roof and Attic

a) RA/1: Secure the longitudinal splitting in truss chords with lag bolts. Reinforce certain roof joists. Replace certain collar beams at the attic ceiling level.

b) RA/2: Replace or drive tight the timber wedges at truss connections. Reinforce the existing connections in certain locations, and provide other connections which presently do not exist.

c) RA/3: Anchor the bottom chords of the roof trusses to the exterior walls to improve lateral stability of the exterior walls. Inspect the trusses at the eaves for signs of deterioration or joint movement.

d) RA/4: Improve the diaphragm stiffness of the attic floor by adding new steel diaphragm chords and renailing the existing floor boards or adding a new plywood floor.

7. Noise Reduction

a) NR/1: Reduce subway-related noise at the source by providing welded rails and/or an improved rail support system.

b) NR/2: Reduce traffic noise by providing gaskets and/or weatherstripping at all of the windows. Consider more significant reductions with the installation of double glazing such as storm windows.

E. REPLACE EXISTING HEATING SYSTEM: Replace the existing heating system with an alternative environmental control system (hot-water heating system) or full HVAC system.

1. Hot-Water Heating System

a) Convert the existing steam boiler to hot-water service.

b) Install new zoned hot-water piping to replace the existing deteriorated steam and condensate piping.

c) Flush out and retain the existing radiators.

d) Insulate and paint the new hot-water piping and radiators.

e) Install thermostats throughout the system.

2. Provide the study and cost estimates for the installation of a full HVAC system.

F. PERFORM ELECTRICAL REPAIRS AND ALTERATIONS

1. Rewire and install new outlets and receptacles in the attic.

2. Replace existing 150-watt PAR flood lights with 75-watt floods.

3. Install diffuser screens over the flood lights.

4. Place the incandescent lights on a rheostat control system.

5. Make other lighting repairs or alterations as called for in the building program.

G. PERFORM PLUMBING REPAIRS

1. Install new drain piping to replace the older existing drain piping.

2. Install new supply piping to replace the older existing supply piping.

3. Install new fixtures as needed to replace the older fixtures in rest rooms that are scheduled for renovation in the building program. Also, provide piping as required to serve each new fixture.

4. Install new fire suppression systems to include:

a) Dry-pipe system in most of the building.

b) Halon system in the attic storage spaces.

H. PERFORM INTERIOR REPAIRS AND ALTERATIONS

1. Repair deteriorated or cracked coats of plaster on the walls and ceilings. Repair large areas of falling plaster in the secretary's office and the Council Chamber.

2. Refinish the walls and ceilings (prepare and repaint).

3. Refinish the doors and other woodwork to include: cornices, architraves, wainscot, baseboard, cabinets, etc., (replace and repaint).

4. Refinish stairs and balustrades. Replace broken or missing balusters.

5. Repair cut-out sections of flooring in the Council Chamber and in the staircase where the structural stabilization was made in 1975. These areas should blend in with the rest of the floor.

6. Refinish all wood floors. (prepare and stain).

7. Replace hardware where missing.

8. Repair plaster holes in the attic walls and ceiling.

9. Rehang the doors and install new hardware, where necessary.

10. Replace chords on the window sashes.

11. Other Repairs and Alterations: NOTE: A--"Building Program" is currently being developed. Other repairs and alterations will result from this program when approved. Handicapped access to the building will also be developed as a part of this program.

I. PERFORM SITE REPAIRS AND ALTERATIONS: NOTE--The scope of these services will result from the approved Structural

Recommendations of this report, depending on whether or not the site must be disturbed during the course of work. Other site alterations may result from areas being disturbed to make the site fully accessible to the physically impaired. Other site improvements may also be necessary.

J. RENOVATE AND INSTALL SPECIAL FEATURES

1. Renovate and reinstall the Simon Willard Clock at the east elevation in place of the sundial.

2. Install a new flagpole.

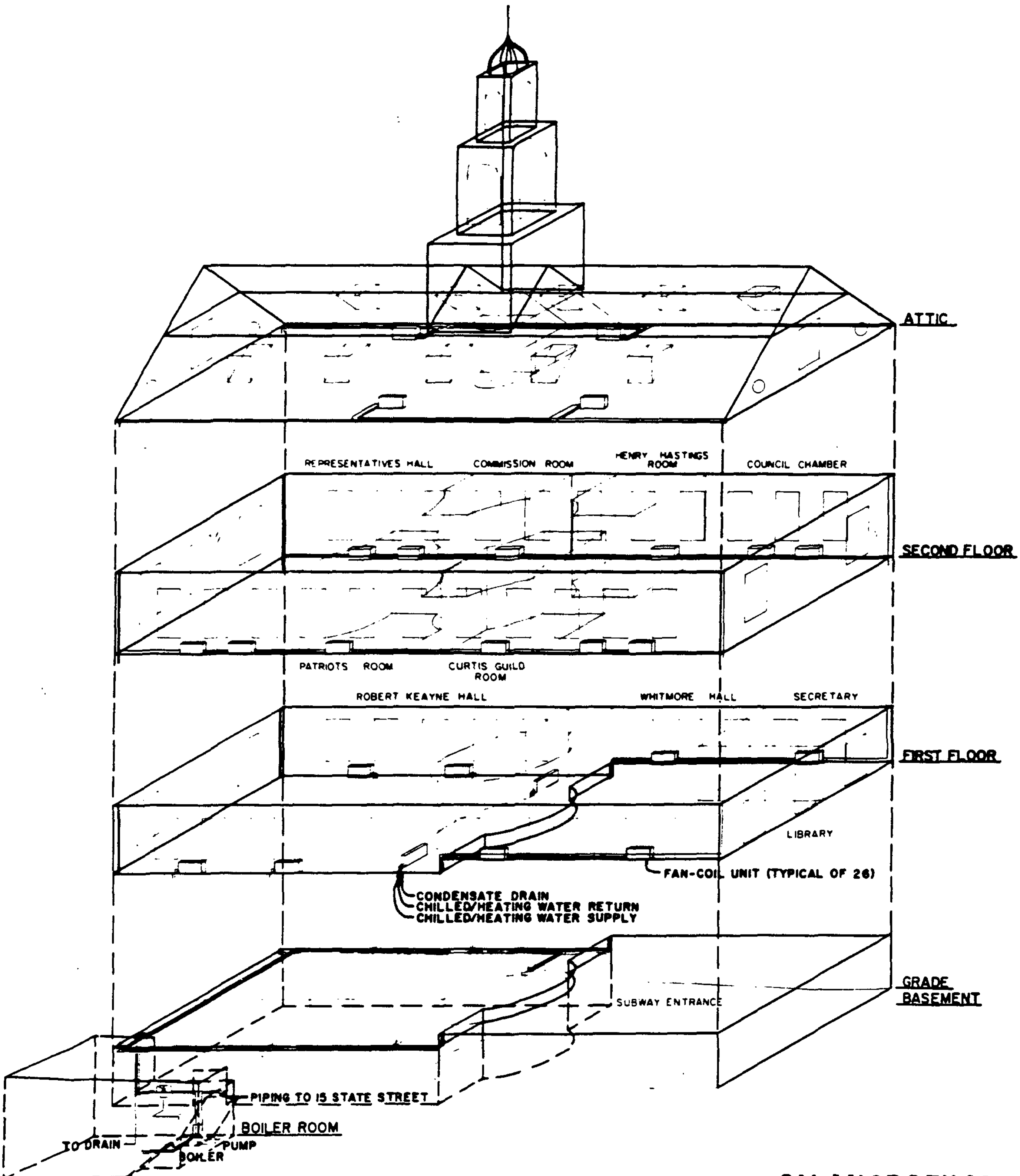
K. RECOMMENDATIONS TO PERFORM WORK: All work above should be performed under a single "Competitive Bid" construction contract, except for item J, Renovate and Install Special Features. The clock repairs may have to be performed by a specialist outside of the normal construction contract, for reasons of scheduling, etc. Under the circumstances, it is better to consider doing this portion of the work by "Day Labor".

VI. PRELIMINARY STUDY DRAWINGS LEADING TO ARCHITECTURAL/ ENGINEERING RECOMMENDATIONS

OLD STATE HOUSE

OPTIONS FOR HVAC

FAN-COIL SYSTEM



ON MICROFILM

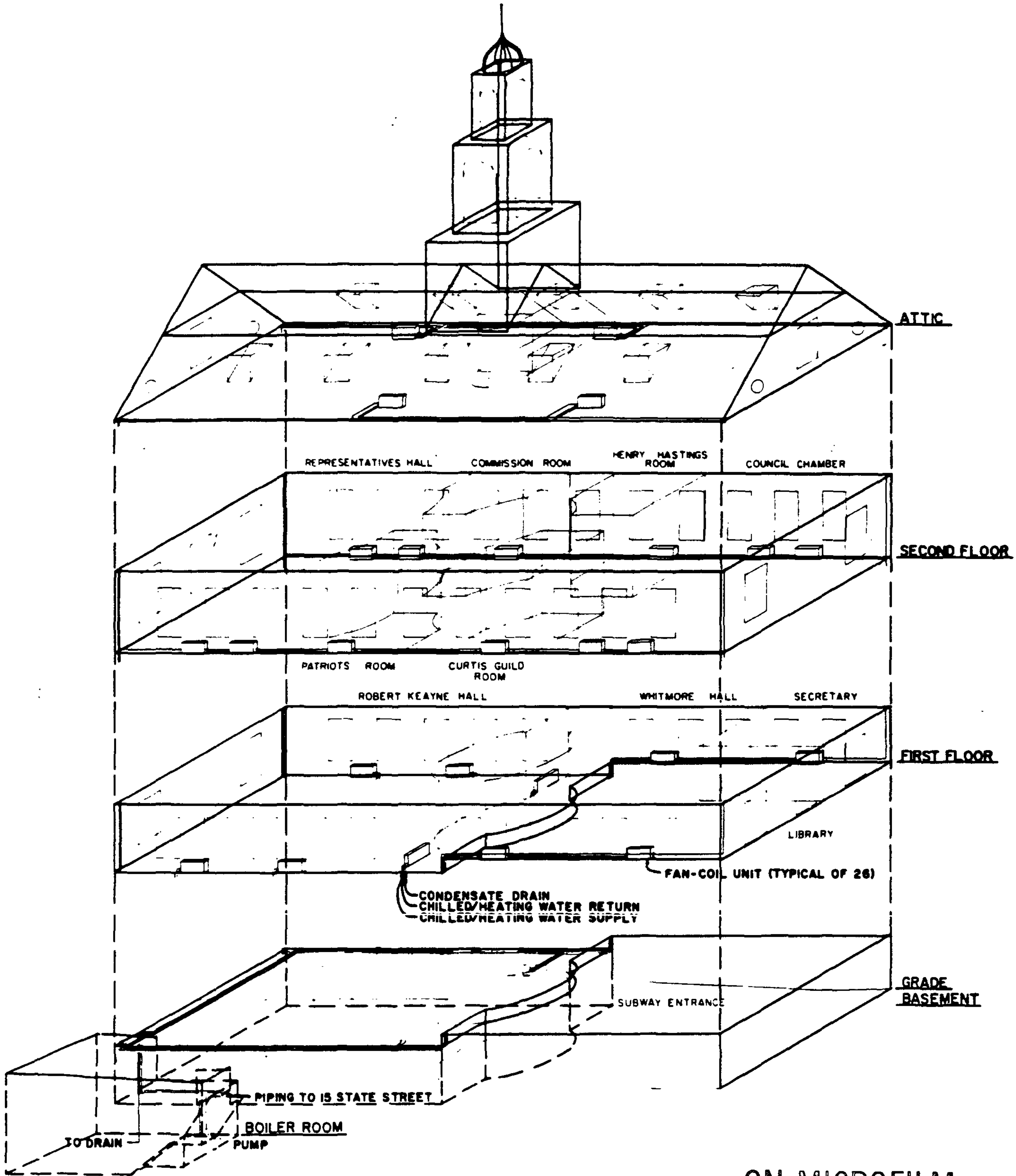
SYSTEM A

DESIGNED P. SUTTON / DRAWN P. SUTTON / TECH. REVIEW H. LAFLEUR / DATE 3/88	SUB SHEET NO. PR-1	TITLE OF SHEET: PROPOSED FAN-COIL — PRELIMINARY STUDY—OLD STATE HOUSE	DRAWING NO. 457 25,026 / FIG. NO. 132 / SHEET 1 OF 8

OLD STATE HOUSE

OPTIONS FOR HVAC

FAN-COIL SYSTEM



ON MICROFILM

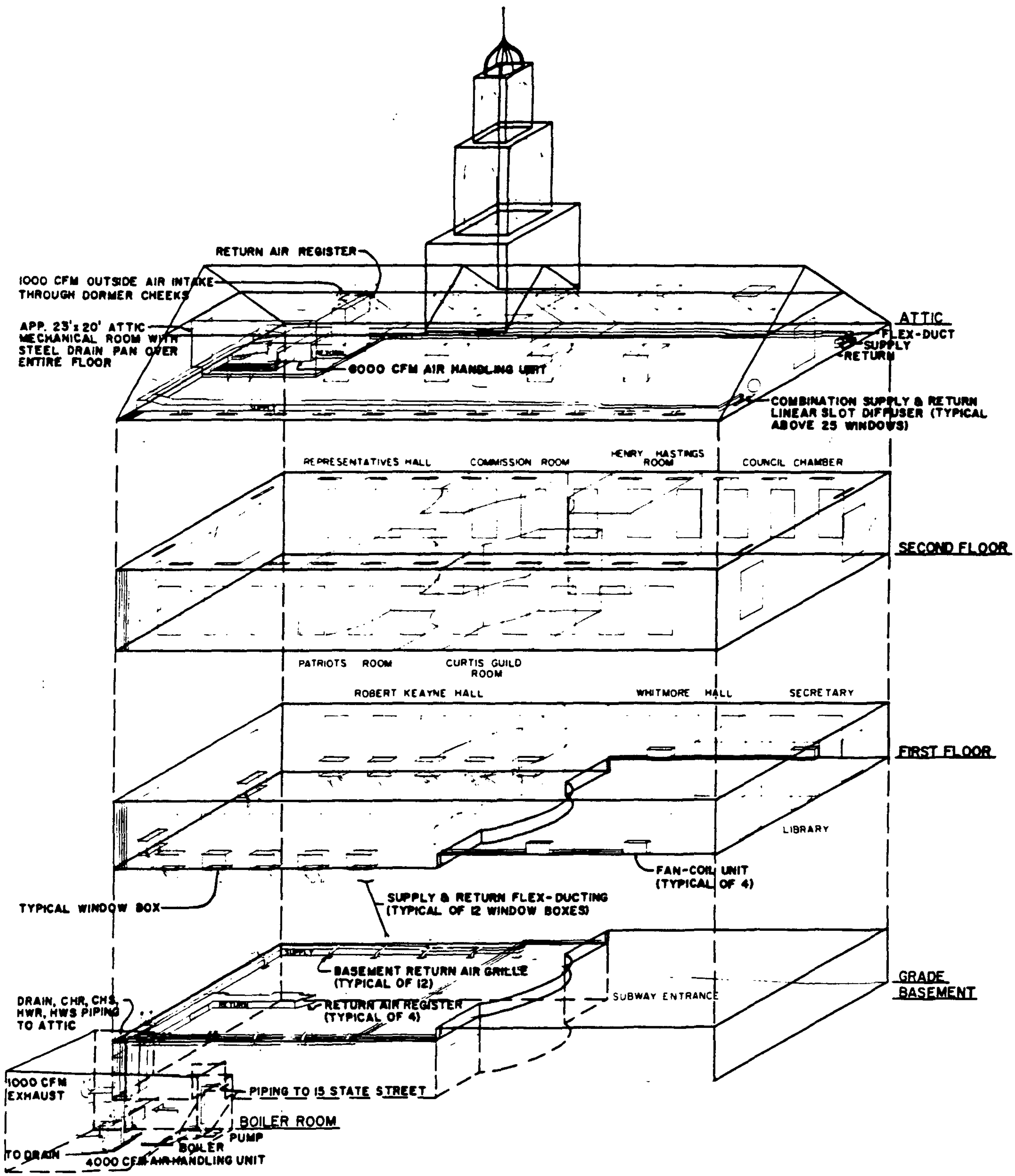
SYSTEM B

DESIGNED P. BUTTON; DRAWN P. BUTTON; TECH. REVIEW H. LAFLEUR; DATE 3/88	SUB SHEET NO. PR-2	TITLE OF SHEET: PROPOSED FAN-COIL — PRELIMINARY STUDY — OLD STATE HOUSE	DRAWING NO. 457 / 25,088; PKG. NO. 132; SHEET 2 OF 6

OLD STATE HOUSE

OPTIONS FOR HVAC

CENTRAL AIR SYSTEM



SYSTEM A

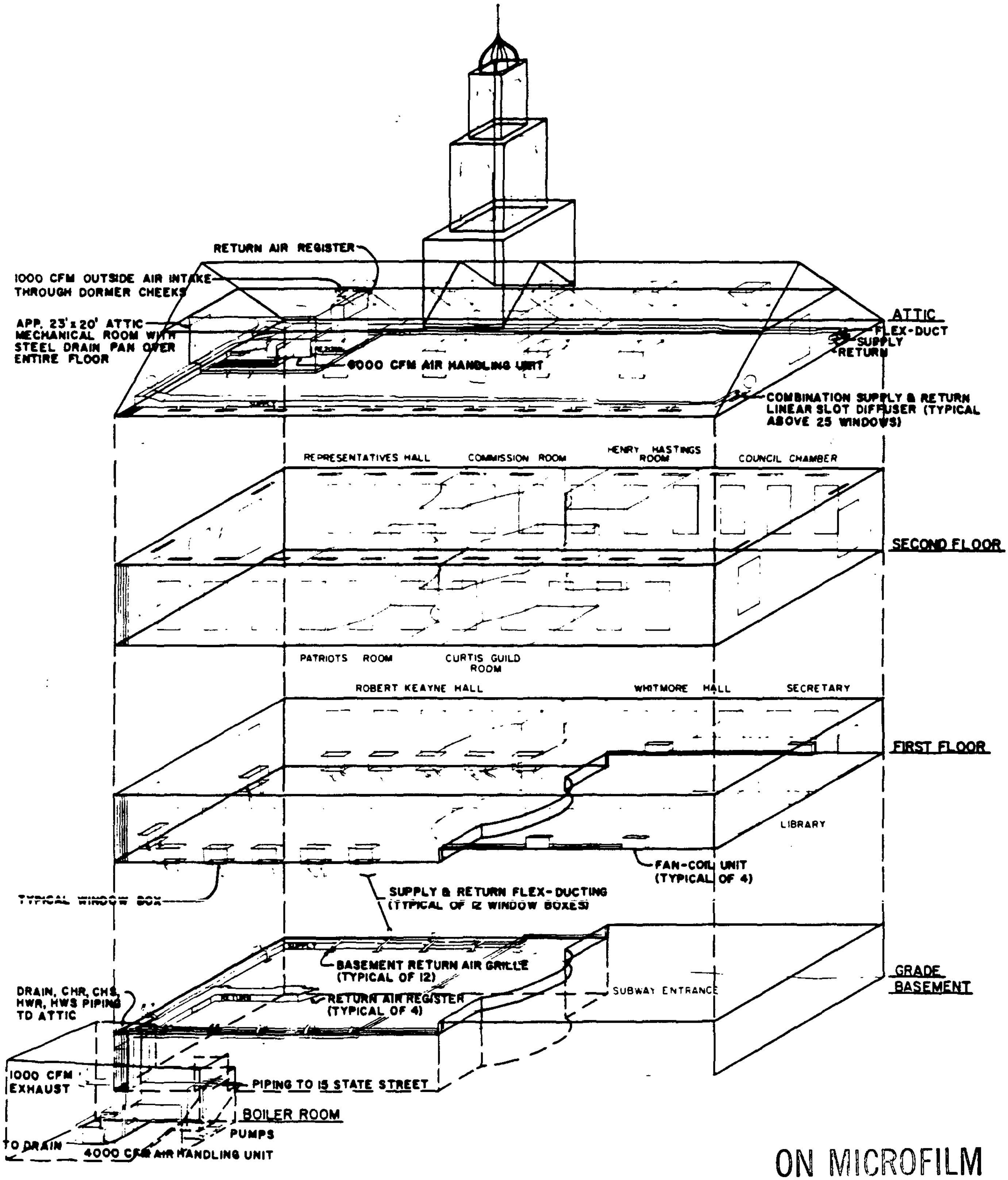
ON MICROFILM

DESIGNED P. BUTTON DRAWN P. BUTTON TECH REVIEW H. LAFLEUR DATE 3/86	SUB SHEET NO PR-3	TITLE OF SHEET PROPOSED HVAC PRELIMINARY STUDY—OLD STATE HOUSE	DRAWING NO 457 / PKG NO 132 / SHEET 3

OLD STATE HOUSE

OPTIONS FOR HVAC

CENTRAL AIR SYSTEM



ON MICROFILM

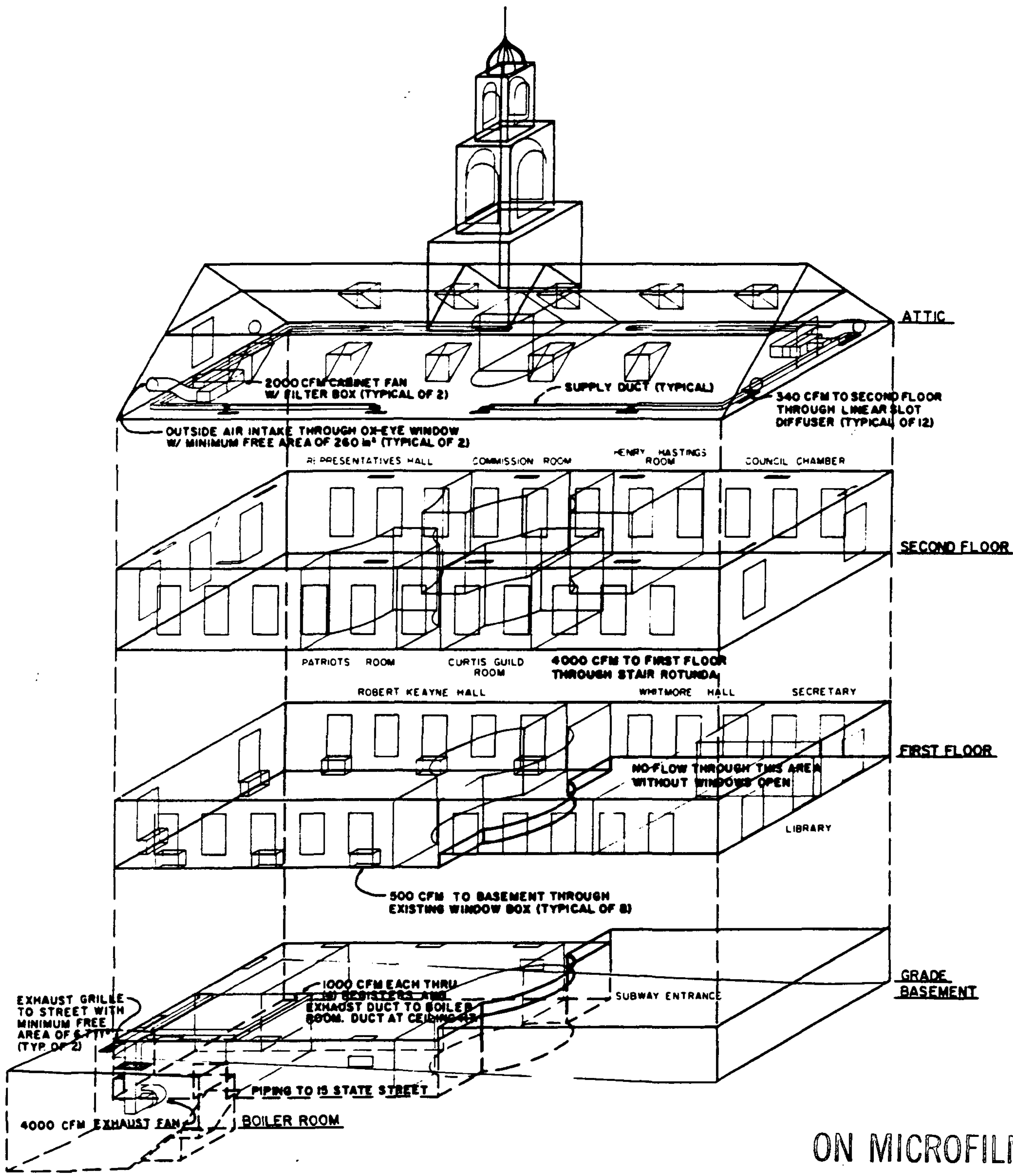
SYSTEM B

DESIGNED P. BUTTON DRAWN P. BUTTON TECH REVIEW H. LAFLEUR DATE 3/88	PR-4	TITLE OF SHEET PROPOSED HVAC PRELIMINARY STUDY—OLD STATE HOUSE	SHEET 4 OF 6

OLD STATE HOUSE

OPTIONS FOR HVAC

VENTILATION ONLY



P. BUTTON
P. BUTTON
TECH REVIEW
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PR-5
TITLE OF SHEET
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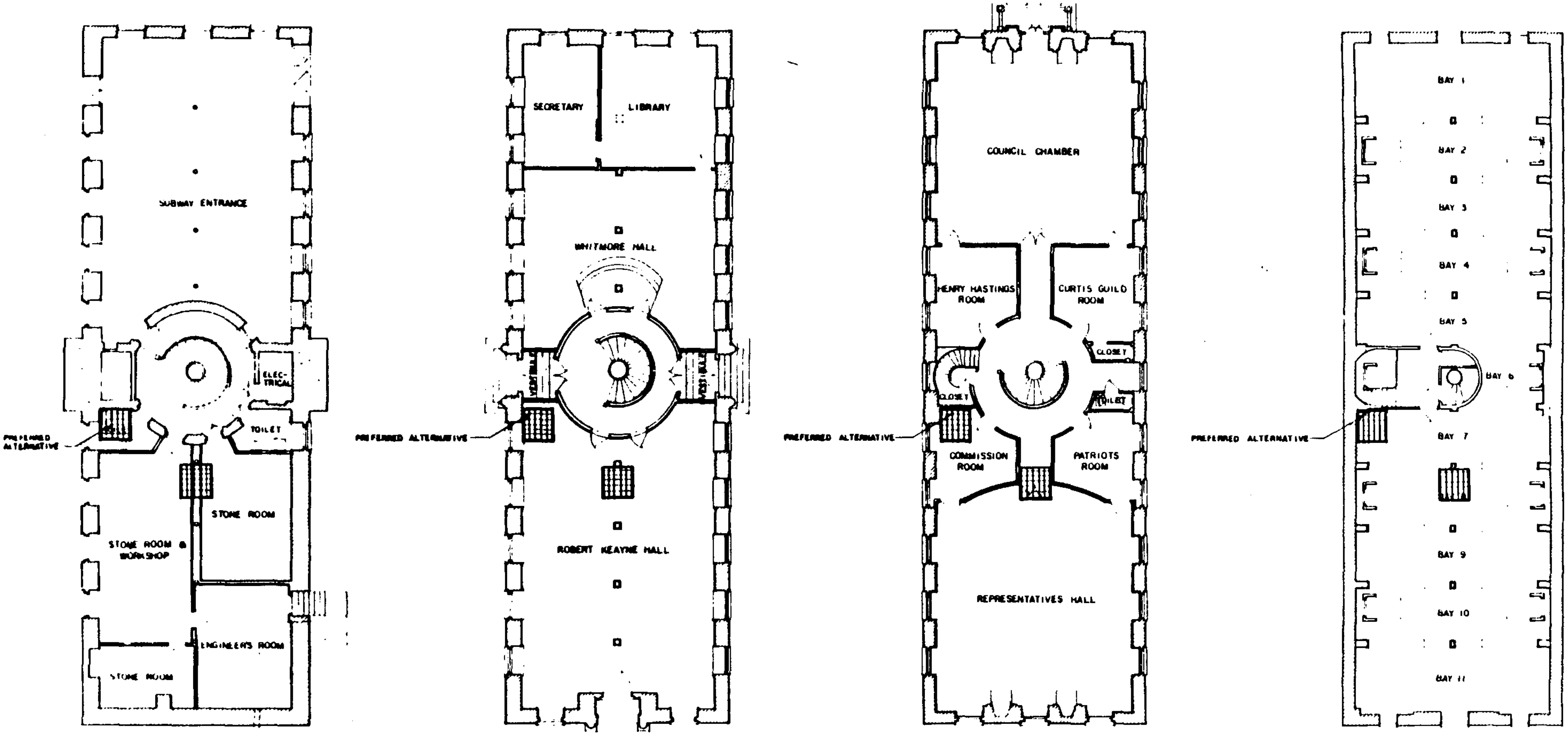
VENTILATION ONLY
PRELIMINARY STUDY — OLD STATE HOUSE
SHEET 5



BASEMENT FLOOR PLAN

FIRST FLOOR PLAN

SECOND FLOOR PLAN

ATTIC FLOOR PLAN

ON MICROFILM

LEGEND

PROPOSED ELEVATOR LOCATION (RESIDENTIAL TYPE RECOMMENDED BECAUSE OF BUILDINGS LIMITED CAPACITY TO ACCOMMODATE THE PIT, MACHINE ROOM, OVERHEAD, AND OTHER CLEARANCES, AND STRUCTURAL SUPPORTS REQUIRED TO OPERATE A COMMERCIAL HYDRAULIC, OR TRACTION ELEVATOR)

SCALE 1/8" = 1'-0"

DESIGNED J. MARSH DRAWN J. MARSH TECH. REVIEW H. LAFLEUR DATE 3/88	PR-6	PROPOSED ELEVATORS PRELIMINARY STUDY — OLD STATE HOUSE	457 25,026 PKG NO 12(SHEET 6 OF 6

VII. ANALYSIS OF IMPACT OF "RECOMMENDATIONS FOR TREATMENT" ON THE STRUCTURE, ITS CONTENTS AND THE HISTORIC SCENE (SECTION 106 COMPLIANCE IN ACCORDANCE WITH 36CFR 800)

In accordance with the requirements set by 36CFR 800 for proposed action on historic structures, the recommendations for the use, and repairs to the Old State House, in this report, should be considered to have no "adverse effect" or have their effects mitigated. The recommendations are based on field investigations and findings, and planning requirements set forth in the approved General Management Plan, and are made in accordance with NPS-28 and the Secretary of the Interior's Guidelines for Rehabilitating Historic Buildings.

Collectively, the continual use for the structure and the planning requirements and preservation/restoration treatment proposed do no more than provide for its continual maintenance. With the preservation/restoration treatment setting the stage, and a preservation guide to help in caring for the structure, it is conceivable that it will be maintained for the education and enjoyment of present and future generations of Americans. Moreover, management of the structure by the NPS, the city of Boston, and the Bostonian Society will assure periodic inspections and see to it that preservation maintenance is carried out.

Recommendations for preservation, restoration, adaptive use, and development can be generally classified as: 1) masonry repairs, 2) woodwork repairs, 3) roof repairs, 4) structural repairs, 5) heating/alternative environmental control repairs or replacement, 6) electrical repairs, 7) plumbing repairs, 8) interior repairs and alterations, and 9) site repairs, and alterations. These recommendations are meant to preserve the structure by maintaining or protecting the integrity of its parts, or the structure as a whole in its existing form. In short, specific effects fostered by the recommendations are as follows:

A. MASONRY REPAIRS: Masonry repairs will include the repainting, refurbishing, and/or cleaning of walls, chimneys, parapet walls, coping, stone steps, etc. All repairs and repainting will be made with like or compatible materials, and refurbishing and/or cleaning will be performed in a manner conducive to the preservation of the visual and/or physical character of the masonry materials. Emphasis will be placed on preserving the historic or existing fabric in every respect, so that there is no adverse effect on the structure. However, if there is an adverse effect on the structure, the impact of the effect will be mitigated.

B. WOODWORK REPAIRS: Woodwork repairs will include the repair, replacement, refinishing or refurbishing of cornices, eaves, fascias, doors, windows, balustrades, pediments and surrounds, balconies, etc. Treatment will be made with like and compatible materials that will match the existing fabric in appearance and quality. In addition, agents for stripping or preparing the woods for treatment will be compatible with these materials. The methods of treatment and preparation leading to treatment will help retain the existing and historic character of the structure, as well as help in energy conservation in the case of windows and doors. Repairs, replacements, refinishing, or refurbishing actions, etc., are not considered adverse effects.

C. ROOF REPAIRS: Roof repairs will include the repair and/or replacement of roofing, gutters, downspouts, etc., in an effort to preserve the historic and/or existing roof and its components, and make the assembly weathertight. Roof framing or finishes may be repaired in some instances to stabilize the roof system. These and other treatments are deemed necessary to preserve and maintain the function of the roof system, and are not considered adverse or irreversible actions.

D. STRUCTURAL REPAIRS: Structural repairs will include the repairs and strengthening of building framing, envelope, foundations, and surrounding or adjacent substructures that threaten the structural integrity of the building or safety of the general public. These repairs will be performed under strict preservation guidelines and local code requirements, and are considered essential to the building's preservation or its existence in today's environment. Any effects of these actions are considered mitigated since they are deemed necessary. Every effort will be made to reduce their impact on the historic structure and scene.

E. HEATING/ALTERNATIVE ENVIRONMENTAL CONTROL REPAIRS OR REPLACEMENT: Heating/alternative environmental control repairs or replacement recommendations are deemed necessary to keep the building occupants comfortable, preserve the building finishes, and to maintain a functional, efficient and energy conserving system. Care has been taken to mitigate the effects of the system on the building by limiting its physical impact upon the building fabric and appearance.

F. ELECTRICAL REPAIRS: Electrical repairs are recommended to protect the building from potential fire hazards, and to help carry out the goals of its use. Removal of the existing and installation of future electrical services in the attic or elsewhere shall be done with the preservation of the building in mind so that the effect of the action is mitigated or causes little or no impact on the structure.

G. PLUMBING REPAIRS: Plumbing repairs are considered to have no adverse effect, since they will involve maintenance of a system that could potentially impact the preservation of the building. The replacement of the old water supply, sewer waste pipes, and fixtures will prevent possible leaks in the system that would damage the building. The installation of the fire detection and suppression systems is deemed necessary for the life safety requirements and the protection of the building and its collections.

H. INTERIOR REPAIRS AND ALTERATIONS: Interior repairs and alterations are recommended to preserve the interior finishes and appearance, as well as to provide a compatible and workable environment for the exhibition, preservation and management of exhibits. Since all of the factors go into the interpretation, preservation, and maintenance of the building, they are considered to have no adverse effect or, in the case of alterations that may call for removing major building elements such as partitions, have their effects mitigated. Actions will be in keeping with preservation guidelines or the requirements set forth in the General Management Plan.

I. SITE REPAIRS AND ALTERATIONS: Site repairs and alterations will be performed in connection with structural foundation work or handicapped accessibility to the building. Since any areas disturbed will be rebuilt as they were before they disturbed, no irreversible actions are foreseen. Consequently, the repairs or alterations are considered to be of little or no adverse effect.

VIII. PACKAGE ESTIMATING DETAIL

REGION	PARK
NORTH ATLANTIC	BOSTON NATIONAL HISTORICAL PARK

PACKAGE NUMBER	PACKAGE TITLE
132	REHABILITATE OLD STATE HOUSE

(If more space is needed, use plain paper and attach)

ITEM	QUANTITY	COST
A. Perform MASONRY REPAIRS	LUMP SUM	$ 104,352
B. Perform WOODWORK REPAIRS	LUMP SUM	104,564
C. Perform ROOF REPAIRS	LUMP SUM	9,644
D. Perform STRUCTURAL REPAIRS	LUMP SUM	650,000
E. Replace EXISTING HEATING SYSTEM with ALTERNATIVE ENVIRONMENTAL CONTROL SYSTEM (Hot Water Heating System)	LUMP SUM	365,000
F. Perform ELECTRICAL REPAIRS and ALTERATIONS	LUMP SUM	21,318
G. Perform PLUMBING REPAIRS	LUMP SUM	13,600
H. Perform INTERIOR REPAIRS and ALTERATIONS	LUMP SUM	1,130,417
I. Perform SITE REPAIRS and ALTERATIONS	LUMP SUM	195,992
J. Renovate and Install SPECIAL FEATURES	LUMP SUM	51,000
		2,645,887
K. CONTINGENCIES		
1. OVERHEAD (25%)		661,472
2. PROFIT (15%)		396,883
TOTAL:		$3,704,242

SUMMARY OF CONSTRUCTION ESTIMATES

CLASS OF ESTIMATE: A ☐ Working Drawings; B ☒ Preliminary Plans; C ☐ Similar Facilities

Proj. Type		Totals from Above B & U	R & T
52	Museum Exhibits		XXXXX
55	Wayside Exhibits		XXXXX
62	Audio-Visual		XXXXX
89	Ruins Stabilization		XXXXX
91	Construction		
92	Utility Contracts		XXXXX

ESTIMATES APPROVED (Signature)	(title)	(date)
Robert L. Hansen	Construction Cost Estimator	3/29/88

IX. RECOMMENDATIONS FOR FURTHER STUDY

Since it was not possible to solve all of the building's problems during the writing of this report, further or continuing study is needed. Included topics for further study are as follows:

A. Monitor the foundation movement in the subway.

B. Monitor the cracks in the building walls.

C. Load test the central staircase.

D. Write and determine the effects of the building planning and programming undertakings on the historic integrity of the structure.

E. Review the recommendations for a full HVAC environmental control system. The review and approval should be performed before any undertakings are implemented.

X. ARCHEOLOGICAL REQUIREMENTS MEMORANDUM

United States Department of the Interior

NATIONAL PARK SERVICE

DSC-Eastern Team
Applied Archeology Center
11710 Hunters Lane
Rockville, Maryland 20852

IN REPLY REFER TO

H3015 (DSC-SEN)
BOST-132-42

MAR 2 1987

Memorandum

To: Team Captain, John B. Marsh, Eastern Team, Denver Service Center

From: Chief, Applied Archeology Center, Eastern Team, Denver Service Center

Reference: Boston National Historical Park, Old State House, Pkg. No. 132, Historic Structures Report

Subject: Archeological Requirements

The purpose of the referenced project, as you know, is to update the existing Historic Structures Report for the Old State House. To do this, and to better define the preservation needs of the building, it may be necessary to expose and examine portions of the structure's foundation. Consequently, in anticipation of archeological clearance for the project, Staff Archeologist John Pousson has reviewed the plans and cross-sections of subway facilities at the site which you sent him, and has assessed the project's potential effects on significant archeological resources.

The State Station of the Massachusetts Bay Transportation Authority and associated subway tunnels are clearly the major existing structural components at the site, and all of the foundation of the Old State House has been tied-in with the underlying station's complex system of steel and reinforced concrete supports. The subterranean structures also extend beneath the streets surrounding the Old State House. There are evidently no original, natural, undisturbed ground surfaces in the vicinity of the building, and the only soil there, other than the geological base for the entire site, is undoubtedly fill associated with subway and other early twentieth century construction. The site cannot be expected to possess significant archeological features and artifacts, in original depositional context, relating to historical activities in and around the structure. There is, however, a possibility that local soils and historical artifacts have been incorporated into the fill at the site.

While the uncertain origin of artifacts in modern fill contexts makes it impossible to ascribe significance to them, the public prominence of the Old State House site will require safeguards in the event that ground disturbances there actually reveal historical artifacts. Therefore, archeological clearance is recommended for the project contingent on archeological review of any plans for testing or other work which involve ground disturbances. Depending on the location and scale of ground disturbances, it may prove advisable to arrange for archeological monitoring. Contracts for testing or other work involving ground disturbances should, in any case, contain standard provisions for the protection of (unanticipated) archeological resources.

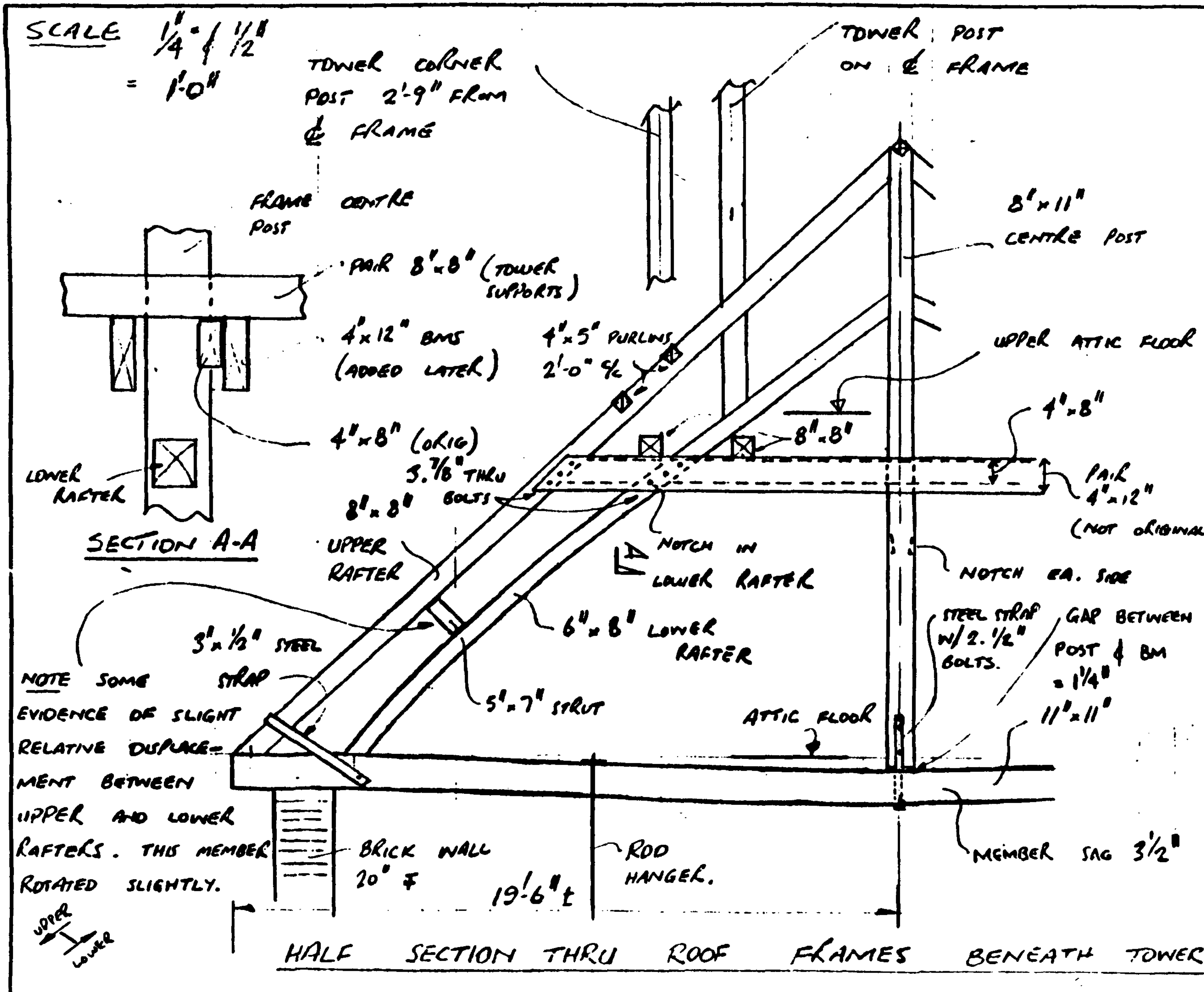
Douglas C. Comer

cc:
Regional Archeologist, NARO
Superintendent, BOST

APPENDIX A

1987 STRUCTURAL ENGINEERING REPORT

CALCULATIONS



319

LeMessurier Associates, Inc

Subject: OLD STATE HOUSE

Made by:

Checked by: [illegible]

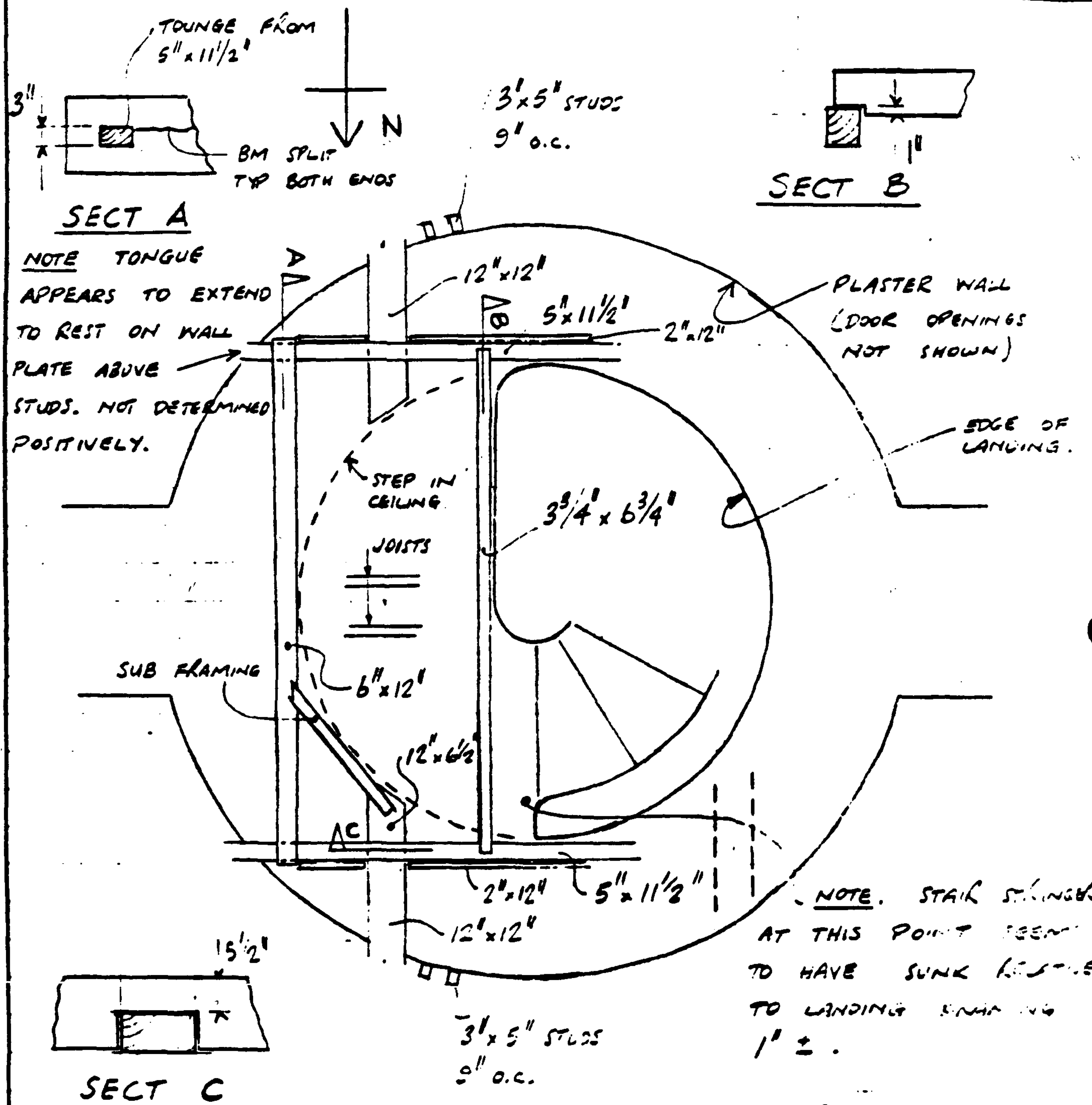
Approved by:

Job No.: 8532

Date: 2/8/74

Sheet No.: 34

LeMessurier Associates, Inc	Subject: OLD STATE HOUSE	Made by: AC	Job No. 8592
		Checked by	Date 2/12/74
		Approved by	Sheet No. 35



NOTE. ALL TIMBERS APPEAR IN GOOD CONDITION. NO VISIBLE SIGNS OF ROT

Scale 1/4" & 1/2" = 1'-0"

PART PLAN OF FRAMING AT 2ND FL STAIR LANDING. MAIN MEMBERS ONLY SHOWN SUB FRAMING OMITTED

Subject: OLD STATE HOUSE

Made by:

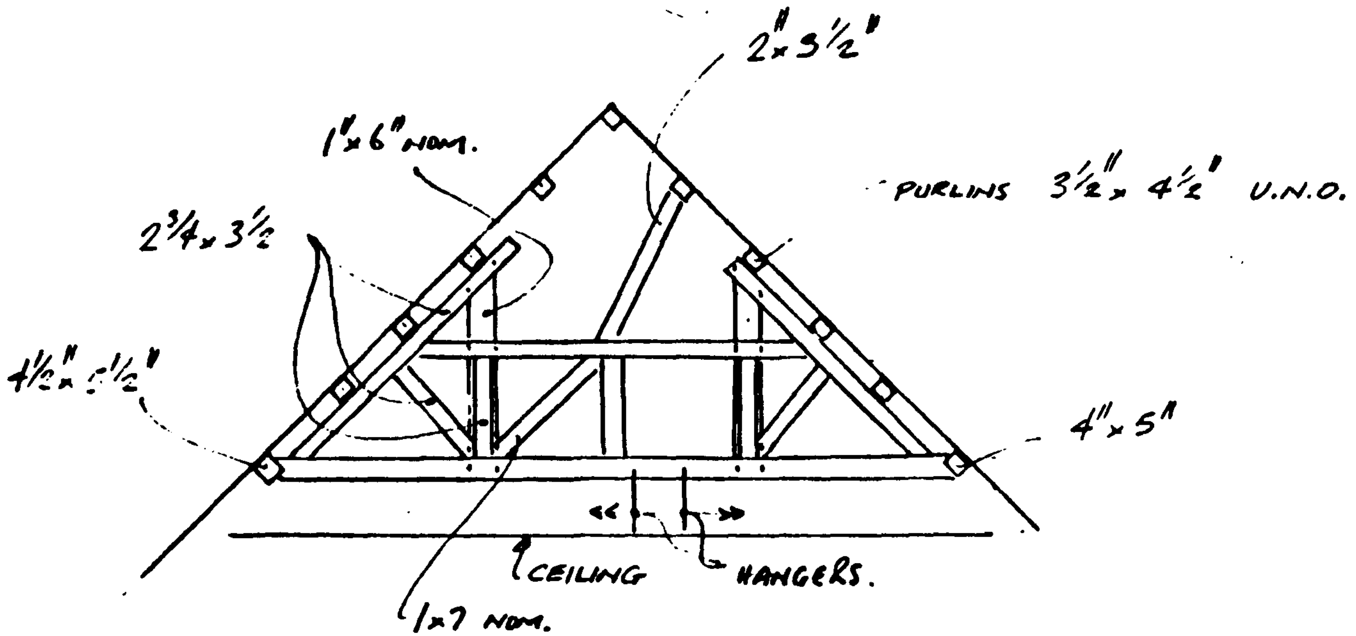
Checked by:

Approved by:

Job No. 8393

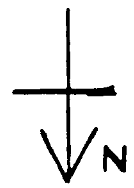
Date 3/5/74

Sheet No 36



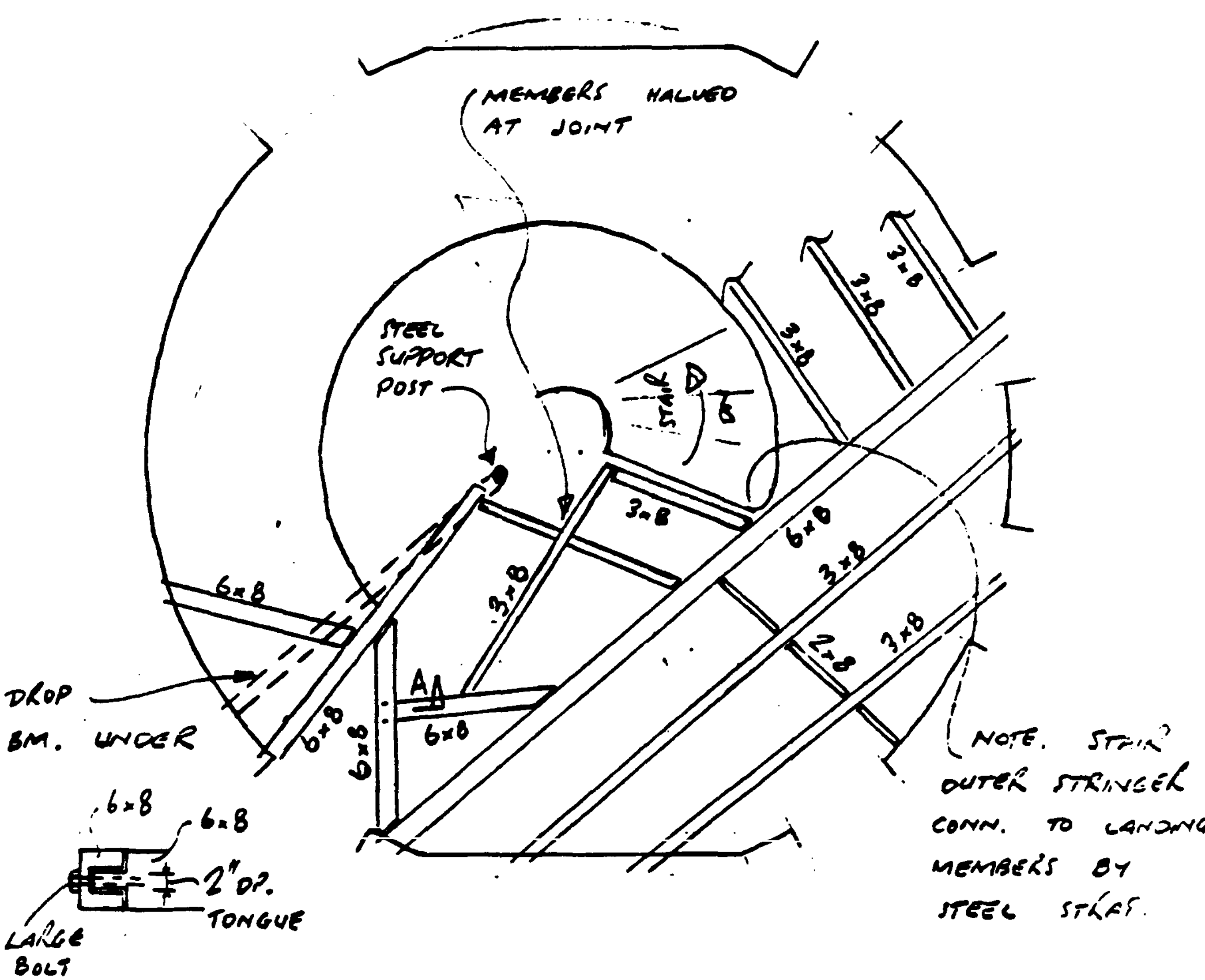
SUPPLEMENTARY ROOF TRUSS LOCATED BETWEEN MAIN TRUSS 1 AND END WALL.

LeMessurier Associates, Inc	Subject OLD STATE HOUSE	Made by JAC Checked by Approved by	Job No. 839C Date 3/7/76 Sheet No. 37



ALL TIMBER IS SAWN. NOMINAL SIZES ARE GIVEN

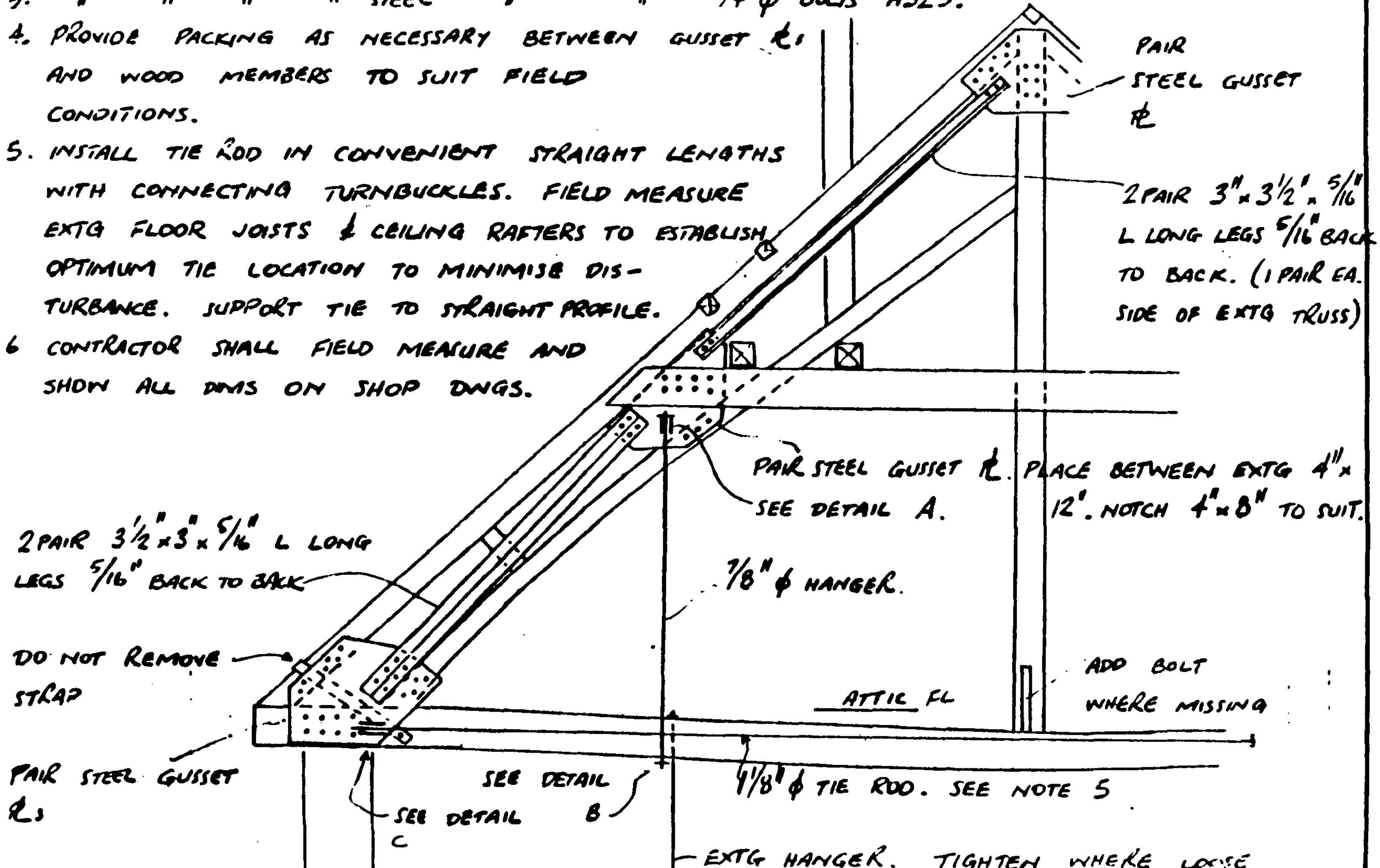
ALL JOINTS ARE NAILED EXCEPT AS NOTED.



PART PLAN OF FRAMING AT FIRST FLOOR STAIR LANDING. MAIN MEMBERS ONLY SHOWN. SUB FRAMING OMITTED.

NOTE

1. STEEL GUSSET PLs TO BE 3/8" THICK.
2. BOLT GUSSET PLs TO WOOD MEMBERS WITH 1" φ THRU' BOLTS
3. " " " " STEEL " " 3/4" φ BOLTS A325.
4. PROVIDE PACKING AS NECESSARY BETWEEN GUSSET PLs AND WOOD MEMBERS TO SUIT FIELD CONDITIONS.
5. INSTALL TIE ROD IN CONVENIENT STRAIGHT LENGTHS WITH CONNECTING TURNBUCKLES. FIELD MEASURE EXTG FLOOR JOISTS & CEILING RAFTERS TO ESTABLISH OPTIMUM TIE LOCATION TO MINIMISE DISTURBANCE. SUPPORT TIE TO STRAIGHT PROFILE.
6 CONTRACTOR SHALL FIELD MEASURE AND SHOW ALL DIMS ON SHOP DWGS.

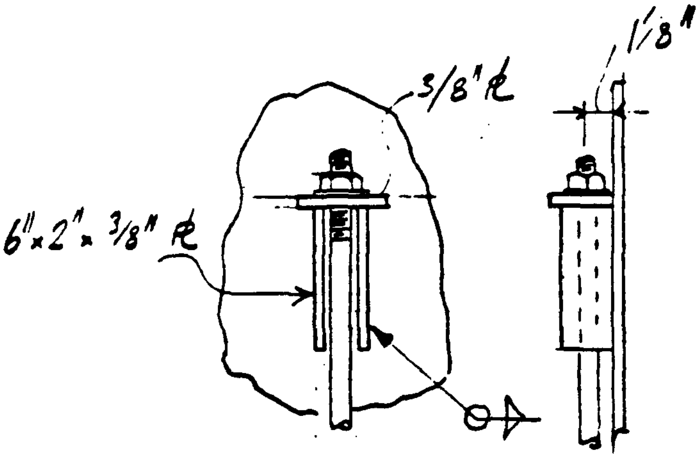


HALF SECTION THRU ROOF FRAMES BENEATH TOWER INDICATING TRUSS STRENGTHENING.

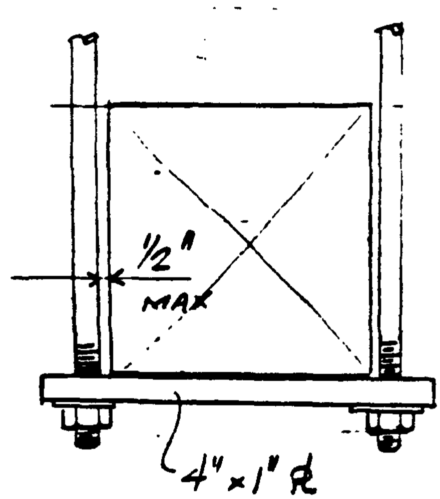
LeMessurier Associates, Inc

Subject	OLD STATE HOUSE
Made by	JAC
Checked by	
Approved by	
Job No.	8292
Date	3/25/74
Sheet No.	38

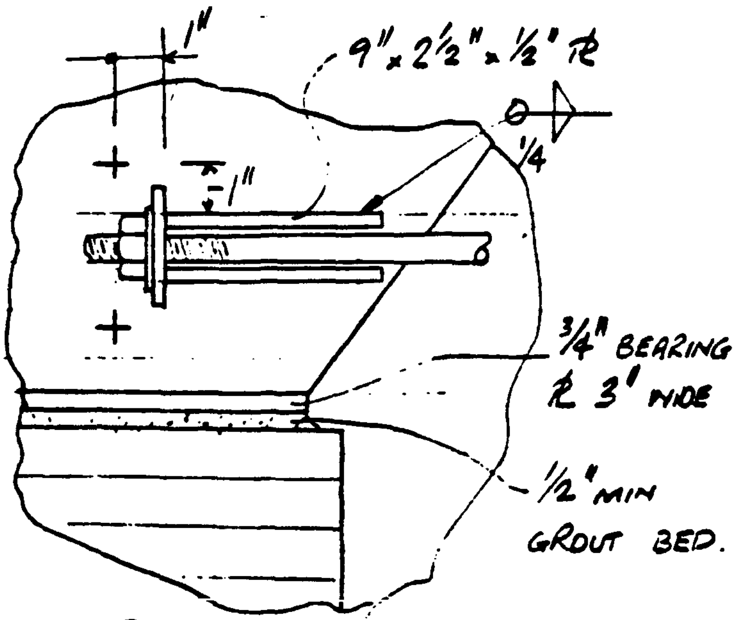
LeMessurier Associates, Inc	Subject: OLD STATE HOUSE	Made by: HK	Job No. 8392
		Checked by	Date 3/25/74
		Approved by	Sheet No. 39



DETAIL A.



DETAIL B.



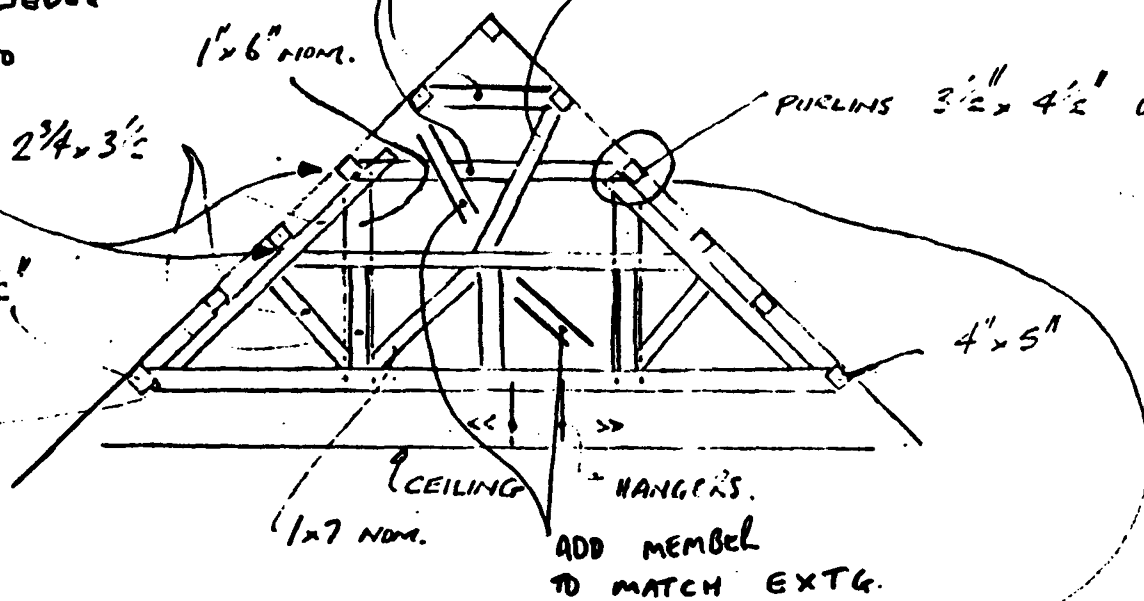
DETAIL C

SEE SHEET 325/1 FOR LOCATION OF DETAILS.

NOTE RE-NAIL ANY LOOSE JOINTS IN TRUSS.

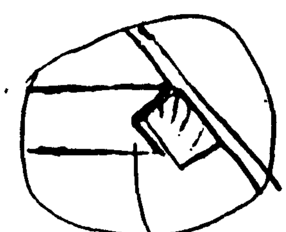
RE SET PURLIN TO TAKE OUT SAG. WEDGE TIGHTLY PURLIN TO RAFTER

ENSURE THIS IS TIGHTLY WEDGED



SUPPLEMENTARY ROOF TRUSS LOCATED BETWEEN MAIN TRUSS / AND END WALL.

STRENGTHENING DETAILS.

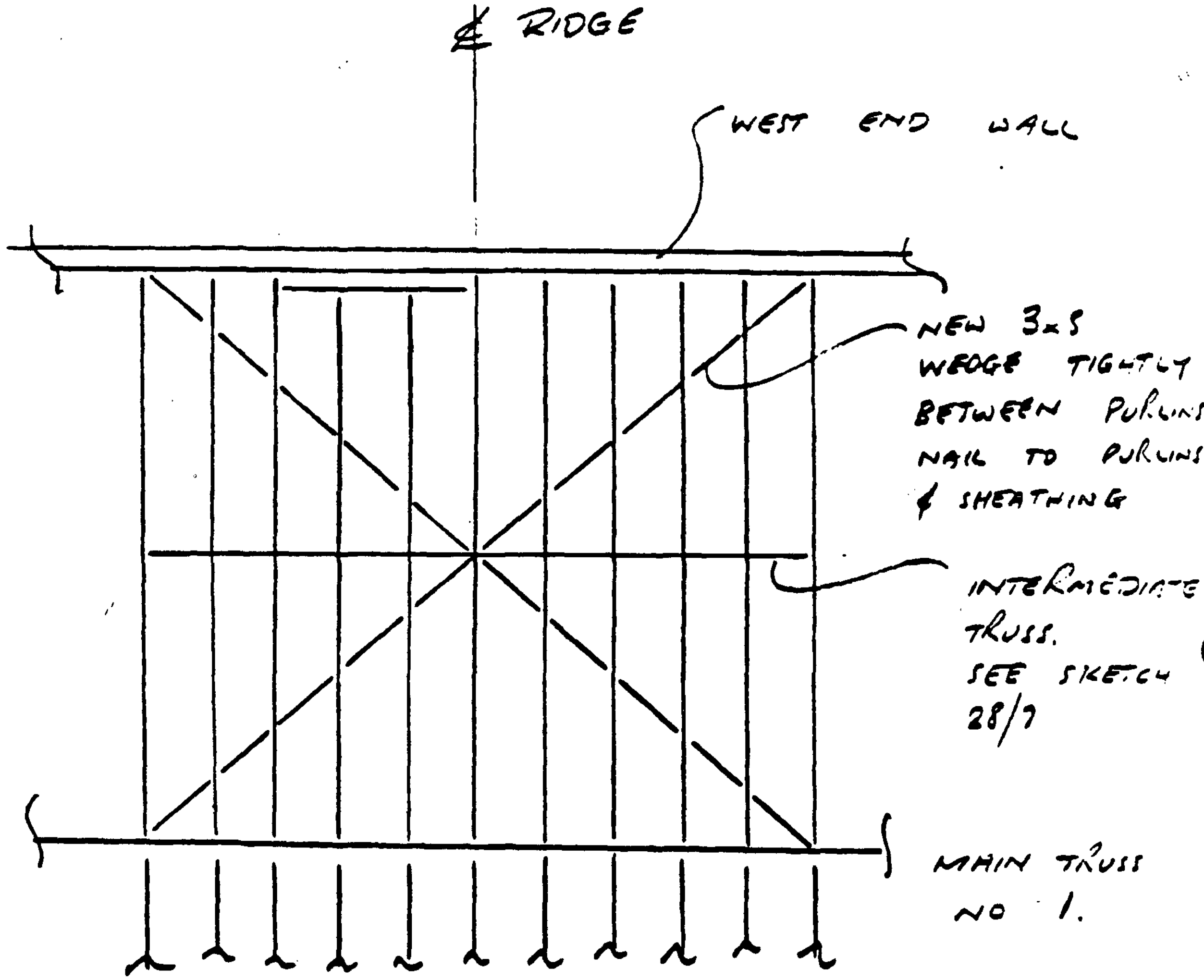


NOTCH HORIZONTAL MEMBER & WEDGE TIGHTLY

Subject | Made by | Checked by | Approved by | Job No. | Date 3/?/7? | Sheet No. 40

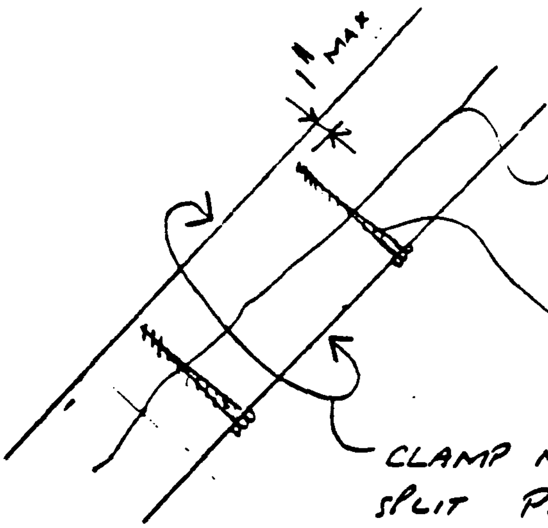
325

LeMessurier Associates, Inc	Subject: OLD STATE HOUSE	Made by: JAC	Job No. 8392
		Checked by	Date 3/25/74
		Approved by	Sheet No. 41



ATTIC ROOF - WEST END. PLAN

LeMessurier Associates, Inc	Subject OLD STATE HOUSE	Made by DOC	Job No. 8392
		Checked by	Date 3/25/74
		Approved by	Sheet No. 42

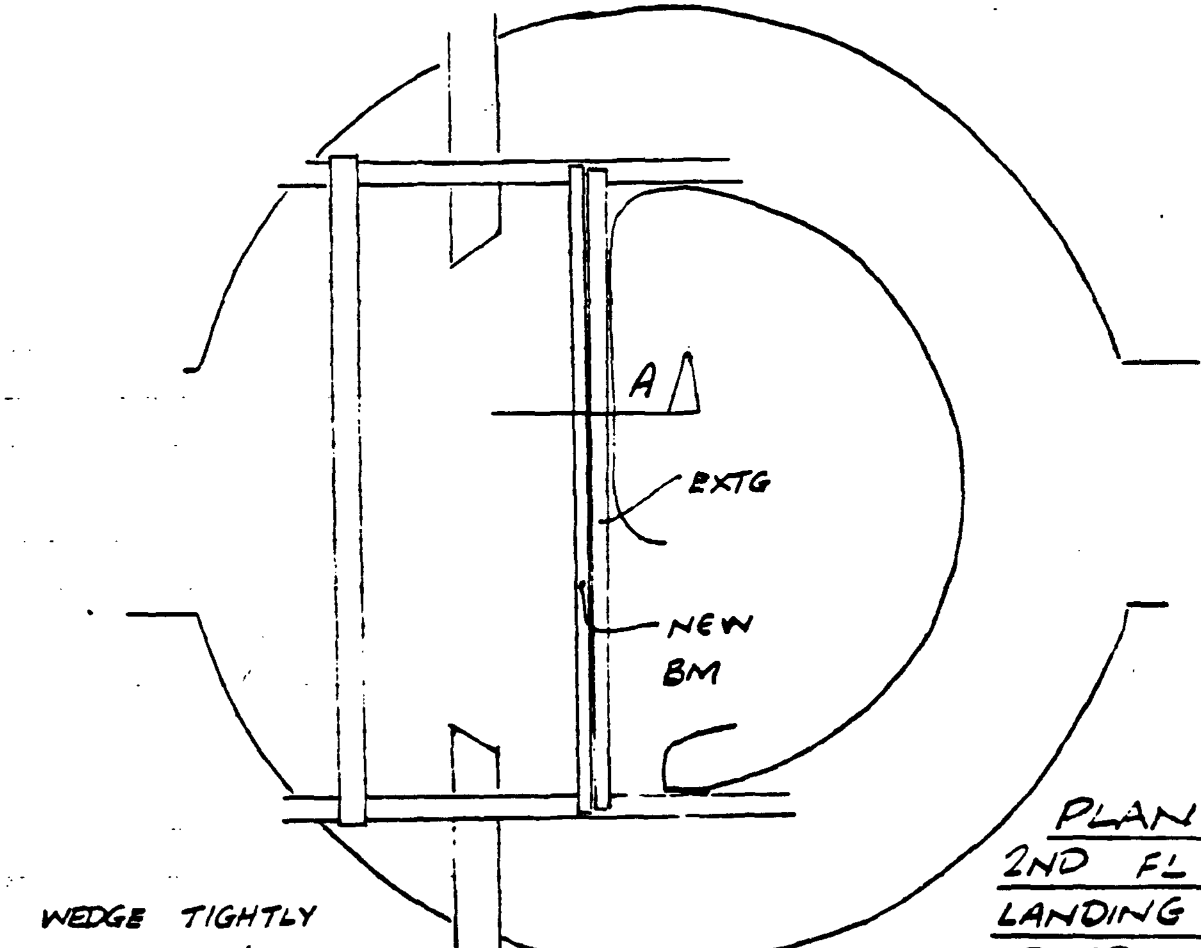


REPAIRS TO SPLIT TRUSS TOP CHORD IN ATTIC LOFT

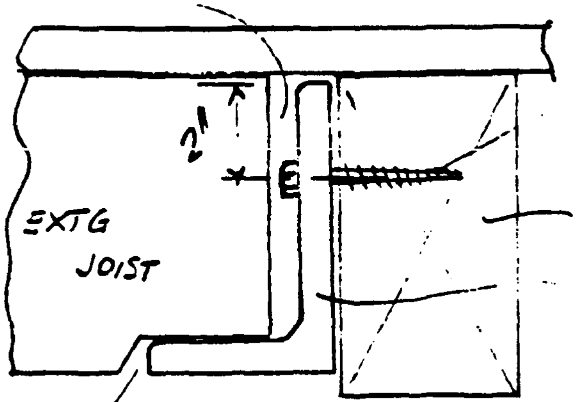
Provide on the following members.

TRUSSES 8 & 9. NORTH & SOUTH SIDES

LeMessurier Associates, Inc	Subject OLD STATE HOUSE	Made by JAC	Job No. 8392
		Checked by	Date 3/25/74
		Approved by	Sheet No. 43



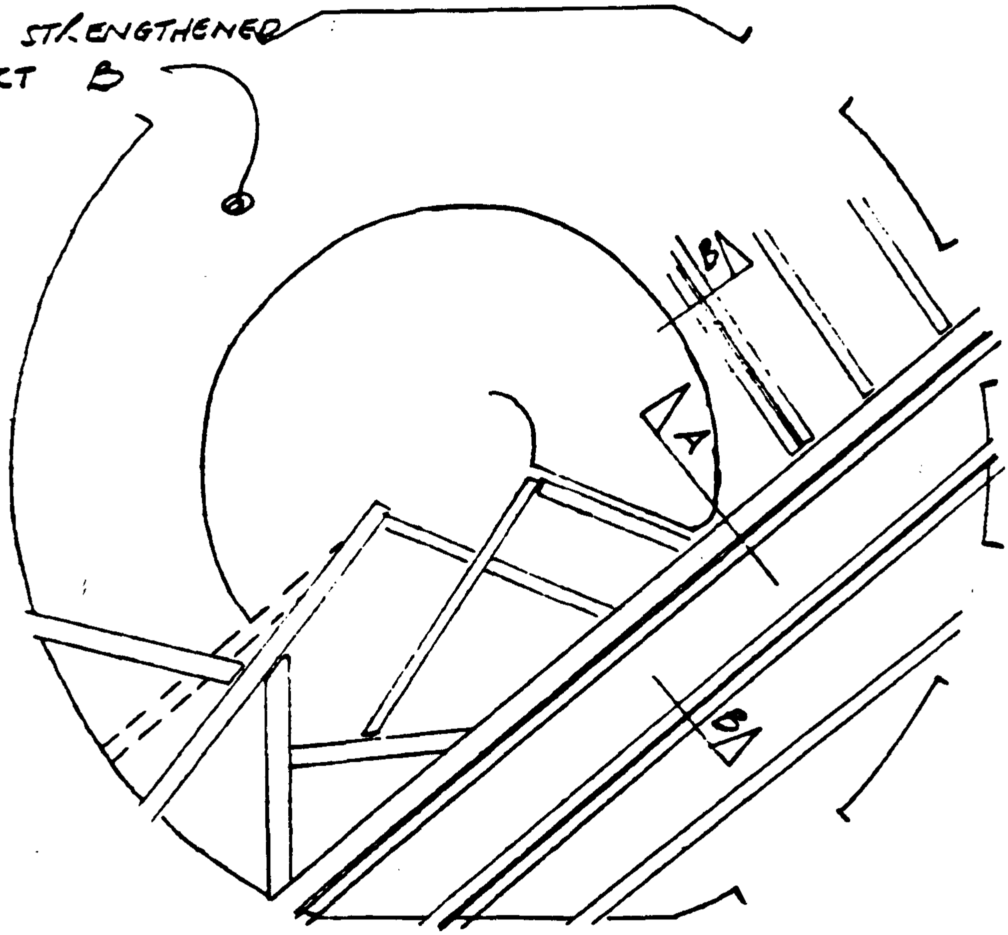
PLAN AT 2ND FL STAIR LANDING SHOWING ADDED FL BM.



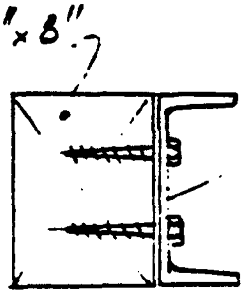
SECTION A

LeMessurier Associates, Inc	Subject: OLD STATE HOUSE	Made by: [illegible]	Job No. 8392
		Checked by	Date 3/25/74
		Approved by	Sheet No. 44

ALLOW FOR ONE JOIST IN THIS AREA TO BE STRENGTHENED AS SECT B



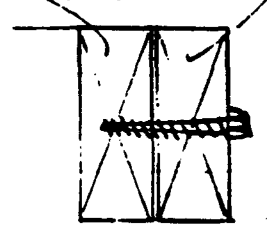
EXTG 6"x8"



MC 8x22.8. BOLT TO EXTG BM W/ 3/8" LAG BOLTS IN PAIRS 16" OC. BEAR 4" MIN EA END.

SECTION A

EXTG 3"x8"

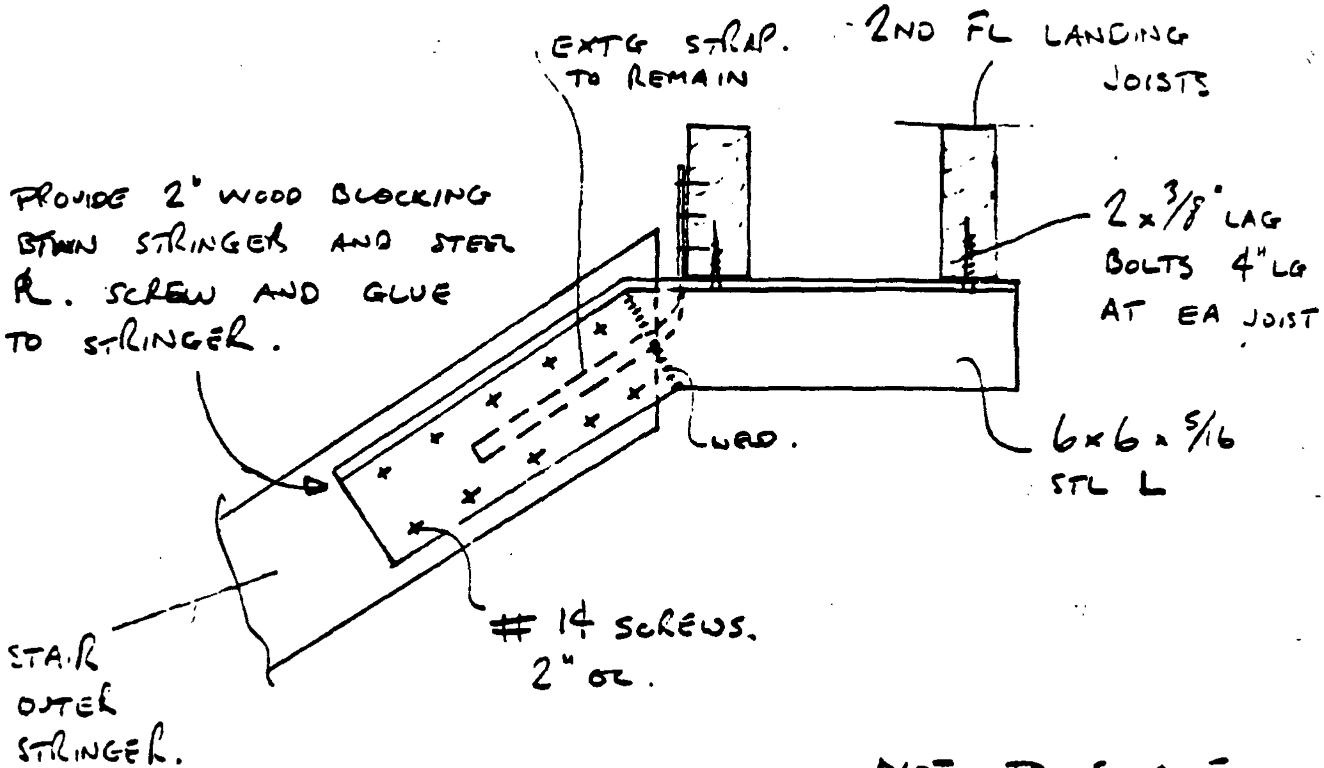


NEW 3"x8" JOIST, CONNECT TO EXTG W/ 1/4" LAG BOLTS 16" OC. BEAR 3" MIN EA. END.

SECTION B

TYP FOR 3"x8" LANDING JOISTS OVER 10' SPAN.

LeMessurier Associates/SCI	Subject OLD STATE HOUSE	Made by JAC	Job No. 8392
		Checked by	Date 9/15/75
		Approved by	Sheet No. 45



NOT TO SCALE

STRENGTHENING OF JOINT BTWN STAIR OUTER STRINGER AND 2ND FLOOR LANDING.

NOTE CONTRACTOR TO FIELD MEASURE AND VERIFY ALL DIMENSIONS.

LeMessurier Consultants
Consulting Engineers

By	Date	File No.	Sheet No.
[illegible]	9-3-87	87137	1.

Subject: OLD STATE HOUSE.
LOADS.

ROOF LOAD.

SLATE	10
1" ROOF SHEATHING	4
PURLINS	3
7/8" PLASTER	4
	21
L.L. SNOW	18
	39 PSF

ZONE 2 PITCH 12:12.

ATTIC FLOOR.

1" FINISH FLOOR	4
1" SUB FLOOR	4
JOISTS	3
PLASTER CEILING	10
DL	21
L.L. (REDUCED).	45
TOTAL.	66 PSF

AREA ON TRUSS = 9.6 × 28 = 270□
R = (270 − 150) · .08 = 9.6%
L.L. = 45 PSF

1ST & 2ND FLOOR.

1" + 7/8" FIN FLR + 1" SUBFLR	11
JOISTS	3
PLASTER CEIL	4
DL	18
LL	100
TOTAL.	118

WALL AREAS.

2ND → ROOF

WALL − WINDOWS

(15 × 238) − 28(8 × 4) = 3574□

1ST → 2ND

(10.5 × 238) − 28(8 × 4) = 2233□

TOTAL BUILDING LOADS.

TOWER (ESTIMATE)		= 60
ROOF + 50% SNOW	= 30# × 113 × 56	= 190
ATTIC FLOOR	= 15# × 112 × 37	= 62
2ND FLOOR	= 18# × 112 × 37	= 75
2' TH. WALL 2ND → ROOF	= 240# × 3574□	= 858
2.5' TH WALL 1ST → 2ND	= 300# × 2233□	= 670
		1915k

(Tower + Roof + Attic floor = 312k)

LeMessurier Consultants Consulting Engineers	By: ACB.	Date: 3-3-87	File No. 87137	Sheet No. 2.
	Subject: OLD STATE HOUSE, EARTHQUAKE & WIND.			

$V = \frac{1}{3} KCSW$ $\qquad K = 1.33$

$C = 0.1$

$= 0.33 \times 1.33 \times 0.1 \times 1.25 \times 1915^{k}$ $\qquad S = 1.25$

$W = 1915^{k}$

$= 105.0^{k}$

E.Q. SHEAR PER FLOOR $= 105.0/2 = 52.5^{k}$. ⇐ CONTROL

WIND ~ ZONE 3 EXPOSURE A 14 psf.

N-S WIND

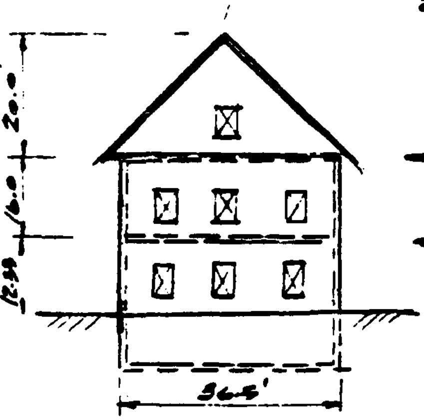
ATTIC LEVEL $= 112.5 \times 25 \times 14 = 39.4^{k}$

2^{ND} FLOOR $= 112.5 \times 13.7 \times 14 = 21.6^{k}$

E-W WIND.

ATTIC LEVEL $= 635^{\square} \times 14 = 8.9^{k}$

2^{ND} FLOOR $= 36.33 \times 13.7 \times 14 = 7.0^{k}$



CHECK SHEAR STRESS IN WALLS ~ ∥ TO EACH END WALL

WALL 2-3 WALL AREA $= (36.5 - \underset{\text{window}}{10.5}) \times 2.0 \times 144 = 7488\ in^2$

WALL 1-2 WALL AREA $= (36.5 - 10.5) \times 2.5 \times 144 = 9360\ in^2$

2-3 $f_{v\,EQ} = 52.5/(2 \times 7488) = 3.5$ psi LOW

1-2 $f_{v\,EQ} = 105.0/(2 \times 9360) = 5.6$ psi LOW.

LeMessurier Consultants Consulting Engineers	By: MS.	Date	File No.	Sheet No. 3.
	Subject: OLD STATE HOUSE EARTHQUAKE & WIND.			

CHECK OVERTURNING.

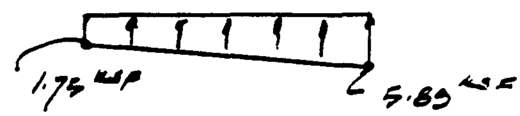
WT OF END WALL $= [(36.5 \times 10) + (16.0 \times 36.5)]\, 240^{\#} + (36.5 \times 12.33)\, 300^{\#} = 362.7^{k}$

$M_{OT\ E.Q.} = [(52.5 \times 28.33) + (52.5 \times 12.33)]/2 = 1067^{ik}$

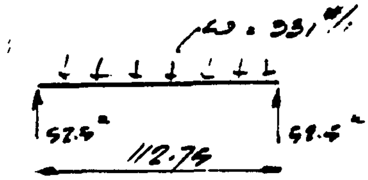
$f_b = \dfrac{362.7}{36.5 \times 2.5} \pm \dfrac{1067}{2.5 \times 36.5^2/6}$

$= 3.97 \pm 1.92$

NO UPLIFT.



CHECK SUBFLOOR AS DIAPHRAGM.



$M = .931 \times 112.75^2/8 = 1480^{ik}$

$S = 1'' \times (36.33 \times 12)^2/6 = 31676\ in^3$

$f_b = \dfrac{1480 \times 12}{81676} = 560$ psi. O.K.

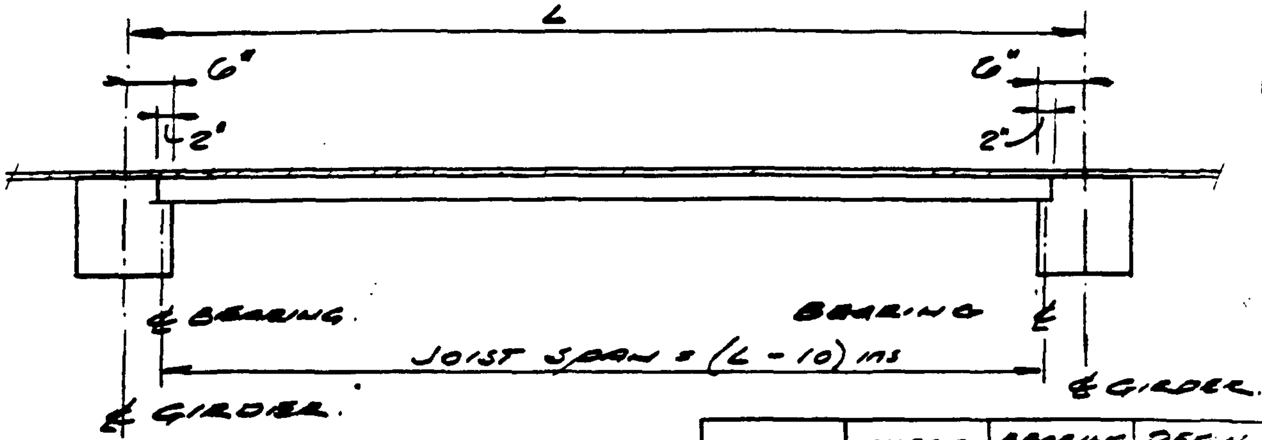
$f_v = \dfrac{3 \times 52.5}{2 \times 36.33 \times 12} = 180$ psi HIGH.

O.K WITH ADD'L 2" FINISH FLOOR.

LeMessurier Consultants
Consulting Engineers

By	Date	File No.	Sheet No.
MB.	10-6-87	87157	3

Subject: OLD STATE HOUSE.
2nd FLOOR FRAMING.



					BENDING	SHEAR	BEARING	DEFLN.
		FT	FT-KIPS	KIPS	P.S.I	PSI	PSI	INCHES
BAY #	L	JOIST SPAN	MOM. $wL^2/8$	REACT. $wL/2$	f_b = M/S	f_v = 1.5R/A	f_{bear} R/2×3½	Δ_{LL}
1	12'-0"	11.75	3.31	1.13	2572	97	161	1.25
2	9'-7½"	8.79	1.85	0.84	1520	72	120	0.39
3	8'-8¼	7.85	1.48	0.75	1216	64	107	0.25
4	9'-11¾"	9.15	2.01	0.88	1652	75	126	0.46
5	8'-10¾	8.06	1.56	0.77	1282	66	110	0.28
6	9'-4"	8.50	1.73	0.82	1421	70	117	0.34
7	9'-7"	8.75	1.84	0.84	1512	72	120	0.39
8	9'-11¾	9.15	2.00	0.88	1643	75	126	0.46
9	9'-1¾	8.31	1.67	0.80	1372	69	114	0.31
10	9'-5⅜	8.61	1.78	0.83	1463	71	118	0.36
11	10-8⅜	10.48	2.62	1.00	2153	86	169	0.79

LOADS.
¾" PLASTER + LATH = 10
1/8 FIN FLR + 1" SUB FLR = 11
JOISTS = 3
2×4 CEIL FRAME = 4
28 PSF
PUBLIC LIVE LOAD 100 PSF.
128 × 1.5 = 192 PLF. (1.5 = JOIST SPACING)

TYPICAL FLOOR JOISTS 3½" × 5"
S_x = 14.6 in^3
I_x = 36.5 in^4
A = 17.5 in^2
E = 1400 k/in² (ASSUME).

LeMessurier Consultants
Professional Engineers

By	Date	File No.	Sheet No. 4A.
Subject			

Allowable floor loads based on the following design stresses. for joists.

Fb	1650	psi.
Ft	950	
Fv	75	
Fc⊥	405	
Fc	1150	E = 1,500,000

By inspection of page 4 all spans qualify for 100 psf except the end spans 1 & 11.

Check span 1. @ east end of building. Level 2
W = 128 × 1650/2592 = 82 PSF bending
OR 128 × 75/92 = 104 " shear.

∴ bending controls.
Live Load = 82 - 28 = 54 PSF.

check span 11 @ west end of building Level 2
W = 128 × 1650/2153 = 98 PSF bending
OR 128 × 75/86 = 117 PSF shear

∴ bending controls
Live Load = 98 - 28 = 70 PSF

Span 11 @ west end of building level 1.
Joists = 4" × 6" @ 22" oc
S = 4×6²/6 = 24 in³ A = 4×6 = 24 in²
M allowable = 1650×24/12000 = 3.3 K'
W " = (3.3 × 8/10.71²) 12/22 = 126 PSF
V allowable = 75 × 24/1.5 × 1000 = 1.2 K
W " = (1.2 × 2/10.71) 12/22 = 122 PSF

∴ Live load = (122 - 28) = 94 PSF Say 100 PSF

Check deflection of end spans under the "qualified" loading. (live load Δ)

Span 1 east end at level 2. 3½ x 5 @ 18"
W = 54 x 1.5 = 81 PLF
Δ = (5/384) .81 x 11.75⁴ x 1728 / 1500000 x 36.5 = .63"
= l/222

Span 11 @ west end at level 2 3½ x 5 @ 18"
W = 70 x 1.5 = 105 PLF
Δ = (5/384) 105 x 10.45⁴ x 1728 / 1500000 x 36.5 = .51"
= l/244

Span 11 @ west end first floor. 4 x 6 @ 22"
W = 97 x (22/12) = 178 PLF
Δ = (5/384) 178 x 10.71⁴ x 1728 / 1500000 x 72 = .5"
= l/258

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Professional Engineers

By	Date	File No.	Sheet No. 4C
Subject			

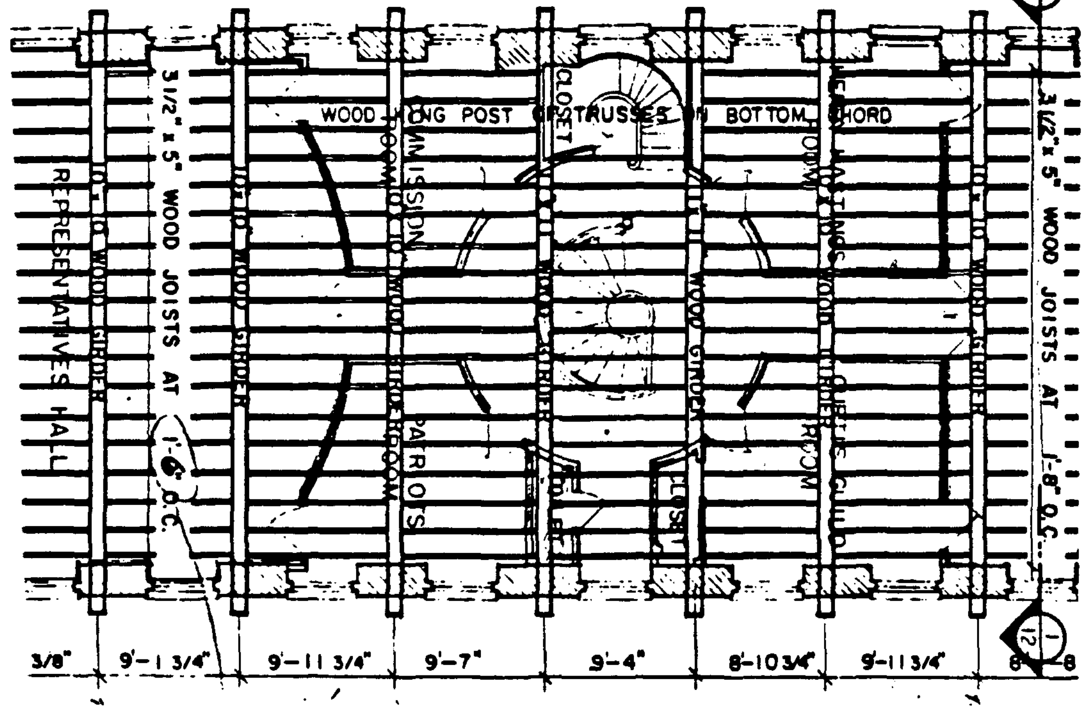
Conclusion. based on joist design.

All spans at level 1 qualify for 100 psf live load.

All spans at level 2 except the end spans qualify for 100 PSF live load.
East end span = 54 PSF
West end span = 70 PSF

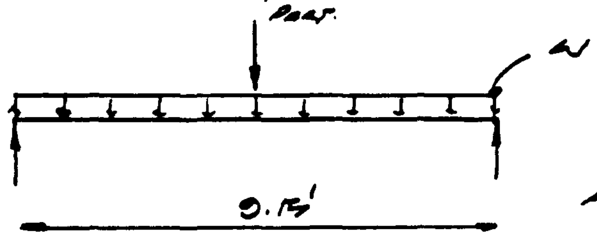
Under full qualified LL as above deflections are somewhat high at
± l/250 1/360 is normal

FIND L.L. CAPACITY OF JOISTS CARRYING PARTITIONS.



SPAN A   SPAN B.

SPAN A.



$\Delta = \dfrac{.522 \times 9.15^3 \times 1728}{48 \times 1300 \times 56.5}$

PARTITION LOAD $= 0.30$ ins.

WT OF PARTITION

1" PLASTER ON LATH EA SIDE + STUDS $= 25\#/ft^2 \times 14.5'$ (HEIGHT) $= 348\#/ft.$

$P = 348 \times 1.5 = 522\#$

$W_{DL} = 28 \times 1.5 = 42$

$W_{LL} = 100 \times 1.5 = 150$

FOR 100 PSF LL + PARTITION.

$M = 3.20^{1-k}$ (DL+LL+PART) $f_b = \dfrac{3.2 \times 12000}{14.6} = 2632$ psi > 1650 N.G.

FOR 25 PSF LL

$M = 2.03^{1-k}$ $f_b = \dfrac{2.03 \times 12000}{14.6} = 1665$ psi ≈ 1650

$V = 0.63$ $f_v = \dfrac{1.5 \times 630}{3\frac{1}{2} \times 5} = 54$ psi O.K.

CONCLUSION. L.L. CAPACITY OF JOISTS AT PARTITIONS = 25 PSF.

LeMessurier Consultants Professional Engineers	By: AB.	Date: 11-20-87	File No. 87137	Sheet No. 4E
	Subject: OLD STATE HOUSE. 2ND FLOOR, AT PARTITIONS.			

IF JOIST AT SPAN (A) A REINFORCED WHAT IS BEAM CAPACITY.?

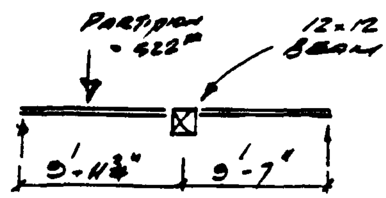
FOR DL = 28, LL = 50 $\quad \omega = (28+50) \times 1.5 = 117$ plf. (joist)

JOIST REACTION $\overset{28^{\#}}{DL} + \overset{50^{\#}}{LL} + \overset{522^{\#}}{PART.} = .117 \times 10.0/2 + .522/2 = 0.85^{k}$

JOIST REACTION $\overset{58}{DL} + \overset{50}{LL} \quad = .117 \times 9.58/2 = 0.56$

1.41^{k}/joist

12x12 BEAM. $\quad A_x = 144$ in², $S_x = 288$ in³



$\omega = 1.41/1.5 = 0.94^{k}$/ft.

$M_{℄} = 0.94 \times 16^2/8 = 30.0^{k\text{-}ft}$

$f_b = \dfrac{30.0 \times 12000}{288} = 1253$ psi $<$ 1300 psi O.K.

$V = 0.94 \times 14.0/2 = 6.58$
AT D FROM SUPPORT

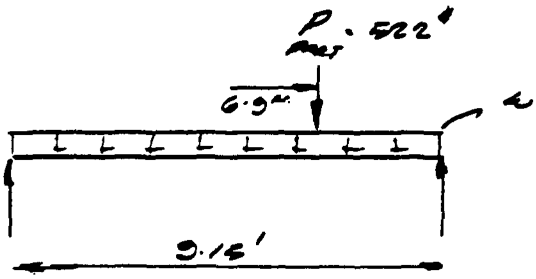
$f_v = \dfrac{6.58 \times 1.5}{144} = 68$ psi $<$ 70 O.K.

CONCLUSION.

IF JOISTS AT SPAN (A) ARE REINF. ADJACENT BEAM CAPACITY IS 50 PSF.

LeMessurier Consultants Professional Engineers	By: [illegible]	Date: 11-13-87	File No. 87137	Sheet No 4F
	Subject: THE OLD STATE HOUSE. FLOOR AT PARTITIONS - 2ND FLOOR.			

AT SPAN B.



FOR DL = 28 PSF + LL = 70 PSF   w = (28+70) × 1.5 = 147 PLF

R_{LHR} = 0.800 k M_{max} = 2.18 1-k (5.41') $f_b = \frac{2.18 \times 12000}{14.6}$

R_{RHR} = 1.07 k   = 1793 psi > 1650 N.G.

FOR DL = 28 PSF + LL = 60 PSF

R_{LHR} = 0.73 k M_{max} = 2.03 1-k (5.5) $f_b = \frac{2.03 \times 12000}{14.6}$

R_{RHR} = 1.0   = 1669 psi ≃ 1650 O.K.

$f_v = \frac{0.94 \times 1.5}{3.5 \times 5}$ = 80 psi < 75 SAY O.K.
AT d FROM SUPPORT.

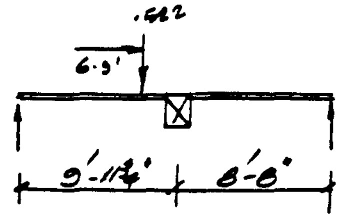
L.L. CAPACITY OF JOIST IS 60 PSF ⇒

LeMessurier Consultants Professional Engineers	By	Date	File No.	Sheet No.
	AB.	11-13-87	87137	46

Subject: THE OLD STATE HOUSE.
FLOOR AT PARTITIONS. ~ 2ND FLOOR.

CHECK BEAM ADJACENT TO JOIST SPAN (8).

FOR DL = 28, LL = 50



L.H. JOIST REACTION = 0.95
R.H. JOIST REACTION = 0.57

1.52 k/JOIST.

$w = 1.52/1.5 = 1.01\ ^k/_{FT}$.

$M = 1.01 \times 16^2/8 = 32.4^{k\text{-}ft}$ $f_b = \frac{32.4 \times 12000}{288} = 1350 > 1300$

CAN SAY O.K.

$V = 1.01 \times 14.0/2 = 7.0^k$
@ d from support

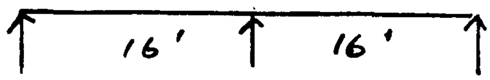
$f_v = 7.0 \times 1.5/144 = 74\ psi < 75$ o.k.

BEAM ADJACENT TO JOIST SPAN (8) HAS CAPACITY OF 50 PSF.

TYPICAL GIRDERS. span 16'-0"

MAX TRIB. WIDTH 10'-0"

$W = .128 \times 10 = 1.28^{k}/ft.$



$M = 1.28 \times 16^2/8 = 41.0^{ft\text{-}k}$

12 × 12

$S_x = 288\ in^3$ $f_b = \dfrac{41.0 \times 12000}{288} = 1708\ psi$

$I_x = 1728\ in^4$

$R = 1.28 \times 16/2 \times 1.15 = 11.78^{k}$ @ center.

$f_v = (11.78 - 1.28 \times 1.7)\frac{3}{2} \times \frac{1}{12 \times 12} = 107\ psi$ @ center support.

Bearing at exterior wall.
Area = 12" × 7" = 84 in²

$f_b = (1.28 \times 16/2)/84 = 122\ psi$ OK.

Bearing at center post 4" × 4"

$f_b = (11.78 \times 2)/4 \times 4 = 1{,}473\ psi$

Very high.

Allowable loads based on the following design stresses for beams. (Typical girders).

Fb 1300 psi
Ft 725
Fv 70
Fc⊥ 405
Fc 925 E = 1,300,000

Bending = (1300 / 1706) 128 = 98 PSF
Live Load = 98 - 28 = 70 PSF

Shear = (70 / 107) 128 = 83
Live Load = 83 - 28 = 56 PSF

OR IF NO CONTINUITY ON BEAM AT CL [illegible] IS ASSUMED. (2 simple spans)

$R = W \times \left(\frac{16}{2} - 1.17\right) = 6.83\ W$

R allowable $= .070 \times 12 \times 12 \times \frac{2}{3} = 6.72$ K

$\therefore W = 6.72 / 6.83 = .98$ KIF $= 98$ PSF

$\therefore$ Live Load $= 98 - 28 = 70$ PSF

Conclusion
Based on beam design the floors good for 70 PSF Live Load.

Bearing condition on center posts needs to be checked.

LeMessurier Consultants Professional Engineers	By	Date	File No.	Sheet No. 5B
	Subject			

Column Capacity.

4" x 4" wood column level 1 - 2. (4x4 true size)

W @ 70 PSF live load + 28 PSF dead load.
= (70+28) 10 x 16 x 1.15 = 18.0 K

l_u = 11.25'

E = 1,300,000 psi.
Fc = 975 psi

$K = .671 \sqrt{E/F_c} = .671 \sqrt{\frac{1300000}{975}} = 24.5$

$l_e/d = 11.25/.33 = 34 > 24.5$

$\therefore F_c' = \frac{.3E}{(l_e/d)^2} = \frac{.3 \times 1300000}{34^2} = 337$ psi

$18000/4 \times 4 = 1125 > 337$

∴ 4" x 4" POSTS NO GOOD MUST BE STRENGTHENED.

USE 6" x 6" POST

LeMessurier Consultants Professional Engineers	By	Date	File No.	Sheet No 5C
	Subject			

CAST IRON COLUMN west end of building below level 1.

Carries 2 floors.

Tributary area = 160 x 2 = 320 ft²

LL reduction = (320 - 150) .08 = 13.6 % Say 14%

load @ 70 PSF live load x .86 = 60 PSF

= 320 x (.06 + .028) = 28.2 K.

height = 9'-3" unsupported.

Per schedule in page 501 Kidder Parker handbook.

Capacity = 76 K. > 28.2 K ok

This is based on the Chicago Building Code formula

$$f = 10000 - 60 \frac{L}{r}.$$

Cast Iron columns are considered ok

LeMessurier Consultants
Consulting Engineers

By	Date	File No.	Sheet No.
MB.	3-18-87	87137	6

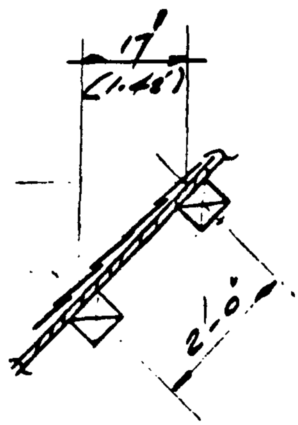
Subject: OLD STATE HOUSE. ROOF FRAMING.

ROOF PURLINS.

BAY 1.

EAST END, SPAN 12'-10"

5×5 @ 2'-0" O.C.

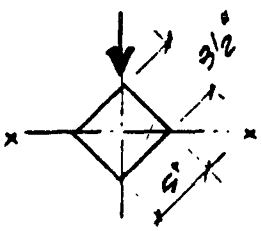


LOADS

SLATE	10
1" SHEATHING	4
PURLINS	3
	17
L.L. SNOW	18
	35 PSF.

$w = (17^{\#} \times 2.0) + (18 \times 1.42') = 60^{\#}/FT.$

$M = .060 \times 12.83^2/8 = 1.23^{1K}$



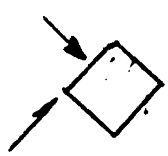
$S_x = \frac{5^2 \times 3.5^2}{6\sqrt{5^2+3.5^2}} = 8.36\ in^3$

$f_b = 1.23 \times 12000/8.36 = 1766\ psi$ N.G.

∴ USE DIAPHRAGM OF SHEATHING SAME AS THAT IN PLACE AT WEST END.

$S_x = 5 \times 3.5^2/6 = 10.2\ in^3$

$M = 1.23 \times 0.7071 = 0.87^{1K}$



SHEATHING TAKES THIS LOAD.

$f_b = 0.87 \times 12000/10.2 = 1023\ psi$

< 1300 O.K.

$\Delta_{LL} = \frac{5 \times .026 \times 12.83^4 \times 1728}{384 \times 1300 \times 17.8} = 0.68" \sim l/226$

OTHER SPANS ARE SHORTER.

LeMessurier Consultants Consulting Engineers	By	Date	File No.	Sheet No. 7
	Subject: OLD STATE HOUSE. ROOF FRAMING.			

BAY 2 SPAN 9'-7"

$M = .060 \times 9.58^2/8 = 0.688^{\text{in}}$

ON DIAGONAL $f_b = 0.688 \times 12000/6.43 = 1283$ psi. O.K.

WITH SHEATHING

$f_b = 0.688 \times 0.707/7.5 = 648$ psi O.K.

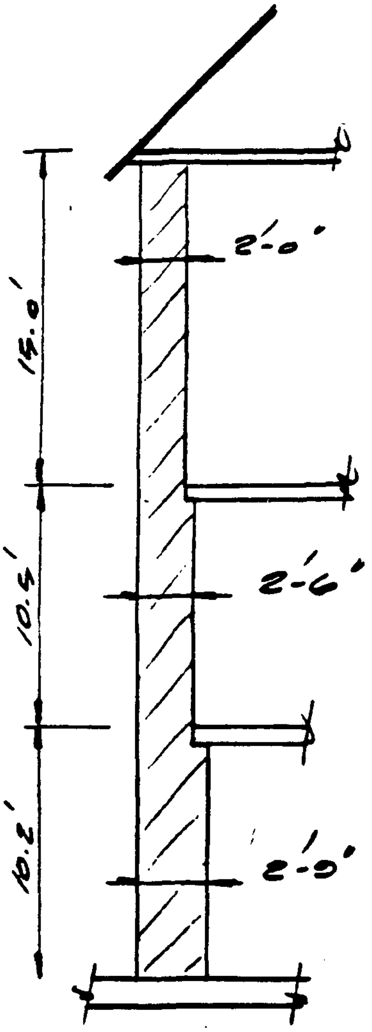
LeMessurier Consultants Consulting Engineers	By: ACS.	Date: 10-13-87	File No.: 87137	Sheet No.: W-1A.
	Subject: OLD STATE HOUSE WALL VIBRATION.			

ASSUME $f'_m = 1000$ psi.

$E_m = 1000 f'_m = 1000\,000$ psi

VIBRATIONS FROM BB&N REPORT.

MICRO INCHES.



$\underline{\Delta_{max}} = 282$ $\quad f_{WALL} = \dfrac{9.6 \times 1{,}000{,}000 \times .000282 \times 12}{(15 \times 12)^2}$

$= 1.0$ psi V. LOW

(NOTE: IF FIXED END CONDITION ASSUMED EACH END $f_w = 5.0$ psi).

$\underline{\Delta} = 126$ $\quad f_w = \dfrac{9.6 \times 1{,}000{,}000 \times .000126 \times 15}{(10.5 \times 12)^2}$

$= 1.1$ psi.

$\underline{\Delta} = 200$

$f_w = \dfrac{9.6 \times 1\,000\,000 \times .0002 \times 16.5}{(10.2 \times 12)^2}$

$= 2.11$ psi

(IF FIXED END ASSUMED $f_w = 10.0$ p

ASSUME SIMPLE SPAN FLOOR TO FLOOR

$\Delta = \dfrac{5wL^4}{384EI}$ $\qquad w = \dfrac{384EI\Delta}{5L^4}$

$M = wL^2/8$ $\qquad w = \dfrac{8M}{L^2}$ $\qquad M = \dfrac{384EI\Delta L^2}{8(5L^4)}$

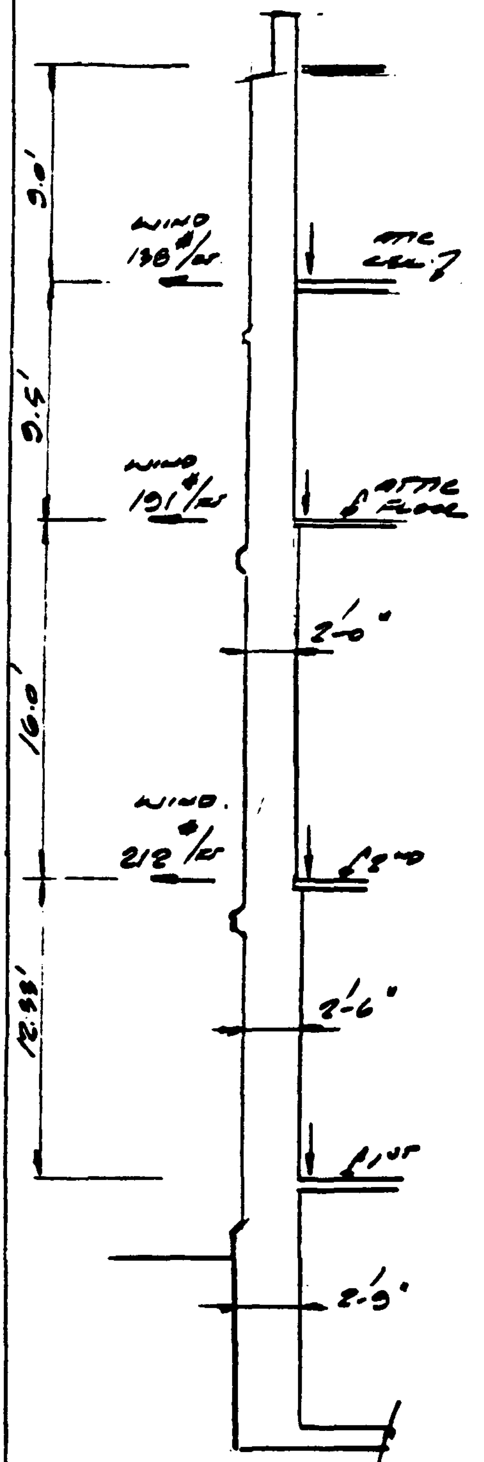
$f = \dfrac{Mc}{I}$ $\qquad M = \dfrac{fI}{c} = \dfrac{384EI\Delta L^2}{8(5L^4)}$

$f = \dfrac{384EI\Delta L^2 c}{8(5L^4)I}$

$f_{WALL} = \dfrac{9.6E\Delta c}{L^2}$ ⟶

LeMessurier Consultants Consulting Engineers	By: [initials]	Date: 10-13-87	File No. 87137	Sheet No. W-1
	Subject: OLD STATE HOUSE EXTERIOR WALLS ~ WEST WALL.			

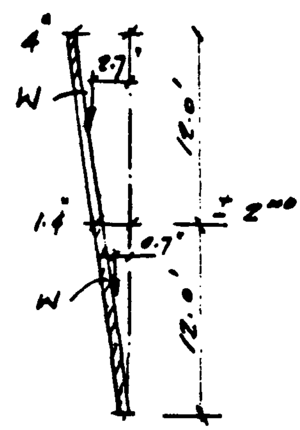
WIND = 15 PSF.



SECTION THRU WEST WALL.

EAST & WEST WALLS SIMILAR.

WALL IS 4" OUT OF PLUMB AT ATTIC FLOOR (LEANING OUT).



CHECK WALL STRESSES DUE TO ECCENTRICITY.

AT 2ND FLOOR ~

W(WALL) = 240# × 28' (AVGE) = 6720 #/LF.

W DL (ATTIC CEIL) = 15 × 6 = 90 #/LF

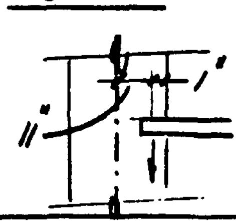
W DL (ATTIC FLOOR) = 25 × 6 = 150 #/LF.

6960 #/LF.

M (WALL WT) = 6720# × 1.3" = 8736

M (ATTIC CEIL + FLOOR) = 240 × (11 - 2.6) = -2016

6720 "-#



LeMessurier Consultants Consulting Engineers	By: ACS.	Date: 10-13-87	File No.: 87137	Sheet No.: W-2.
	Subject: OLD STATE HOUSE. EXTERIOR WALLS ~ WEST WALL			

WALL STRESS AT 2ND FLOOR DUE TO ECCENTRICITY

AT 2ND FLOOR.

$$f = \frac{P}{A} \pm \frac{M}{S}$$

$$= \frac{6560}{12 \times 24} \pm \frac{6720 \times 6}{12 \times 24^2}$$

$$= 24 \pm 6$$

$= 30$ OR 18 ~ NO TENSION O.K.

AT 1ST FLOOR.

$W_{\text{WALL 2ND} \to \text{ROOF}} = 240 \times 28 = 6720$

$W_{\text{WALL 1ST} \to \text{2ND}} = 300 \times 12.33 = 3700$

DL (ATTIC CEIL) : $15 \times 6 = 90$

DL (ATTIC FLR) : $25 \times 6 = 150$

DL (2ND FLR) : $25 \times 6 = 150$

$10{,}810^{\#}$

$M_{\text{(WALL 2ND} \to \text{ROOF)}} = 6720 \times 2.7'' = 18\,144$

$M_{\text{1ST} \to \text{2ND}} = 3700 \times 0.7'' = 2590$

$M_{\text{ATTIC CEIL + FLOOR}} = 240^{\#} \times (11 - 4) = -1680$

$M_{\text{2ND FLOOR}} = 150^{\#} \times (11 - 1.4) = -1440$

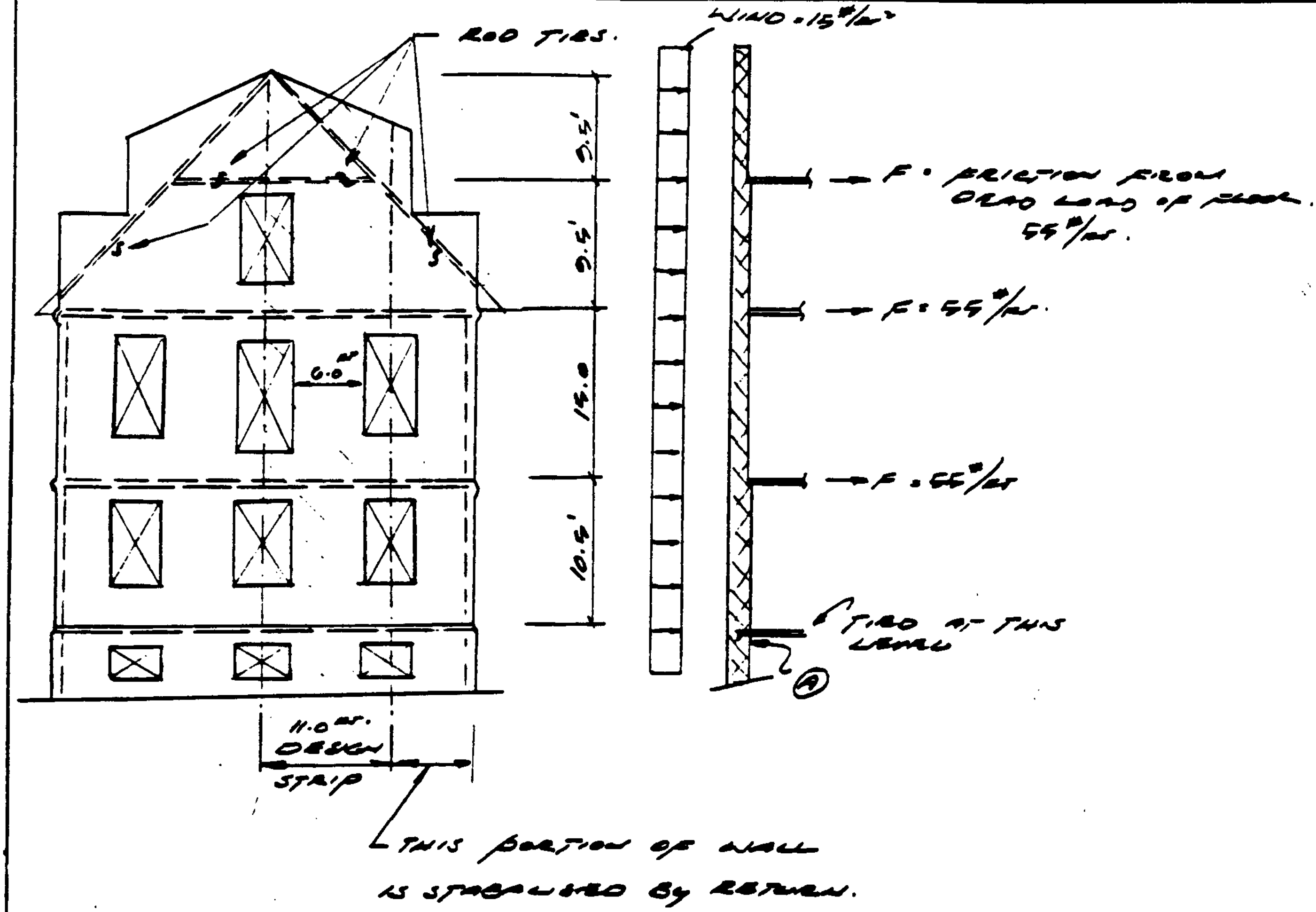
17614 "-#

$$f = \frac{10810}{12 \times 30} \pm \frac{17614 \times 6}{12 \times 30^2}$$

$$= 30 \pm 10$$

$= 40$ OR 20 ~ NO TENSION. O.K.

LeMessurier Consultants Consulting Engineers	By: AES	Date: 10-21-87	File No.: 87136	Sheet No.: W-3
	Subject: OLD STATE HOUSE. EXTERIOR WALLS. ~ EAST & WEST.			



CHECK STABILITY OF WALL ASSUMING WALL IS RESTRAINED AT EACH FLOOR BY FRICTION FORCE OF FLOOR D.L.

$\downarrow R_{\text{at wall}} = 28^{\text{psf}} \times 10.5/2 = 147\ \#/\text{ft}.$

$F = 147 \times 0.75 \times 0.5 = 55\ \#/\text{ft}.$ (COEF OF FRICTION 0.5, USE 75% OF D.L)

$\Sigma M @ (A) = 0.015 \times 44.5^2/2 - (.055 \times 35) - (.055 \times 24.5) - (.055 \times 10.5) = 10.9^{\text{ft-k}}/\text{ft}.$

M ON DESIGN STRIP $= 10.9 \times 11 = 120^{\text{ft-k}}/\text{strip}.$

$f_b = \dfrac{120 \times 12000}{72 \times 33^2/6} = 110$ psi N.G.

WALL CANNOT CANTILEVER OFF GROUND LEVEL

TIE IS REQ'D AT ATTIC LEVEL.

LeMessurier Consultants Consulting Engineers	By: MB.	Date: 10-21-87	File No.: 87136.	Sheet No.: W-4.
	Subject: OLD STATE HOUSE. EXTERIOR WALLS ~ EAST & WEST.			

ASSUME WALL IS TIED AT THE ATTIC FLOOR AND AT 1ST FLOOR.

$M_{WIND} = 0.015 \times 25.5^2/8 = 1.22$ ^k'/FT.

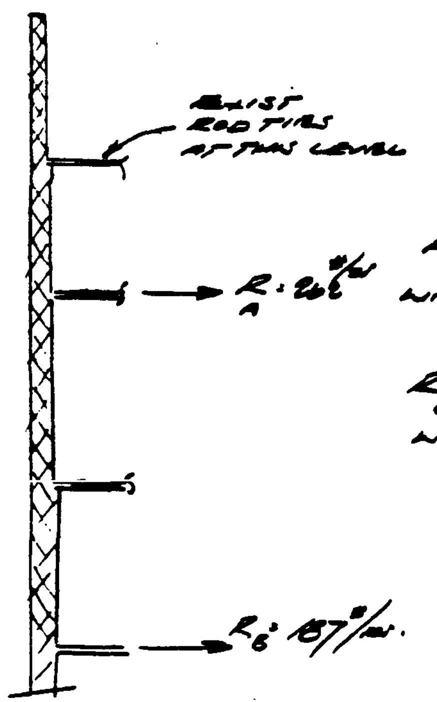
M_{WIND} (DESIGN STRIP) $= (1.22 \times 11) = 13.41$

$f_b = \dfrac{13.41 \times 12000}{72 \times 24^2/6} = 23$ psi (AT MID-SPAN).

P AT MIDSPAN $= 31^{FT} \times 240^{\#} = 7.44^k$ (WT OF WALL).

$f_a = \dfrac{7.44}{24 \times 12} = 26$ psi > 23 psi WIND

O.K. NO TENSION.

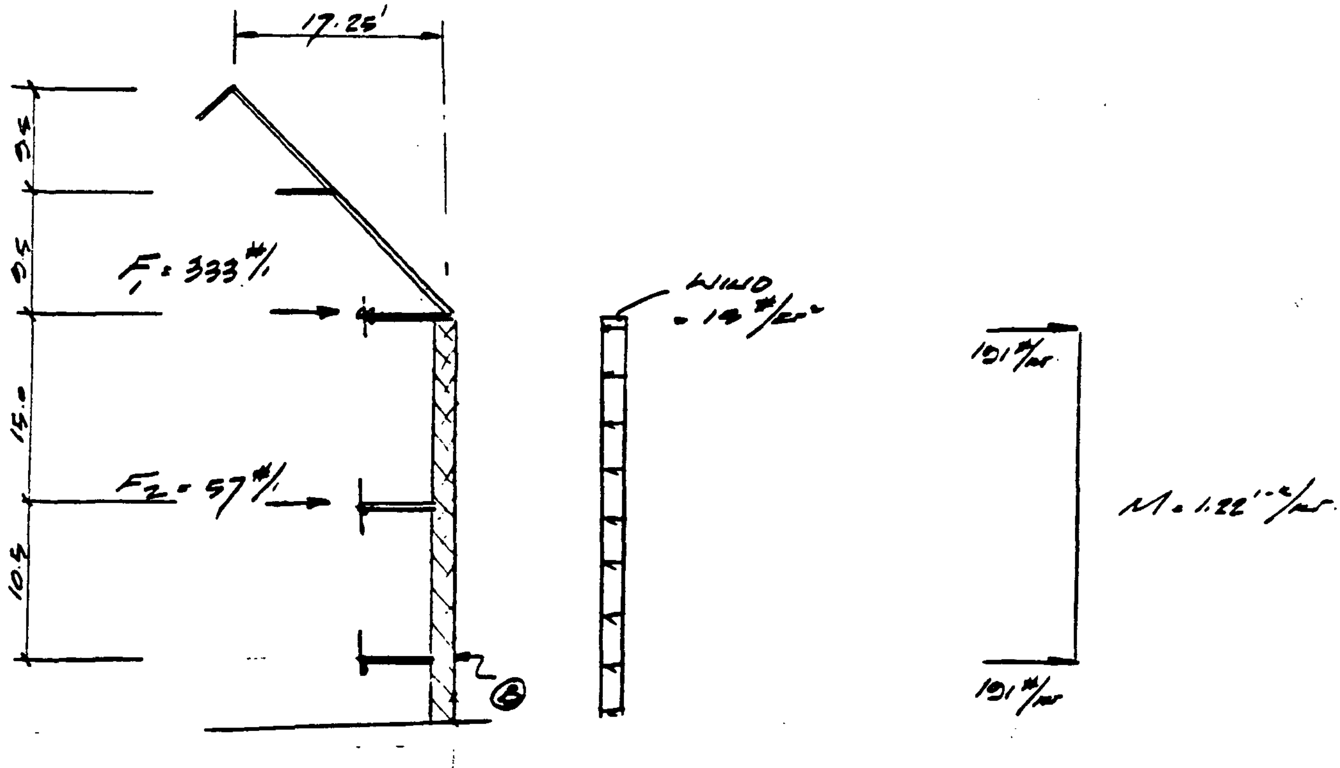


$R_{A\,WIND} = .015^k \times 17.5' = 262^{\#}/FT.$

$R_{B\,WIND} = .015^k \times 12.5' = 187^{\#}/FT.$

PROVIDE TIES TO WALLS AT ATTIC FLOOR LEVEL.

LeMessurier Consultants Consulting Engineers	By	Date	File No.	Sheet No.
	[illegible]	2 NOV 87	87137	W-5
	Subject: OLD STONE HOUSE. NORTH & SOUTH WALLS.			



CHECK STABILITY OF WALL ASSUMING WALL IS RESTRAINED AT ATTIC & 2ND FLOOR BY FRICTION OF DEAD LOAD.

TRUSS REACTION.

ROOF DL = 21#/FT² × 25 = 525#/FT

ATTIC DL = 21#/FT² × 17.3 = 363

= 888 × 0.75 × 0.5 = 333#/FT. = F_1

(0.75: USE 75% D.L.; 0.5: FRICTION FACTOR.)

2ND FLOOR.

DL = 18#/FT² × 8.5' = 153 × 0.75 × 0.5 = 57#/FT = F_2

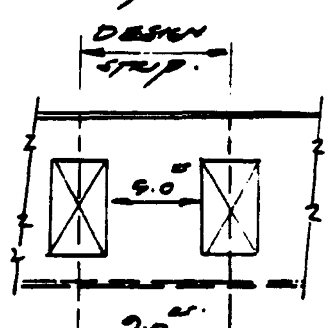
IF WALL SPANS FROM 1ST FLOOR → ATTIC FLOOR.

$R_{\text{AT ATTIC}}$ = .015 × 25.5/2 = 101#/FT. < 333#/FT RESTRAINT PROVIDED BY FRICTION. O.K.

M_{WIND} = .015 × 25.5²/8 = 1.22 '-k/FT.

$M_{\text{WIND ON DESIGN STRIP}}$ = 1.22 × 9 = 10.9 '-k

f_b AT MIDSPAN = $\frac{10.9 \times 12000}{60 \times 24^2/6}$ = 22.7 psi



FIND STRESS IN WALL DUE TO D.L. ONLY.

5'-0" DESIGN STRIP.

ROOF + ATTIC	= 888 #/FT.	× 9.0	= 7992
WALL = 12.8 FT × 240 # MIDSPAN → ATTIC	= 3072 #/FT	× 5.0	= 15360
2ND FLOOR	= 57 #/FT.	× 9.0	= 513
	4017 #/FT		23865 #

f_a : $\frac{23865}{60 \times 24}$ = 16.5 psi.
D.L. ONLY

COMBINED STRESS DUE TO GRAVITY + WIND.

16.5 ± 22.7 = −6.2 psi TENSION
= +39.2 psi COMPRESSION.

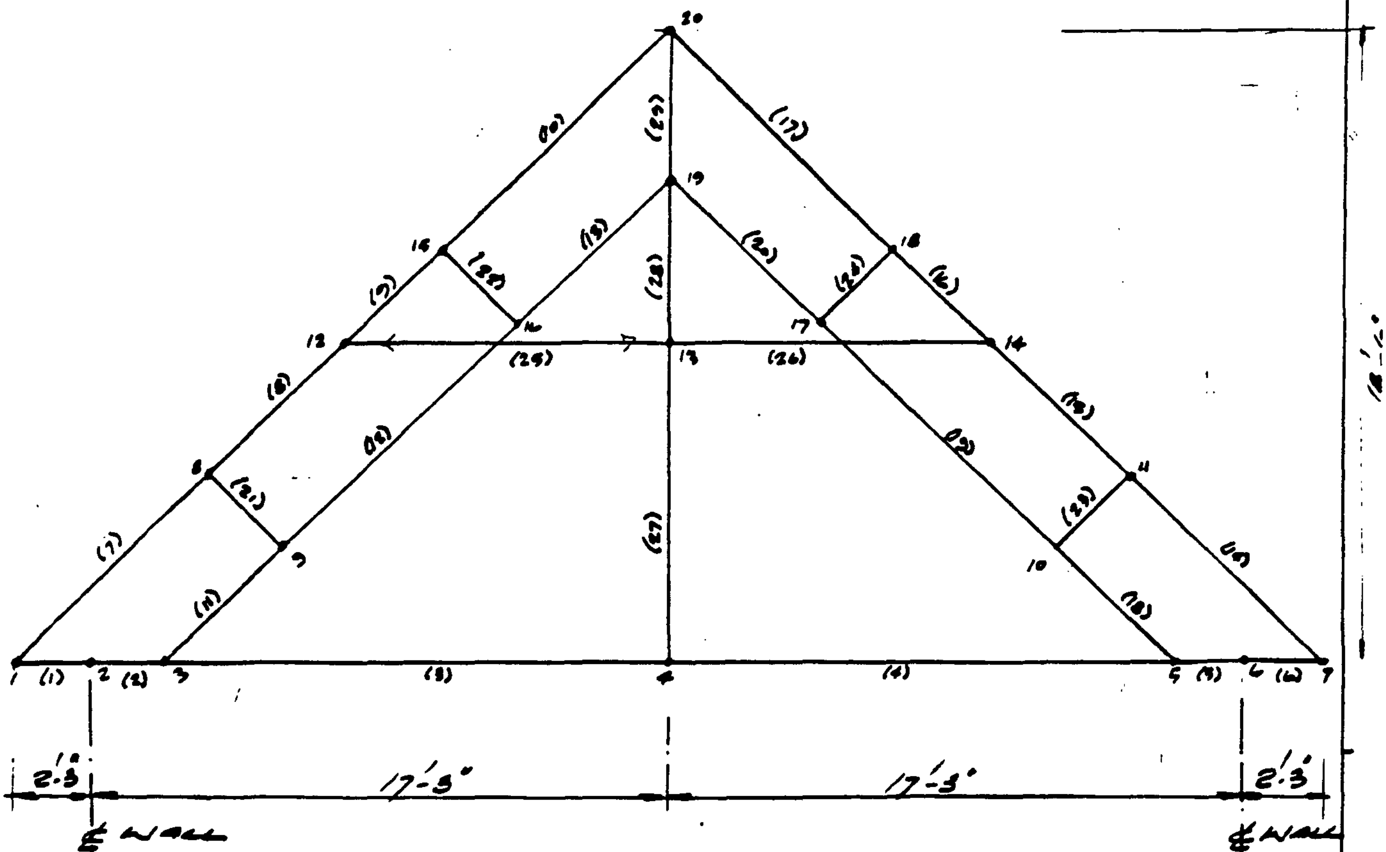
O.K.

FIND STRESS IN WALL DUE TO DL + LL.
AT GRADE.

ROOF + ATTIC DL		= 888
2ND FLR DL		= 57
1ST FL DL		= 57
2ND FLR LL	70 × 17.75/2	= 621
1ST FL LL	70 × 17.75/2	= 621
ATTIC LL	50 × 17.75	= 888
SNOW LL	18 × 17.75	= 320
~~2FT WALL~~	~~2 × 120 × 15~~	~~= 3600~~
2.5FT WALL	25 × 120 × 15	= 4500
		11552

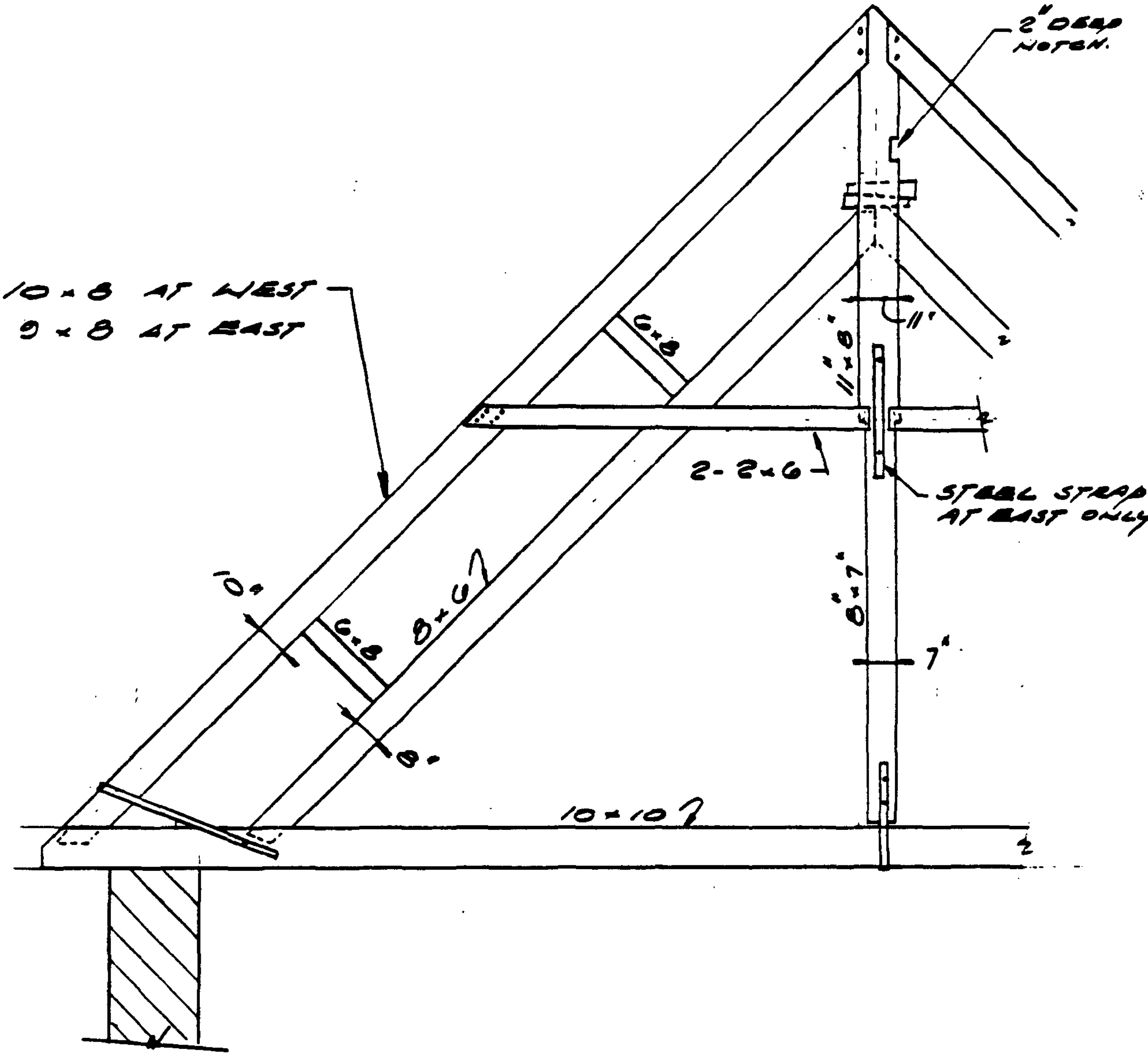
f_b = $\frac{11552 \times 9^{FT}}{12 \times 5 \times 30}$ = 58 psi
AT PIERS

LeMessurier Consultants Consulting Engineers	By	Date	File No.	Sheet No.
	RLB.	3-11-87	87137	T-1
	Subject: OLD STATE HOUSE.			



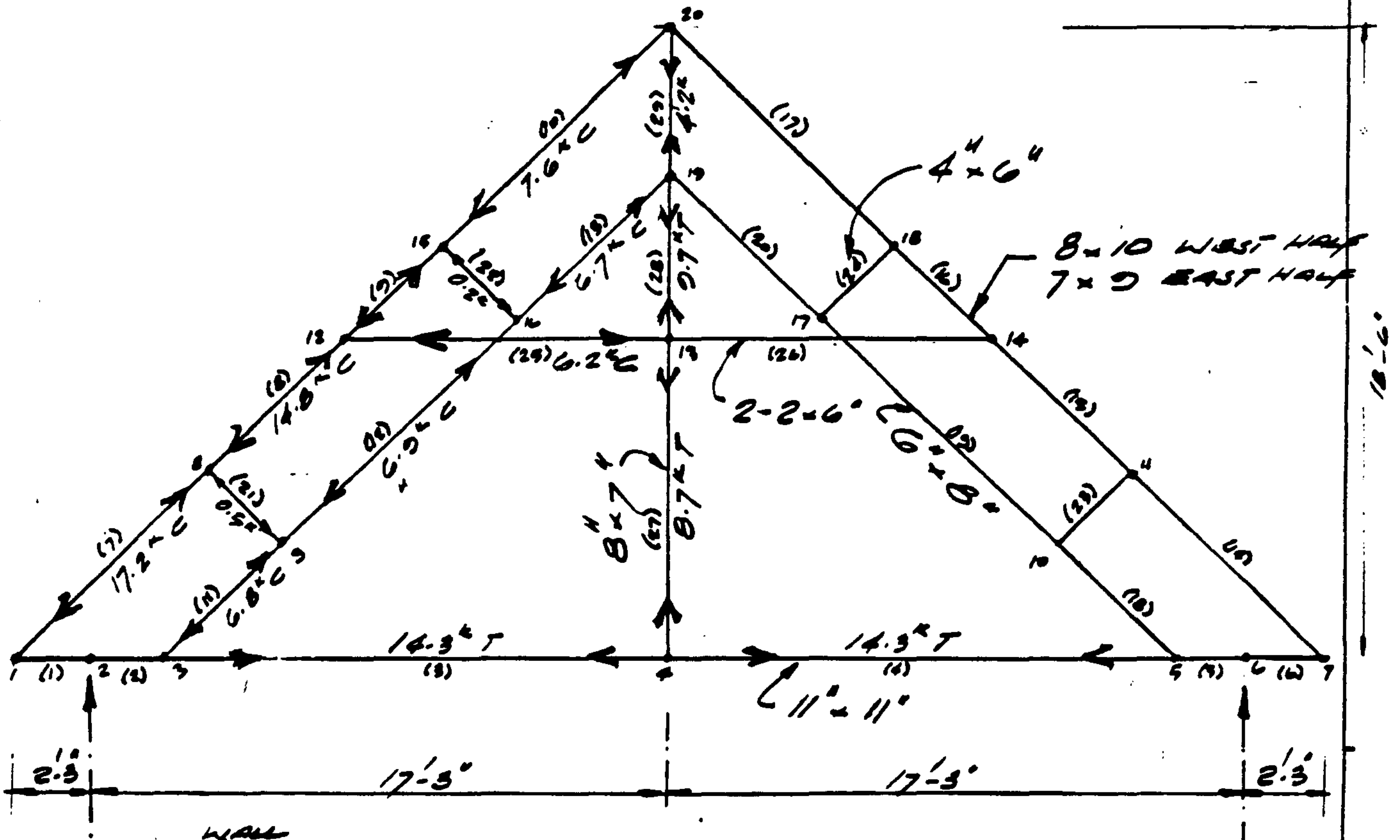
TYPICAL ROOF TRUSS.

LeMessurier Consultants Consulting Engineers	By MB.	Date 6.16-87	File No. 83235	Sheet No. 13
	Subject OLD STATE HOUSE ROOF TRUSS			



EXISTING CONDITIONS AT TYPICAL ROOF TRUSS.

LeMessurier Consultants Consulting Engineers	By: RB.	Date: 3-11-87	File No.: 87137	Sheet No.: T-1
	Subject: OLD STATE HOUSE.			



TYPICAL ROOF TRUSS.

R = 21.4k
DL+LL

MEMBER LOADS FOR DL + SNOW + 50# ATTIC L.L.

TRUSS SYMM. ABOUT ℄

LeMessurier Consultants Consulting Engineers	By [illegible]	Date 10-15-87	File No. 87137	Sheet No. T-2
	Subject OLD STATE HOUSE.			
	TYPICAL TRUSS			

AT TYPICAL INTERIOR TRUSS. (SEE SHEET 1 FOR LOADS)

TRIB. WIDTH = 9.6 FT.

LOADS. SELF WT.

TOP DIAGONAL CORD	DL = (21 × 9.6) + 15		= 217 #/FT
	LL = 18 × 9.6'		= 173 #/FT.
ATTIC CEILING (PLASTER ON LATH)	DL = (10 × 9.6') + 5		= 101 #/FT.
ATTIC FLOOR	DL = (21 × 9.6) + 25		= 227 #/FT.
REDUCED	LL = 45 × 9.6		= 432 #/FT.

MEMBERS 3 & 4. 11 × 11 $A_s = 121\ in^2$

$S_x = 222\ in^3$

$T = 14.4^k$ $f_t = 14.4/121 = 119$ psi

$V = 5.6^k$ $f_v = 1.5 \times 5.6/121 = 69$ psi

$M = 13.9^{1-k}$ (AT MID-SPAN) $f_b = 13.9 \times 12/222 = 750$ psi.

ASSUME HEM-FIR POSTS & TIMBERS

$F_b = 1300$

$F_t = 725$

$\perp F_c = 405$

$// F_c = 925$

$E = 1300000$

FLEXURE & AXIAL TENSION.

$$\frac{f_t}{F_t} + \frac{f_b}{F_b} \leq 1.$$

$$\frac{119}{725} + \frac{750}{1300} = 0.74 \quad \text{O.K.}$$

LeMessurier Consultants Consulting Engineers	By: [illegible]	Date: 10-15-87	File No.: 87137	Sheet No.: T-3
	Subject: OLD STATE HOUSE. TYPICAL TRUSS.			

7×9 AT EAST $A_x = 63 \text{ in}^2$ $S_x = 95 \text{ in}^3$

MEMBER 7 8×10 AT WEST $A_x = 80 \text{ in}^2$ $S_x = 133 \text{ in}^3$

$P = 17.2^k$ $f_c = 17.2/63 = 273$

$V = 1.27^k$ $f_v = 1.5 \times 1.27/63 = 30$

$M = 2.82^{i-k}$ $f_b = 2.82 \times 12/95 = 356$

COMBINED AXIAL & COMPRESSION.

$\frac{l_e}{d_e} = 7.9 \times 12/8 = 11.8 \approx 11$ $F_c' = F_c$

$\frac{f_c}{F_c} + \frac{f_b}{F_b}$

$\frac{273}{725} + \frac{356}{1300} = 0.65 < 1$ O.K.

MEMBER 8

$P = 14.8^k$ $f_c = 14.8/63 = 234$ psi

$V = 2.0^k$ $f_v = 1.5 \times 2.0/63 = 48$ psi

$M = 4.68^{i-k}$ $f_b = 4.68 \times 12/95 = 591$ psi

$\frac{l_e}{d_e} = 5.1 \times 12/8 = 7.6 < 11$

$\frac{f_c}{F_c} + \frac{f_b}{F_b} = \frac{234}{725} + \frac{591}{1300} = 0.77 < 1$ ~ O.K.

MEMBER 10.

$P = 7.6^k$ $f_c = 7.6/63 = 121$ psi

$V = 1.9^k$ $f_v = 1.5 \times 1.9/63 = 45$ psi

$M = 4.36^{i-k}$ $f_b = 4.36 \times 12/95 = 550$ psi

$\frac{f_c}{F_c} + \frac{f_b}{F_b} = \frac{121}{725} \quad \frac{550}{1300} = 0.58 < 1$ ~ O.K.

MEMBERS 11, 12 & 13. 6×8 $A_x = 48\text{ in}^2$ $S_x = 48\text{ in}^3$

$P = 6.9^k$ $f_a = 6.9/48 = .143$ psi

$M = 1.5$ $f_b = 1.5 \times 12/48 = 375$ psi

$V = 0.13$

$\ell = 9.46$

$K = 0.67\sqrt{\frac{1400}{0.94}} = 25.7$

$\frac{\ell_e}{d} = 9.46 \times 12/8 = 14.2$

$F_c' = F_c\left[1 - \frac{1}{3}\left(\frac{\ell_e/d}{K}\right)^4\right] = 950\left[1 - \frac{1}{3}\left(\frac{14.2}{25.7}\right)^4\right] = 920$ psi

$\frac{f_a}{F_c'} + \frac{f_b}{F_b} = \frac{143}{725} + \frac{375}{1300} = 0.48 < 1$ o.k.

MEMBER 25 2-2×6 → ▯ ▯ ← BRACED BY FLOOR JOISTS.

$\ell = 10.0^{ft}$ $A_x = 24\text{ in}^2$

$\frac{\ell_e}{d} = 10 \times 12/6 = 20$ $S_x = 24\text{ in}^3$

$K = 25.7$

$F_c' = F_c\left[1 - \frac{1}{3}\left(\frac{\ell_e/d}{K}\right)^4\right] = 725\left[1 - \frac{1}{3}\left(\frac{20}{25.7}\right)^4\right] = 637$ psi

$P = 6.2^k$ $f_a = 6.2/24 = 258$ psi

$M = 0.9^{ik}$ $f_b = 0.9 \times 12/24 = 450$ psi

$V = 0.5^k$ $f_v = 1.5 \times 0.5/24 = 31$ psi

$\frac{f_c}{F_c'} + \frac{f_b}{F_b} = \frac{258}{637} + \frac{450}{1300} = 0.75 < 1$ o.k.

MEMBER 21. 4×6 $A_x = 24\text{ in}^2$

$P = 0.5^k$ $f_a = 0.5/24 = 20$ psi o.k.

LeMessurier Consultants Professional Engineers	By ABB.	Date 10-15-87	File No. 87137	Sheet No. T-5
	Subject: OLD STATE HOUSE. TYPICAL TRUSS.			

MEMBERS 1 & 2. 11×11 $A_x = 121 \text{ in}^2$ $S_x = 222 \text{ in}^3$

$P = 11.5^k$
$V = 8.6^k$
$M = 28.7^{"k}$ ~ (CAN IGNORE MOMENT. DUE TO MODELLING ONLY).

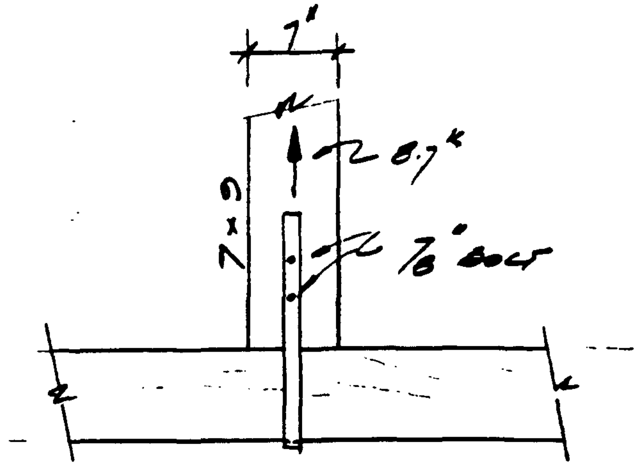
$f_t = 11.5/121 = 95 \text{ psi}$

$f_v = 1.5 \times 8.6/121 = 107 \text{ psi}.$

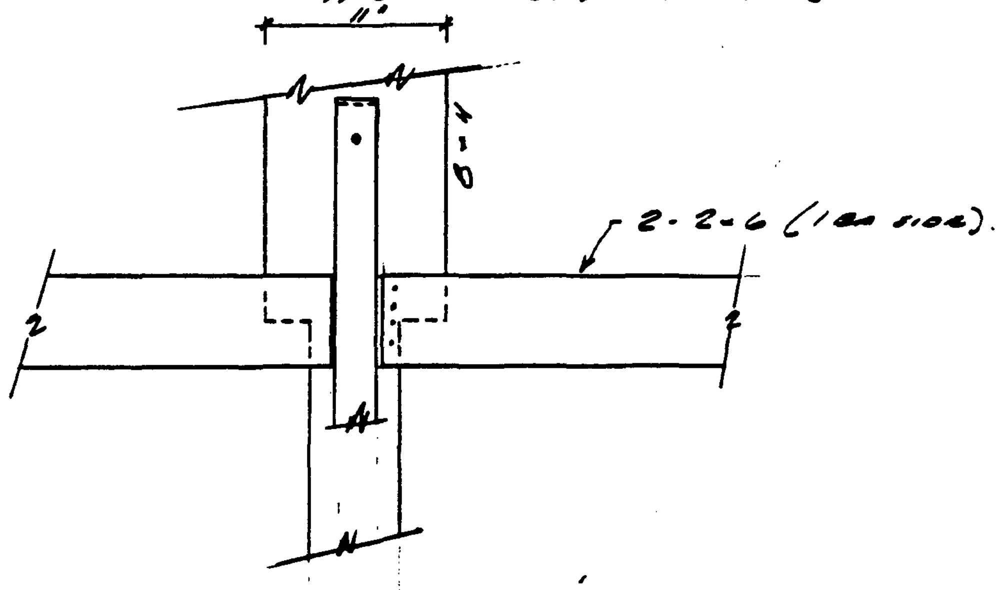
MEMBER 27 $8" \times 7"$

$f_t = 8.7/(8 \times 7) = 155 \text{ psi} < 725$ ok.

LeMessurier Consultants Consulting Engineers	By: ABB	Date	File No.	Sheet No.: T-5A
	Subject: OLD STATE HOUSE Typical Truss			

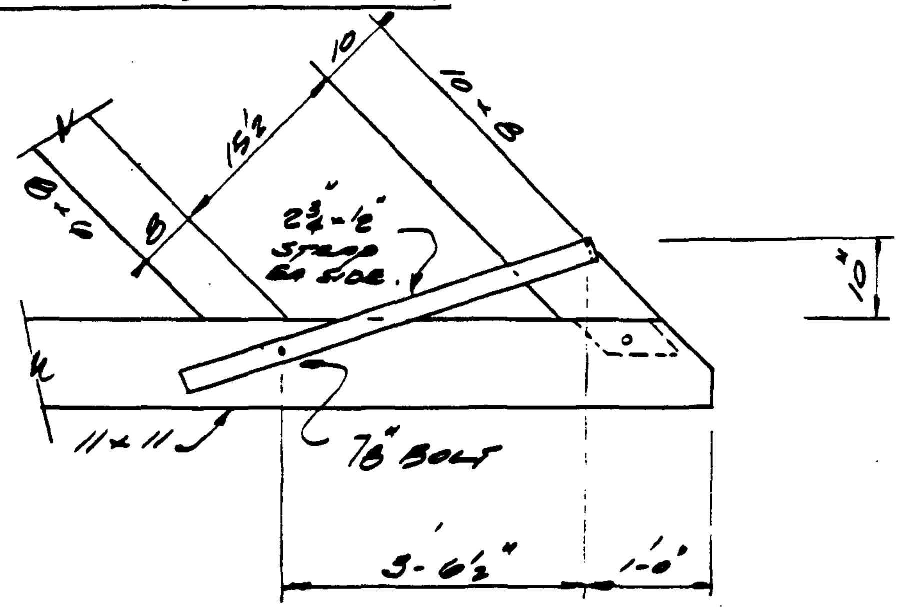


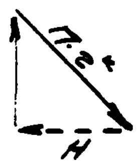
7/8" BOLT $\frac{P}{n} = 3.7 \times 2 = 7.4^k < 8.7^k$ ~ 17% overstress
can say O.K. with slightly
higher bolt allowable.



LeMessurier Consultants Consulting Engineers	By: AB.	Date: 3-17-87	File No. 87137	Sheet No. T-53
	Subject: OLD STATE HOUSE. TYPICAL TRUSS.			

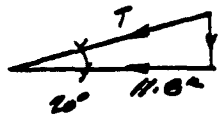
CONNECTIONS.





$H = 17.2^k \times \sin 43.5 = 11.8^k$

FORCE ON STRAP



$T = 11.8 / \cos 20 = 12.6^k$

7/8" φ BOLT $l = 11½$ — $P = 3.7^k$, $Q = 1.59^k$ } FROM DESIGN SPEC NATIONAL FOREST PRODUCTS.

HANKINSON FORMULA

FROM NOMOGRAPH P72 $P_{ALLOW} = 3.1^k << 12.6^k$

N.G.

ADD'L BOLTS ARE REQ'D AT CONN.

BEARING UNDER TOP OF STRAP $= \frac{12.6}{2¾ \times 8} = 572$ psi > 405 psi

N.G.

```
1. STAAD PLANE FRAME

        * * * * * * * * * * * * * * * * * * * * * * * * * *
        *                                                 *
        *              S T A A D - III                    *
        *              REVISION 5.10                      *
        *              PROPRIETARY PROGRAM OF             *
        *              RESEARCH ENGINEERS,INC.            *
        *              DATE = 29-OCT-87                   *
        *              TIME = 16:13:52                    *
        *                                                 *
        * * * * * * * * * * * * * * * * * * * * * * * * * *


*** STAAD-III MESSAGE ***
    NAME OF INPUT  FILE IS ZFA1:[LA.87137]TRUSS.DAT;13
    NAME OF OUTPUT FILE IS ZFA1:[LA.87137]TRUSS.OUT1;1

  2. UNITS FEET KIPS
  3. OUTPUT WIDTH 72
  4. JOINT COORDINATES
  5. 1    -19.5    0.
  6. 2    -17.25   0.
  7. 3    -15.0    0.
  8. 4      0.     0.
  9. 5     15.0    0.
 10. 6     17.25   0.
 11. 7     19.5    0.
 12. 8    -13.71   5.50
 13. 9    -11.58   3.25
 14. 10    11.58   3.25
 15. 11    13.71   5.50
 16. 12   -10.0    9.0
 17. 13     0.0    9.0
 18. 14    10.0    9.0
 19. 15    -6.83  12.0
 20. 16    -4.71   9.76
 21. 17     4.71   9.76
 22. 18     6.84  12.0
 23. 19     0.0   14.23
 24. 20     0.0   18.5
 25. MEMBER INCIDENCES
 26. 1 1 2
 27. 2 2 3
 28. 3 3 4
 29. 4 4 5
 30. 5 5 6
 31. 6 6 7
 32. 7 1 8
 33. 8 8 12
 34. 9 12 15
 35. 10 15 20
 36. 11 3 9
 37. 12 9 16
 38. 13 16 19
```

```
39. 14 7 11
40. 15 11 14
41. 16 14 18
42. 17 18 20
43. 18 5 10
44. 19 10 17
45. 20 17 19
46. 21 9 8
47. 22 16 15
48. 23 10 11
49. 24 17 18
50. 25 12 13
51. 26 13 14
52. 27 4 13
53. 28 13 19
54. 29 19 20
55. MEMBER RELEASES
56. 1 4 7 11 14 18 21 22 23 24 27 START MZ
57. 3 6 10 13 17 20 21 22 23 24 29 END MZ
58. SUPPORTS
59. 2 PINNED
60. 6 FIXED BUT MZ FX
61. UNITS INCHES
62. MEMBER PROPERTIES
63. 1 TO 6 PRIS AX 121 IZ 1220
64. 7 TO 10 14 TO 17 PRIS AX 64 IZ 340
65. 11 TO 13 18 TO 20 PRIS AX 48 IZ 256
66. 21 TO 24 PRIS AX 24 IZ 72
67. 25 26 PRIS AX 24 IZ 72
68. 27 28 29 PRIS AX 88 IZ 470.
69. CONSTANTS
70. E 1400. ALL
71. UNITS FEET
72. LOADING 1 DEAD LOADS
73. MEMBER LOADS
74. 7 TO 10 14 TO 17 UNIF GY -0.217
75. 3 4 UNIF GY -0.227
76. 25 26 UNIF GY -0.101
77. LOADING 2 SNOW LIVE LOAD
78. MEMBER LOADS
79. 7 TO 10 14 TO 17 UNIF GY -0.173
80. LOADING 3 ATTIC LIVE LOAD
81. MEMBER LOADS
82. 3 4 UNIF GY -0.432
83. LOAD COMBINATION 4 DL + SNOW LOAD
84. 1 1.0 2 1.0
85. LOAD COMBINATION 5 DL + SNOW + ATTIC LIVE LOAD
86. 1 1.0 2 1.0 3 1.0
87. PERFORM ANALYSIS RELEASE
```

BANDWIDTH STATISTICS

OLD JOINT NUMBERS -	1	2	3	4	5	6	7	8	9	10	11	12
NEW JOINT NUMBERS -	1	2	4	7	11	15	20	3	6	16	18	5
OLD JOINT NUMBERS -	13	14	15	16	17	18	19	20				
NEW JOINT NUMBERS -	9	13	8	10	19	17	14	12				

```
ORIGINAL BANDWIDTH =       9
REDUCED  BANDWIDTH =       5


*** STAAD-III MESSAGE *** STIFFNESS MATRIX STATISTICS

          NUMBER OF JOINTS                 =       20

          NUMBER OF SUPPORTS               =        2

          NUMBER OF MEMBERS                =       29

          NUMBER OF ELEMENTS               =        0

          NUMBER OF LOADINGS               =        3

          NUMBER OF EQUATIONS              =       57

          MAXIMUM BANDWIDTH                =       18

          TOTAL STORAGE AVAILABLE          =  2000000

          STORAGE ALREADY USED             =    13091

          NUMBER OF EQUATIONS PER BLOCK    =       57

          NUMBER OF MATRIX BLOCKS          =        1

   88. LOAD LIST 4 5
   89. PRINT DISPLACEMENTS ALL
```

JOINT DISPLACEMENT (INCH RADIANS)

JOINT	LOAD	X-TRANS	Y-TRANS	Z-TRANS	X-ROTAN	Y-ROTAN	Z-ROTAN
1	4	-0.00106	-0.04019	0.00000	0.00000	0.00000	0.00000
	5	-0.00183	-0.03368	0.00000	0.00000	0.00000	0.00000
2	4	0.00000	0.00000	0.00000	0.00000	0.00000	0.00033
	5	0.00000	0.00000	0.00000	0.00000	0.00000	-0.00057
3	4	0.00106	-0.02492	0.00000	0.00000	0.00000	-0.00170
	5	0.00183	-0.07229	0.00000	0.00000	0.00000	-0.00417
4	4	0.01327	-0.07921	0.00000	0.00000	0.00000	0.00000
	5	0.01726	-0.12411	0.00000	0.00000	0.00000	0.00000
5	4	0.02549	-0.02485	0.00000	0.00000	0.00000	0.00169
	5	0.03268	-0.07232	0.00000	0.00000	0.00000	0.00418
6	4	0.02654	0.00000	0.00000	0.00000	0.00000	-0.00033
	5	0.03451	0.00000	0.00000	0.00000	0.00000	0.00057
7	4	0.02760	-0.04028	0.00000	0.00000	0.00000	0.00000
	5	0.03634	-0.03364	0.00000	0.00000	0.00000	0.00000
8	4	0.09471	-0.15551	0.00000	0.00000	0.00000	0.00151
	5	0.10101	-0.16636	0.00000	0.00000	0.00000	0.00143
9	4	0.10641	-0.14418	0.00000	0.00000	0.00000	-0.00229
	5	0.09341	-0.17393	0.00000	0.00000	0.00000	-0.00204
10	4	-0.07993	-0.14417	0.00000	0.00000	0.00000	0.00229
	5	-0.05864	-0.17368	0.00000	0.00000	0.00000	0.00203
11	4	-0.06814	-0.15558	0.00000	0.00000	0.00000	-0.00151
	5	-0.06628	-0.16658	0.00000	0.00000	0.00000	-0.00143
12	4	0.03792	-0.10287	0.00000	0.00000	0.00000	-0.00091
	5	0.04238	-0.11894	0.00000	0.00000	0.00000	-0.00095
13	4	0.01325	-0.07659	0.00000	0.00000	0.00000	0.00000
	5	0.01744	-0.11654	0.00000	0.00000	0.00000	0.00000
14	4	-0.01142	-0.10301	0.00000	0.00000	0.00000	0.00092
	5	-0.00751	-0.11851	0.00000	0.00000	0.00000	0.00094
15	4	0.13374	-0.20496	0.00000	0.00000	0.00000	-0.00289
	5	0.13700	-0.22540	0.00000	0.00000	0.00000	-0.00295
16	4	0.14113	-0.19769	0.00000	0.00000	0.00000	0.00134
	5	0.13429	-0.22763	0.00000	0.00000	0.00000	0.00117
17	4	-0.11459	-0.19761	0.00000	0.00000	0.00000	-0.00134
	5	-0.09878	-0.22662	0.00000	0.00000	0.00000	-0.00116
18	4	-0.10729	-0.20484	0.00000	0.00000	0.00000	0.00290
	5	-0.10168	-0.22418	0.00000	0.00000	0.00000	0.00295
19	4	0.01323	-0.07449	0.00000	0.00000	0.00000	0.00000
	5	0.01727	-0.11158	0.00000	0.00000	0.00000	0.00000
20	4	0.01308	-0.07661	0.00000	0.00000	0.00000	0.00000
	5	0.01700	-0.10989	0.00000	0.00000	0.00000	0.00000

************** END OF LATEST ANALYSIS RESULT **************

90. PRINT MEMBER FORCES ALL

MEMBER END FORCES

ALL UNITS ARE -- KIP FEET

MEMB	LOAD	JT	AXIAL	SHEAR-Y	SHEAR-Z	TORSION	MOM-Y	MOM-Z
1	4	1	-6.64	-8.13	0.00	0.00	0.00	0.00
		2	6.64	8.13	0.00	0.00	0.00	-18.30
	5	1	-11.49	-12.76	0.00	0.00	0.00	0.00
		2	11.49	12.76	0.00	0.00	0.00	-28.71
2	4	2	-6.64	6.77	0.00	0.00	0.00	18.30
		3	6.64	-6.77	0.00	0.00	0.00	-3.08
	5	2	-11.49	8.62	0.00	0.00	0.00	28.71
		3	11.49	-8.62	0.00	0.00	0.00	-9.32
3	4	3	-11.49	1.91	0.00	0.00	0.00	3.08
		4	11.49	1.50	0.00	0.00	0.00	0.00
	5	3	-14.52	5.56	0.00	0.00	0.00	9.32
		4	14.52	4.32	0.00	0.00	0.00	0.00
4	4	4	-11.49	1.50	0.00	0.00	0.00	0.00
		5	11.49	1.91	0.00	0.00	0.00	-3.08
	5	4	-14.52	4.32	0.00	0.00	0.00	0.00
		5	14.52	5.56	0.00	0.00	0.00	-9.31
5	4	5	-6.64	-6.76	0.00	0.00	0.00	3.08
		6	6.64	6.76	0.00	0.00	0.00	-18.30
	5	5	-11.49	-8.62	0.00	0.00	0.00	9.31
		6	11.49	8.62	0.00	0.00	0.00	-28.71
6	4	6	-6.64	8.13	0.00	0.00	0.00	18.30
		7	6.64	-8.13	0.00	0.00	0.00	0.00
	5	6	-11.49	12.76	0.00	0.00	0.00	28.71
		7	11.49	-12.76	0.00	0.00	0.00	0.00
7	4	1	10.41	1.32	0.00	0.00	0.00	0.00
		8	-8.27	0.93	0.00	0.00	0.00	1.56
	5	1	17.11	1.34	0.00	0.00	0.00	0.00
		8	-14.97	0.92	0.00	0.00	0.00	1.69
8	4	8	8.27	-0.75	0.00	0.00	0.00	-1.56
		12	-6.91	2.19	0.00	0.00	0.00	-5.94
	5	8	14.97	-0.79	0.00	0.00	0.00	-1.69
		12	-13.61	2.23	0.00	0.00	0.00	-6.01
9	4	12	1.58	2.22	0.00	0.00	0.00	5.44
		15	-0.41	-0.98	0.00	0.00	0.00	1.54
	5	12	8.21	2.21	0.00	0.00	0.00	5.44
		15	-7.04	-0.97	0.00	0.00	0.00	1.51
10	4	15	0.41	1.17	0.00	0.00	0.00	-1.54
		20	2.12	1.50	0.00	0.00	0.00	0.00

MEMBER END FORCES

ALL UNITS ARE -- KIP FEET

MEMB	LOAD	JT	AXIAL	SHEAR-Y	SHEAR-Z	TORSION	MOM-Y	MOM-Z
	5	15	7.05	1.17	0.00	0.00	0.00	-1.51
		20	-4.51	1.49	0.00	0.00	0.00	0.00
11	4	3	6.87	0.18	0.00	0.00	0.00	0.00
		9	-6.87	-0.18	0.00	0.00	0.00	0.83
	5	3	4.30	0.13	0.00	0.00	0.00	0.00
		9	-4.30	-0.13	0.00	0.00	0.00	0.60
12	4	9	6.87	0.03	0.00	0.00	0.00	-0.83
		16	-6.87	-0.03	0.00	0.00	0.00	1.08
	5	9	4.30	0.05	0.00	0.00	0.00	-0.60
		16	-4.30	-0.05	0.00	0.00	0.00	1.09
13	4	16	6.87	-0.17	0.00	0.00	0.00	-1.08
		19	-6.87	0.17	0.00	0.00	0.00	0.00
	5	16	4.30	-0.17	0.00	0.00	0.00	-1.09
		19	-4.30	0.17	0.00	0.00	0.00	0.00
14	4	7	10.42	1.32	0.00	0.00	0.00	0.00
		11	-8.27	0.93	0.00	0.00	0.00	1.56
	5	7	17.11	1.34	0.00	0.00	0.00	0.00
		11	-14.97	0.92	0.00	0.00	0.00	1.69
15	4	11	8.27	-0.75	0.00	0.00	0.00	-1.56
		14	-6.91	2.19	0.00	0.00	0.00	-5.93
	5	11	14.97	-0.78	0.00	0.00	0.00	-1.69
		14	-13.61	2.23	0.00	0.00	0.00	-5.99
16	4	14	1.58	2.22	0.00	0.00	0.00	5.44
		18	-0.41	-0.98	0.00	0.00	0.00	1.53
	5	14	8.22	2.20	0.00	0.00	0.00	5.42
		18	-7.05	-0.97	0.00	0.00	0.00	1.48
17	4	18	0.41	1.17	0.00	0.00	0.00	-1.53
		20	2.12	1.50	0.00	0.00	0.00	0.00
	5	18	7.05	1.18	0.00	0.00	0.00	-1.46
		20	-4.51	1.49	0.00	0.00	0.00	0.00
18	4	5	6.86	0.18	0.00	0.00	0.00	0.00
		10	-6.86	-0.18	0.00	0.00	0.00	0.83
	5	5	4.30	0.13	0.00	0.00	0.00	0.00
		10	-4.30	-0.13	0.00	0.00	0.00	0.60
19	4	10	6.86	0.03	0.00	0.00	0.00	-0.83
		17	-6.86	-0.03	0.00	0.00	0.00	1.08
	5	10	4.30	0.05	0.00	0.00	0.00	-0.60
		17	-4.30	-0.05	0.00	0.00	0.00	1.07
20	4	17	6.86	-0.17	0.00	0.00	0.00	-1.08
		19	-6.86	0.17	0.00	0.00	0.00	0.00

MEMBER END FORCES

ALL UNITS ARE -- KIP FEET

MEMB	LOAD	JT	AXIAL	SHEAR-Y	SHEAR-Z	TORSION	MOM-Y	MOM-Z
	5	17	4.30	-0.17	0.00	0.00	0.00	-1.07
		19	-4.30	0.17	0.00	0.00	0.00	0.00
21	4	9	0.16	0.00	0.00	0.00	0.00	0.00
		8	-0.16	0.00	0.00	0.00	0.00	0.00
	5	9	0.08	0.00	0.00	0.00	0.00	0.00
		8	-0.08	0.00	0.00	0.00	0.00	0.00
22	4	16	0.19	0.00	0.00	0.00	0.00	0.00
		15	-0.19	0.00	0.00	0.00	0.00	0.00
	5	16	0.22	0.00	0.00	0.00	0.00	0.00
		15	-0.22	0.00	0.00	0.00	0.00	0.00
23	4	10	0.16	0.00	0.00	0.00	0.00	0.00
		11	-0.16	0.00	0.00	0.00	0.00	0.00
	5	10	0.08	0.00	0.00	0.00	0.00	0.00
		11	-0.08	0.00	0.00	0.00	0.00	0.00
24	4	17	0.19	0.00	0.00	0.00	0.00	0.00
		18	-0.19	0.00	0.00	0.00	0.00	0.00
	5	17	0.21	0.00	0.00	0.00	0.00	0.00
		18	-0.21	0.00	0.00	0.00	0.00	0.00
25	4	12	6.91	0.45	0.00	0.00	0.00	0.49
		13	-6.91	0.56	0.00	0.00	0.00	-1.06
	5	12	6.98	0.46	0.00	0.00	0.00	0.57
		13	-6.98	0.55	0.00	0.00	0.00	-0.98
26	4	13	6.91	0.56	0.00	0.00	0.00	1.06
		14	-6.91	0.45	0.00	0.00	0.00	-0.49
	5	13	6.98	0.55	0.00	0.00	0.00	0.98
		14	-6.98	0.46	0.00	0.00	0.00	-0.57
27	4	4	-2.99	0.00	0.00	0.00	0.00	0.00
		13	2.99	0.00	0.00	0.00	0.00	0.00
	5	4	-8.64	0.00	0.00	0.00	0.00	0.00
		13	8.64	0.00	0.00	0.00	0.00	0.00
28	4	13	-4.12	0.00	0.00	0.00	0.00	0.00
		19	4.12	0.00	0.00	0.00	0.00	0.00
	5	13	-9.74	0.00	0.00	0.00	0.00	0.00
		19	9.74	0.00	0.00	0.00	0.00	0.00
29	4	19	5.09	0.00	0.00	0.00	0.00	0.00
		20	-5.09	0.00	0.00	0.00	0.00	0.00
	5	19	-4.05	0.00	0.00	0.00	0.00	0.00
		20	4.05	0.00	0.00	0.00	0.00	0.00

************** END OF LATEST ANALYSIS RESULT **************

91. SECTION 0.25 0.5 0.75 MEMBER 3 7 8 9 10 11 12 13

92. PRINT SECTION FORCES ALL

MEMBER FORCES AT INTERMEDIATE SECTIONS

ALL UNITS ARE -- KIP FEET

MEMB	LOAD	SEC	AXIAL	SHEAR-Y	SHEAR-Z	TORSION	MOM-Y	MOM-Z
3	4	0.25	-11.49	1.06	0.00	0.00	0.00	-2.48
		0.50	-11.49	0.21	0.00	0.00	0.00	-4.35
		0.75	-11.49	-0.65	0.00	0.00	0.00	-4.02
	5	0.25	-14.52	3.09	0.00	0.00	0.00	-6.91
		0.50	-14.52	0.62	0.00	0.00	0.00	-13.88
		0.75	-14.52	-1.85	0.00	0.00	0.00	-11.57
7	4	0.25	10.41	0.76	0.00	0.00	0.00	-2.08
		0.50	10.41	0.20	0.00	0.00	0.00	-3.03
		0.75	10.41	-0.37	0.00	0.00	0.00	-2.86
	5	0.25	17.11	0.78	0.00	0.00	0.00	-2.11
		0.50	17.11	0.21	0.00	0.00	0.00	-3.10
		0.75	17.11	-0.35	0.00	0.00	0.00	-2.96
8	4	0.25	8.27	-1.11	0.00	0.00	0.00	-0.38
		0.50	8.27	-1.47	0.00	0.00	0.00	1.26
		0.75	8.27	-1.83	0.00	0.00	0.00	3.37
	5	0.25	14.97	-1.15	0.00	0.00	0.00	-0.46
		0.50	14.97	-1.51	0.00	0.00	0.00	1.24
		0.75	14.97	-1.87	0.00	0.00	0.00	3.39
9	4	0.25	1.58	1.91	0.00	0.00	0.00	3.13
		0.50	1.58	1.60	0.00	0.00	0.00	1.27
		0.75	1.58	1.29	0.00	0.00	0.00	-0.30
	5	0.25	8.21	1.90	0.00	0.00	0.00	3.20
		0.50	8.21	1.59	0.00	0.00	0.00	1.29
		0.75	8.21	1.28	0.00	0.00	0.00	-0.28
10	4	0.25	0.41	0.50	0.00	0.00	0.00	-3.51
		0.50	0.41	-0.16	0.00	0.00	0.00	-3.91
		0.75	0.41	-0.83	0.00	0.00	0.00	-2.74
	5	0.25	7.05	0.51	0.00	0.00	0.00	-3.49
		0.50	7.05	-0.16	0.00	0.00	0.00	-3.90
		0.75	7.05	-0.83	0.00	0.00	0.00	-2.73
11	4	0.25	6.87	0.18	0.00	0.00	0.00	-0.21
		0.50	6.87	0.18	0.00	0.00	0.00	-0.41
		0.75	6.87	0.18	0.00	0.00	0.00	-0.62
	5	0.25	4.30	0.13	0.00	0.00	0.00	-0.15
		0.50	4.30	0.13	0.00	0.00	0.00	-0.30
		0.75	4.30	0.13	0.00	0.00	0.00	-0.45
12	4	0.25	6.87	0.03	0.00	0.00	0.00	-0.89
		0.50	6.87	0.03	0.00	0.00	0.00	-0.95
		0.75	6.87	0.03	0.00	0.00	0.00	-1.02
	5	0.25	4.30	0.05	0.00	0.00	0.00	-0.72
		0.50	4.30	0.05	0.00	0.00	0.00	-0.84

MEMBER FORCES AT INTERMEDIATE SECTIONS

ALL UNITS ARE -- KIP FEET

MEMB	LOAD	SEC	AXIAL	SHEAR-Y	SHEAR-Z	TORSION	MOM-Y	MOM-Z
		0.75	4.30	0.05	0.00	0.00	0.00	-0.97
13	4	0.25	6.87	-0.17	0.00	0.00	0.00	-0.81
		0.50	6.87	-0.17	0.00	0.00	0.00	-0.54
		0.75	6.87	-0.17	0.00	0.00	0.00	-0.27
	5	0.25	4.30	-0.17	0.00	0.00	0.00	-0.82
		0.50	4.30	-0.17	0.00	0.00	0.00	-0.54
		0.75	4.30	-0.17	0.00	0.00	0.00	-0.27

************** END OF LATEST ANALYSIS RESULT **************

93. PRINT REACTIONS ALL

SUPPORT REACTIONS -UNIT KIP FEET

JOINT	LOAD	FORCE-X	FORCE-Y	FORCE-Z	MOM-X	MOM-Y	MOM Z
2	4	0.00	14.90	0.00	0.00	0.00	0.00
	5	0.00	21.38	0.00	0.00	0.00	0.00
6	4	0.00	14.90	0.00	0.00	0.00	0.00
	5	0.00	21.38	0.00	0.00	0.00	0.00

************* END OF LATEST ANALYSIS RESULT *************

94. PRINT MEMBER INFO ALL

MEMBER INFORMATION

MEMBER	START JOINT	END JOINT	LENGTH (FEET)	BETA (DEG)	RELEASES
1	1	2	2.250	0.00	000001000000
2	2	3	2.250	0.00	000000000000
3	3	4	15.000	0.00	000000000001
4	4	5	15.000	0.00	000001000000
5	5	6	2.250	0.00	000000000000
6	6	7	2.250	0.00	000000000001
7	1	8	7.986	0.00	000001000000
8	8	12	5.100	0.00	000000000000
9	12	15	4.365	0.00	000000000000
10	15	20	9.429	0.00	000000000001
11	3	9	4.718	0.00	000001000000
12	9	16	9.465	0.00	000000000000
13	16	19	6.493	0.00	000000000001
14	7	11	7.986	0.00	000001000000
15	11	14	5.100	0.00	000000000000
16	14	18	4.357	0.00	000000000000
17	18	20	9.436	0.00	000000000001
18	5	10	4.718	0.00	000001000000
19	10	17	9.465	0.00	000000000000
20	17	19	6.493	0.00	000000000001
21	9	8	3.098	0.00	000001000001
22	16	15	3.084	0.00	000001000001
23	10	11	3.098	0.00	000001000001
24	17	18	3.091	0.00	000001000001
25	12	13	10.000	0.00	000000000000
26	13	14	10.000	0.00	000000000000
27	4	13	9.000	0.00	000001000000
28	13	19	5.230	0.00	000000000000
29	19	20	4.270	0.00	000000000001

************ END OF DATA FROM INTERNAL STORAGE ************

95. SAVE

```
*** STAAD-III MESSAGE ***
    RESULTS   SAVED ON FILE ZFA1:[LA.87137]STAADTEM1.SAV;1
    LOAD DATA SAVED ON FILE ZFA1:[LA.87137]STAADTEM2.SAV;1
```

96. FINISH

*************** END OF STAAD-III ***************

LeMessurier Consultants Professional Engineers	By WLS	Date	File No.	Sheet No.
	Subject: OLD STATE HOUSE ~ STAIR LOAD TEST			

OUTSIDE DIAMETER 11'-0"
INSIDE DIAMETER 3'-0"
18 TREADS

$1^{ST} \rightarrow 2^{ND}$ AREA $= \left(\pi \times 11^2/4 - \pi \times 3^2/4\right) \times 315/360$

$= 78 \text{ FT}^2$

MAXIMUM LOADING
175# ea TREAD OUTSIDE RAIL = 175 × 18 = 3150
175# ALT. TREADS INSIDE RAIL = 175 × 9 = 1575
4725#

$4725\#/78 \text{ FT}^2 = 60 \text{ PSF} \Rightarrow$

Report No. 6673A

MEASUREMENTS OF VIBRATION AND NOISE IN THE OLD STATE HOUSE, BOSTON, MA, IN REGARD TO ITS REHABILITATION

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Frank N. Iacovino

BBN Project No. 03753

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Attn: Mr. Ralph Tolbert

Submitted by:

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SUMMARY

Measurements were made of the vibrations and noise produced in Boston's Old State House by subway train passages under the building, by street traffic, and by people walking in the building.

The greatest vibrational displacement of the building's walls were found not to exceed 0.2 mils and were associated with subway traffic. The greatest vibrational displacement of the floors was found to amount to about 3.5 mils and to result from footfalls.

The most severe vibrational velocity measured at the ground floor was 0.018 in/sec. This is considerably less than the 0.05 in/sec maximum velocity indicated by the German Standard DIN 4150 as acceptable at the foundations of buildings of historical value. The greatest vibrational velocities measured on the upper walls for the most part did not exceed 0.05 in/sec, but some were as high as 0.25 in/sec. One may expect walls to vibrate more than the comparatively heavy and well-constrained foundation structures, but available standards provide no guidance concerning acceptable wall vibration magnitudes.

Although definitive statements concerning the effects of vibrations on the long term integrity of the Old State House can be made only on the basis of a structural analysis which is beyond the scope of the present study, the foregoing comparisons imply that the observed vibrations have little potential for causing damage, even though they may be distinctly perceptible.

Reduction of vibrations caused by passing subway trains may be accomplished by improving the smoothness of the rails under the Old State House and/or providing a more resilient track fixation system than is currently in use there. Vibrations due to street traffic are relatively insignificant; their reduction would require smoothing of the road surfaces (to avoid potholes and bumps) and/or limiting the speeds, weights and proximities of

passing vehicles. Reduction of vibrations due to foot traffic in the building may be accomplished by limiting the volume and speed of this traffic.

The greatest noise levels observed on the ground floor amounted to 62 dBA due to subway train passages and 57 dBA due to street traffic. On the upper floors, the greatest noise level measured due to subways was 61 dBA and that due to street traffic was 64 dBA.

The maximum generally acceptable levels of occasionally intruding noises amount to 60 dBA for museum exhibits, 55 dBA for offices and 50 dBA for meetings and small lectures. Thus, the noise environment in the Old State House is generally excessive for the intended space usages. All of the noise measurements were made when all windows were closed; opening of windows would make the situation worse.

Reduction of intruding street traffic noise would require sealing of all gaps at the windows by means of weatherstripping and adding a second layer of glazing, e.g., in the form of heavy-duty storm windows. Reduction of intruding subway noise is more complicated, since this noise is structurally transmitted and radiated from walls, floors, and ceilings in loudspeaker-like fashion. One may consider reducing this noise at its source by implementation of the same means as were discussed for reduction of vibrations produced by subway trains. Otherwise, one would need to construct secondary interior walls and floors to shield the rooms' interiors from the sound radiated from the primary structures.

INTRODUCTION

In relation to its plans for rehabilitation of Boston's Old State House, the National Park Service has voiced several concerns about the vibration and noise environment within the building. The foremost of these concerns is for the effect that vibrations generated by street traffic and by subway train passages under the building may have on the building's long-term structural integrity. Additional concerns relate to the effects that noise and vibrations may have on the comfort of people engaged in various activities that are expected to be carried on in the building.

In order to address these concerns, an investigation was undertaken that consisted of performance of a series of measurements and of evaluation of their results in relation to relevant criteria. It is the purpose of this report to summarize this investigation and its results.

CRITERIA

Vibration

The most direct evaluation of the damage-causing potential of vibrations involves determination of the strains (and/or stresses) induced in building components by the vibrations of concern and comparison of these stresses and strains to related failure criteria for the materials and components in question. Because direct measurement of stress or strain is extremely difficult, particularly without marring the structures, it is preferable to measure the displacements associated with vibrations and to infer the strains from these by means of suitable calculations. This is one of the approaches that was taken in the present investigation.*

A somewhat less direct, probably less reliable, but simpler, approach toward evaluation of the damage-causing potential of vibrations involves direct comparison of measured vibration data with criteria expressed in terms of vibrational parameters. However, meaningful vibration criteria need to be based on extensive data for the general type of structure of concern.

Although the U.S. Bureau of Mines (e.g., Refs. 1-3) has carried out numerous investigations to determine how much ground vibration (largely due to blasting) buildings can accept without suffering plaster damage or other minor damage, these studies have been confined to dwellings which are much newer than the Old State House and which are of different materials and structural configurations. Thus, the 2 in/sec vibrational velocity criterion, proposed by the Bureau of Mines to protect buildings from minor damage, is not applicable to the Old State House.

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*The displacement data obtained from the vibration measurements described in a later section of this report were communicated to LeMessurier Associates for further analysis and for interpretation regarding structural integrity.

Similar investigations undertaken in other countries - notably Canada, Sweden, Ireland and Germany - and related criteria (Ref. 3) also deal with relatively modern buildings and constructions. Therefore, these criteria also do not apply for the Old State House.

However, one German standard (Ref. 4) specifies acceptable vibration levels according to building type and condition. For "ruins and buildings of great historical value" this standard indicates a maximum allowable velocity of 2 mm/sec for "sudden shocks" (e.g., due to blasts) and 1.3 mm/sec for "sustained vibrations". The vibrations to which this standard applies are measured on the foundation, at ground level. For floors subject to impacts the standard indicates that vertical vibrations of 20 mm/sec may be acceptable in general, but it does not give specific values relevant for historical buildings.

Although German "ruins and buildings of great historical value" may differ considerably from the Old State House, no better information appears to be available. Thus, use of a vibrational velocity criterion of 1.3 mm/sec (which corresponds to 0.05 in/sec) as measured at the foundation is suggested. The criterion of 20 mm/sec (which amounts to 0.8 in/sec) may be useful for the preliminary evaluation of floors.

It should be noted that the generally accepted threshold of perceptibility of vibration corresponds to a velocity of less than 0.01 in/sec (Ref. 5). This fact indicates that vibrations that may be perceptible may not necessarily be of concern in regard to structural damage.

Noise

Criteria regarding the levels of background and intruding noise that can be tolerated without interfering with various activities are reasonably well established (e.g., Refs. 6,7).

However, some judgment is required in selection of appropriate values.

Suitable criteria are stated most simply in terms of a standardized "A-weighted" noise level, expressed in dBA. The following table indicates the recommended steady background noise criteria for several space usages considered for the rehabilitated Old State House, together with the maximum levels of occasional intrusive noise that may be acceptable.

	Maximum Acceptable Noise Levels (dBA)	
Space Usage	Steady Background	Occasional Intrusion
Museum, Library	40 - 50	60
Meetings, Seminars, Small Lectures	30 - 40	50
Office Activities	40 - 45	55

MEASUREMENTS

Procedure

Vibration and noise measurements were carried out in the Old State House on August 31 and September 1, 1987. These measurements were made in the late afternoon and early evening hours, in order to capture the effects of relatively heavy street and subway traffic.

Sensors were placed at selected measurement points, and the output of the sensor at each measurement point was tape-recorded for a time interval that encompassed at least ten subway train passages. The recorded data was later analyzed in the laboratory to separate the effects of subway train passages from those of street traffic and footfalls (people walking in the building) and to reduce the data to quantities compatible with the various criteria.

The data acquisition and reduction systems were calibrated by means of field standards, whose calibration is traceable to the National Bureau of Standards. Additional details concerning the instrumentation appear in Appendix A.

Vibration

The locations at which vibration sensors (accelerometers) were placed are indicated in Figs. 1 to 4.

Wall vibrations were measured in the directions perpendicular to the planes of the walls using accelerometers fastened (by means of clay) in the corners formed by the window sills and the brick walls. These locations were chosen because they permitted sampling of the most significant wall motions without damaging the wall structure or marring any of the finishes.

Vertical vibrations of the walls were measured by means of accelerometers fastened to the floors at the walls. Vertical vibrations of the floors were measured by use of accelerometers placed at relatively representative, unsupported points on the floors; a similar approach was used for the stairway.

Noise

Noise sensors (microphones) were placed on tripods near the center of each of the main spaces in the building, at the locations shown in Figs. 1 to 4. Like the vibration data, the noise data was tape-recorded for later laboratory analysis.

RESULTS OF MEASUREMENTS

Vibrations

Table 1, which appears on the next page, summarizes the results obtained from all of the aforementioned vibration measurements. For each measurement point it presents the range of the observed maximum vibratory displacements (which may be used for strain and component failure evaluation), together with the observed maximum vibratory velocity (which may be compared directly with the German Standard criterion).

Noise

Table 2, below, summarizes the results of the noise measurements that were carried out. The noise levels indicated for subway and traffic represent those corresponding to peaks; the ambient level reported is the average level observed in the absence of any discrete noise events.

TABLE 2

OBSERVED NOISE LEVELS

	Noise Level (dBA)		
Location	Subway	Street Traffic	Ambient
Ground Floor	60-62	52-57	37
First Floor	52-61	52-64	46-48
Second Floor	52-57	50-64	46-47

Note that all of these noise measurements were made when all windows were closed. With open windows, significantly higher noise levels are expected.

TABLE 1

OBSERVED VIBRATIONS

Measurement Location	Point*	Dir.**	Maximum Vibratory Displacement (Microinches) Subway	Traffic†	Footfalls	Maximum Vibratory Velocity (in/sec) Subway	Traffic†	Footfalls
Ground Floor								
Workshop Floor	1a	V	28- 45	N.A.		.002-.015	N.A.	
Workshop Wall	1b	V	89-200	100-200		.009-.018	.008	
First Floor								
R. Keayne Hall								
No. Wall	2a	V	28- 71	22		.003-.251	<.003	
No. Wall	2b	H	63-126	62- 77		.006-.071	.006	
So. Wall	4a	V	32-130	38- 45		.007-.025	.005	
So. Wall	4b	H	22- 79	13- 22		.003-.009	.001-.004	
Floor	5a	V	26- 45	22- 25	840-1260	.006-.019	.004-.009	.10-.14
Library								
So. Wall	3a	V	11- 42	9- 32		.003-.013	.007	
So. Wall	3b	H	10- 58	10- 18		.002-.021	.003	
Stairway								
Betw. 1st & 2nd Fl.	6a	V	40-141	52- 89	630- 710	.013-.028	.009-.018	.31-.73
Second Floor								
Council Chamber								
No. Wall	1f	V	35- 79	32- 45		.005-.019	.005	
No. Wall	1g	H	84-140	84-112		.009-.046	.007-.017	
East Wall	2f	V	28-100	11- 25		.003-.009	.004	
East Wall	2g	H	32-125	37- 65		.006-.025	.003-.008	
So. Wall	3f	V	63-200	63		.009-.105	<.009	
So. Wall	3g	H	35-180	35-180		.007-.043	.004-.008	
Floor	5f	V	45- 89	45-100	2200-2500	.023-.097	.023-.041	.15-.26
Representatives Hall								
West Wall	4f	V	15- 50	13- 25		.003-.008	<.003	
West Wall	4g	H	16- 45	16- 25		.002-.009	.002-.006	
Floor	7a	V	72-158	50-158	2200-3200	.007-.021	.007-.019	.13-.23
Curtis Guild Room								
So. Wall	5g	H	37-280	35- 50		.005-.087	.004-.007	
Attic								
West Floor	6f	V	28-110	44- 71	3100-3500	.003-.009	.002-.004	.11-.28
East Floor	7f	V	56-140	50-180	1120-1250	.009-.020	.007-.016	.13-.34

*Measurement locations indicated on Figs. 1-4.

**Measurement directions: V = vertical, H = horizontal, perpendicular to wall.

†Street traffic or general background.

CONCLUSIONS

Vibration

The maximum wall vibrational displacements that were observed do not exceed 0.2 mils (200 microinches). The maximum vertical floor vibrational displacement that was observed amounts to about 3.5 mils. Vibrations of this magnitude are encountered in many modern buildings, but their damage-causing potential for the Old State House should be evaluated by a competent structural engineer.

The most severe vibrational velocity measured at the foundation (i.e., at the ground floor) of the Old State House amounted to 0.018 in/sec, which is considerably smaller than the corresponding 0.05 in/sec maximum acceptable value indicated by the German Standard DIN 4150 for historical buildings.

Most of the maximum vibrational velocities measured on the walls of the Old State House also are significantly less than 0.05 in/sec. However, a few are greater; the greatest wall vibration velocities observed amount to about 0.25 in/sec. It is not at all surprising to find that the walls vibrate more than the comparatively heavy and well-constrained foundation, but the available standards provide no guidance concerning the magnitude of acceptable wall vibrations.

The most severe floor vibrations due to footfalls in all cases were found to exceed those due to subway or street traffic. The greatest floor vibrational velocities generated by footfalls were of the order of 0.3 in/sec, whereas those due to external sources reached 0.1 in/sec in only a few instances. The most severe footfall-induced vibrations observed on the stairway amounted to a little over 0.7 in/sec. All of these values fall below the 0.8 in/sec value suggested by DIN 4150 for floors in general, but all are well in excess of the threshold of perception.

Although definitive statements concerning the long-term integrity of the Old State House can be made only on the basis of a structural analysis which is beyond the scope of the work reported here, the foregoing comparisons imply that the observed vibrations have no little potential for causing damage, even though they may be distinctly perceptible.

Vibration Reduction

Reduction of vibrations induced by subway train passages can best be accomplished by attacking these vibrations at their source. Vibrations observed in the building result essentially from rail vibrations which are caused by interaction of wheel and rail irregularities and transmitted through the tunnel structure. Thus, vibration reduction in the building may be accomplished by smoothing the rails and wheels and/or by mounting the rails on resilient supports.

If the subway rails that pass under the Old State House are jointed, then vibration reductions by factors up to 2 may be obtained by replacing the jointed by welded rails (Ref. 8). If the rails are welded and supported by means of MBTA's widely used "Type 1 direct fixation," then vibration reductions in the Old State House may be obtained most expediently by replacing this fixation with a more resilient track support system, such as the "Cologne egg." Use of the Cologne egg system (which the MBTA has designated "direct fixation, Type 2") may be expected to result in vibration reductions by factors between 1.4 and 4.0 (Ref. 9).

The vibrations due to street traffic are considerably less severe than those due to subway train passages; thus reduction of traffic related vibrations probably is not required. Except for keeping street traffic (particularly, heavy vehicles) away from the building, slowing traffic on all nearby streets, and keeping the streets in good repair (so as to avoid vibration producing potholes and bumps), little can be done practically to reduce vibrations induced by street traffic.

Similarly, the only means for reducing vibrations induced by footfalls consists of controlling foot traffic - i.e., limiting the number of people in the building and ensuring that everyone walks slowly.

Noise

The noise produced by subway train passages was found frequently to exceed the maximum levels usually deemed acceptable for occasional intrusions. Only ground floor spaces used for museum exhibits were found to be generally satisfactory from the noise standpoint.

Frequent relatively loud street traffic noise events also were found to result in higher levels than are usually deemed acceptable for occasional intrusions for all expected space uses, except for museum use of the basement.

The continuous background noise due to street traffic and other city sounds observed in the Old State House also exceeds the conditions generally deemed acceptable for meetings and office functions. This is true everywhere, except for the basement. The background noise conditions on the first and second floors are barely acceptable for museum use.

Noise Reduction

Subway trains generate noise primarily as the result of rail vibrations induced by wheel-rail interaction. These vibrations are transmitted through the structure and cause the walls of the building to radiate sound somewhat as do loudspeakers. To reduce this noise within the building, new inner constructions that are resiliently supported from the existing structure would be required. That is, one would need to build "a box within a box". Such an arrangement could result in noise reductions of up to 20 dBA.

It may also be possible to reduce subway-related noise at the source by improving the smoothness of the subway rails (and wheels) and placing the rails on more resilient supports. If the subway rails that pass under the Old State House are not welded already, then introduction of welded rail there may reduce the corresponding structurally transmitted noise by 3 to 5 dBA (Ref. 8). If the rails are supported on the previously mentioned Type 1 fixation system, then replacement of this system by the Type 2 (Cologne egg) system may result in a noise reduction of 15 to 20 dBA (Ref. 9).

Traffic noise is transmitted into the building predominantly through the windows (either directly through the glass area or through gaps at the sash edges). To reduce this noise transmission, the existing windows will need to be sealed tightly with appropriate gaskets and/or weatherstripping. Good-quality weatherstripping and general restoration of the windows to good condition may be expected to result in noise reductions of 2 to 4 dBA.

To obtain further improvement one would need to reduce sound transmission through the glass areas themselves. Although this may be difficult in the historical context of this project, the most straightforward approach would involve adding a layer of glazing (such as storm windows) to the existing windows. Adding of "heavy-duty" storm windows (with more than ordinary double-strength glass) may be expected to reduce the intruding street noise by 5 to 8 dBA.

It should be noted that ventilation presently is provided by opening the windows, and that opening of the windows may be expected to increase the noise levels beyond those reported here, thus making an already unsatisfactory condition even worse.

It should also be noted that reduction of the intruding street noise without attendant reduction in the subway-induced noise may be expected to make the latter more audible. Both types of noise therefore should be reduced simultaneously, if possible.

REFERENCES

1. D.E. Siskind, et al., "Structure Response and Damage Produced by Ground Vibration from Surface Mine Blasting," Bureau of Mines Report of Investigations RI 8507 (1980).

2. H.R. Nicholls, et al., "Blasting Vibrations and Their Effects on Structures," U.S. Bureau of Mines Bulletin 656 (1971).

3. R.J. Steffens, "Structural Vibration and Damage," Building Research Establishment Report, Her Majesty's Stationary Office (1974).

4. "Vibrations in Building Construction," German Standards Institute DIN 4150 (1970).

5. "Guide for the Evaluation of Human Exposure to Whole-Body Vibration," International Standards Organization, ISO Standard 2631 (1974).

6. A.G. Peterson and E.E. Gross, Jr., Handbook of Noise Measurement, General Radio Co., Concord, MA (1972).

7. L.L. Beranek, "Criteria for Noise and Vibration in Communities, Buildings, and Vehicles. Ch. 18 of Noise and Vibration Control, L.L. Beranek, Ed., McGraw-Hill Book Co., New York (1971).

8. "Reduction of Noise and Vibration in Buildings Near the New York City Subway," BBN Report No. 4481 (August 1980).

9. "Effects of Track Fixation on Transit Train Passage Noise and Vibration at the Southwest Corridor Project," BBN Report No. 6549 (July 1987).

APPENDIX A: INSTRUMENTATION

Vibration

The vibration information was acquired in the field using BBN Model 510 seismic accelerometers as sensors. The accelerometer signal was filtered using an Ithaco Model 4113 variable filter to remove unwanted high frequency information (above 250 Hz), amplified using an Ithaco Model 453 amplifier, and recorded on a Racal Store 7DS precision FM tape recorder.

The tape recordings were analyzed in the laboratory by playing the tape-recorded data into a Bruel & Kjaer Model 2231 sound level meter, set to operate in the peak hold mode. Representative spectra were generated by playing the recorded data into a General Radio Model 1921 Real Time analyzer, coupled to a Hewlett Packard Model 7015B X-Y plotter.

Noise

The noise data was obtained in the field by means of Bruel and Kjaer Model 4134 condensor microphones, mounted on General Radio Model 1560-P42 preamplifiers. The amplified microphone signals were recorded on a Kudelski Nagra IV S-J precision tape recorder.

The recorded data was analyzed in the laboratory by playing it into a Bruel and Kjaer Model 2203 precision sound level meter connected to Bruel and Kjaer Model 2305 graphic level recorder. The sound level meter was set to produce A-weighting, and the graphic level recorder was used to produce a time history of the noise level, from which history the maximum values were extracted.

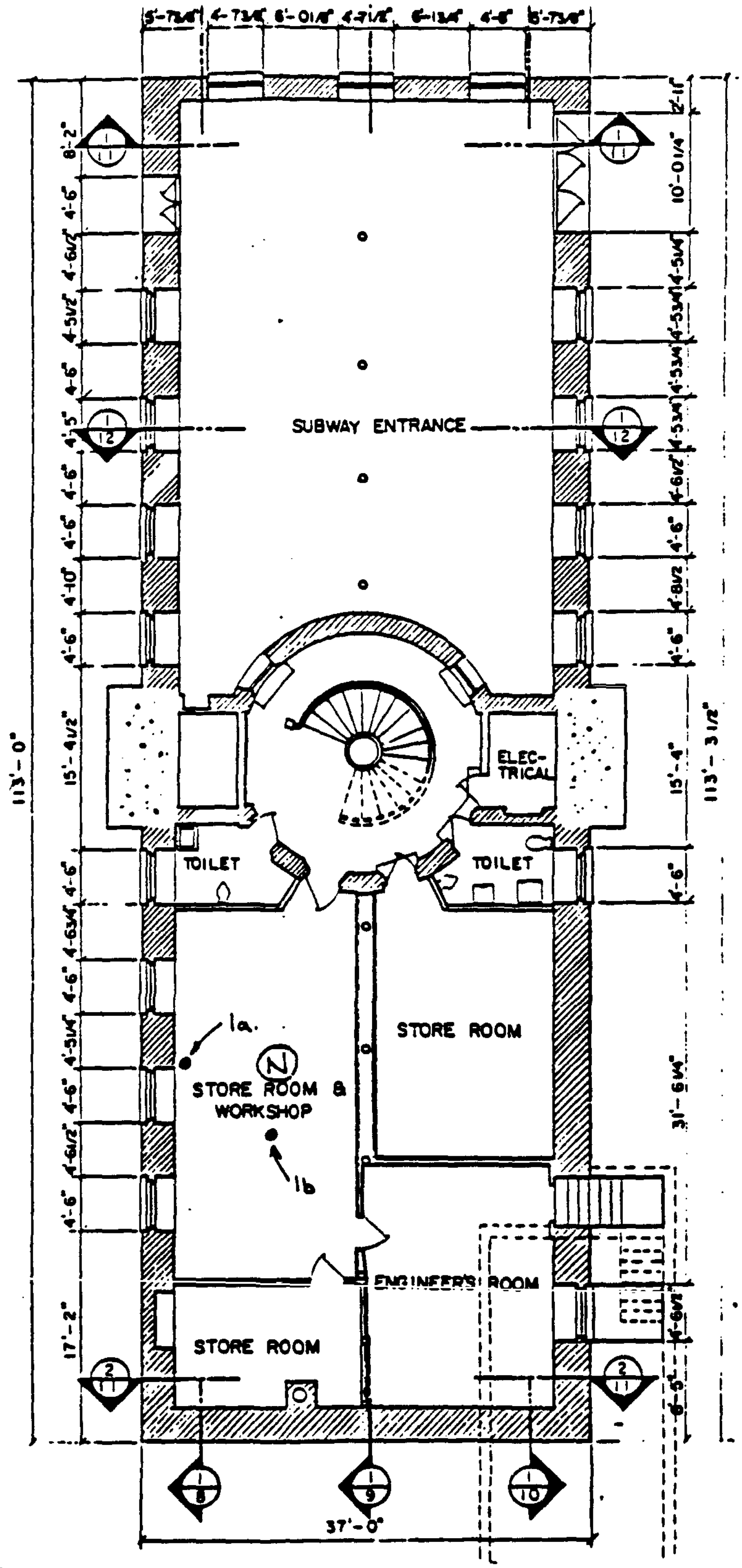


FIG. 1. GROUND FLOOR MEASUREMENT LOCATIONS FOR VIBRATION (NUMBERS) AND NOISE ("N).

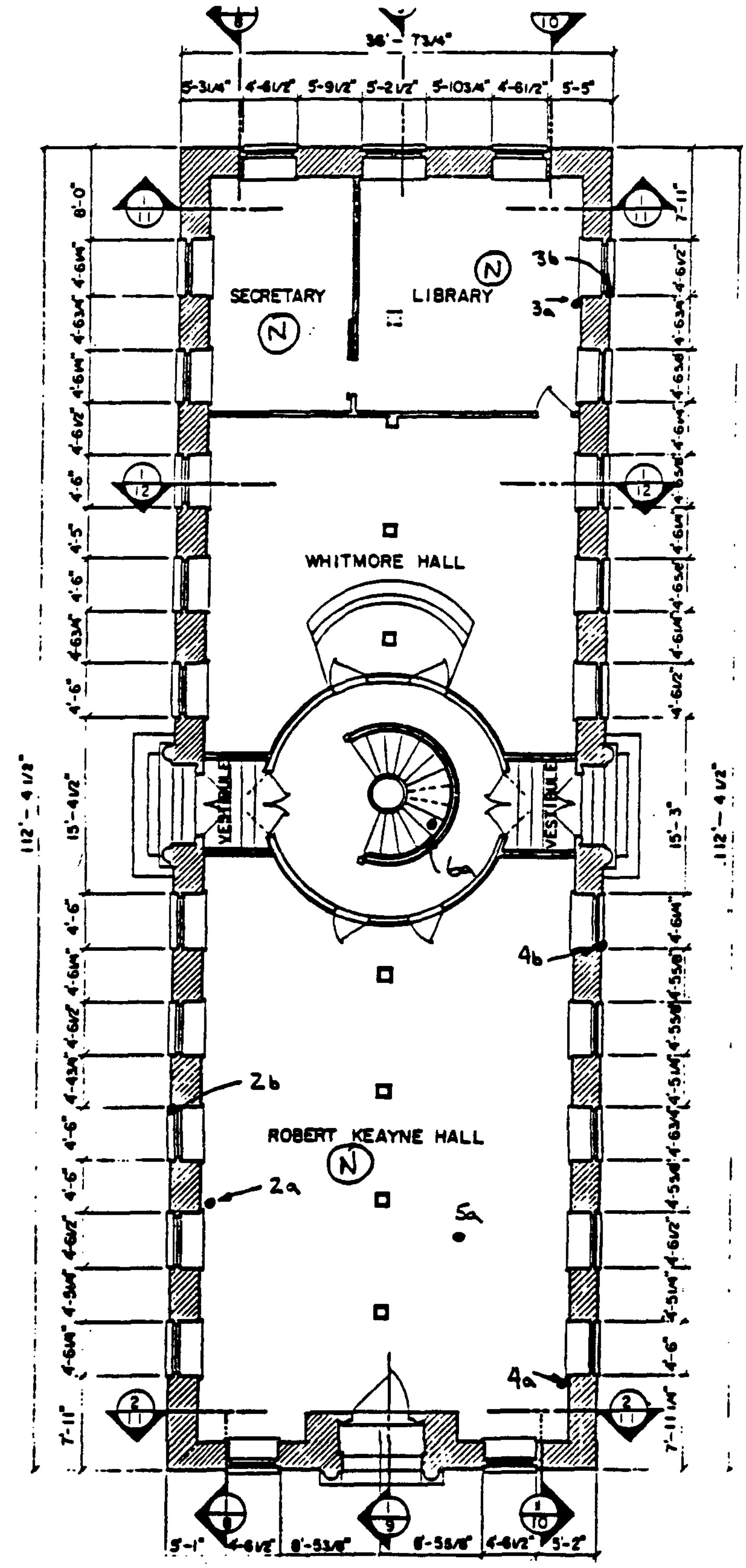


FIG. 2. FIRST FLOOR MEASUREMENT LOCATIONS FOR VIBRATION (NUMBERS) AND NOISE ("N).

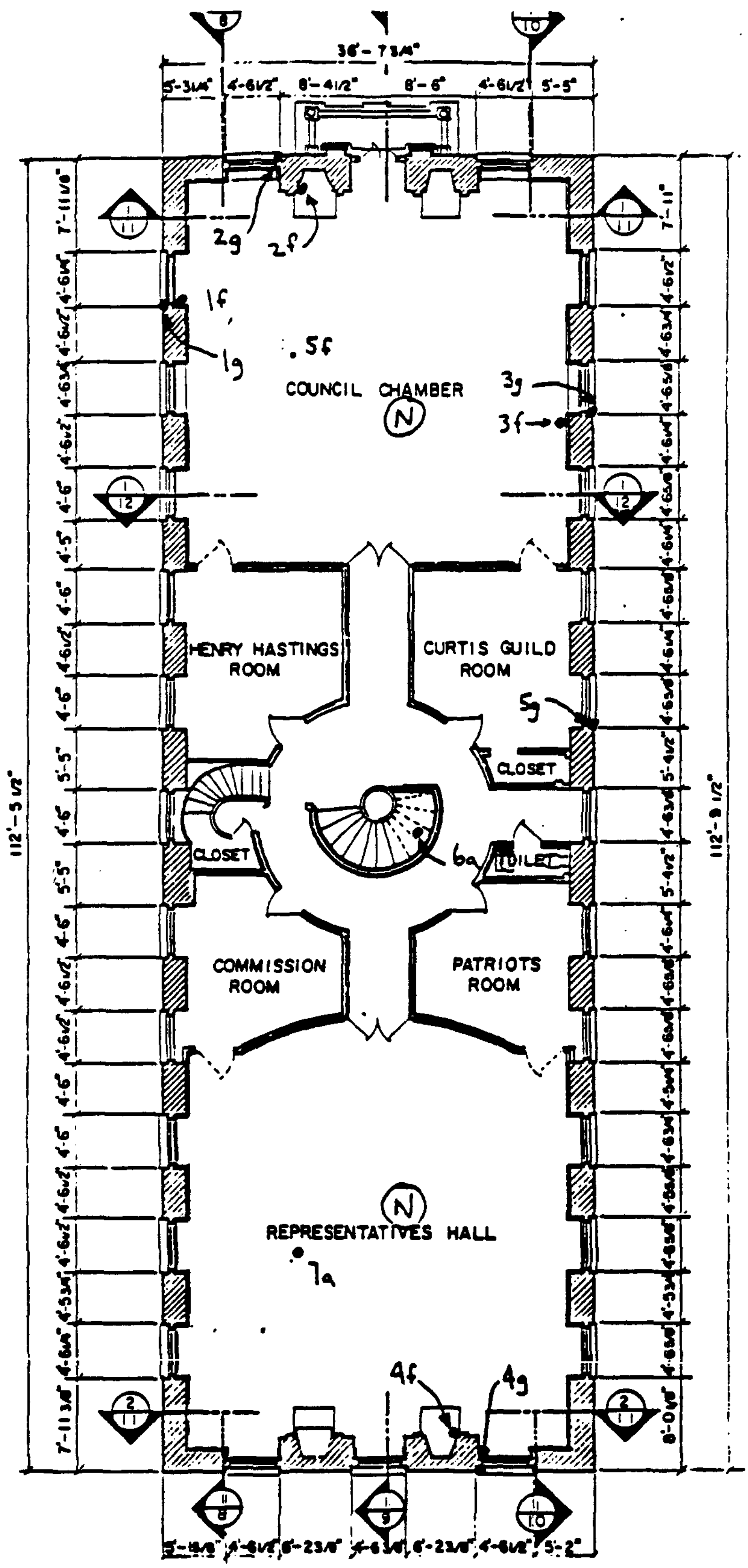


FIG. 3. SECOND FLOOR MEASUREMENT LOCATIONS FOR VIBRATION (NUMBERS) AND NOISE ("N).

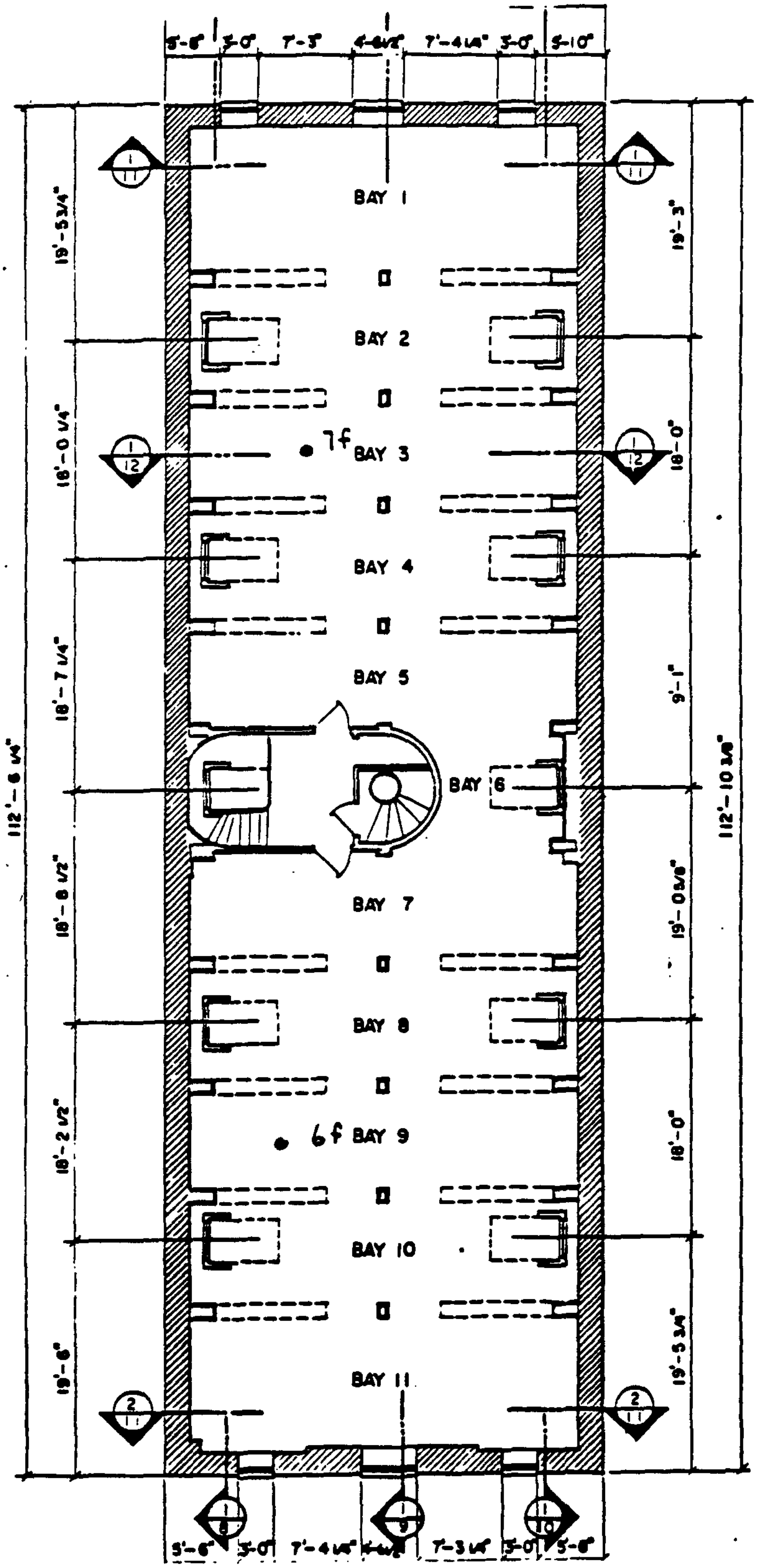


FIG. 4. ATTIC MEASUREMENT LOCATIONS FOR VIBRATION.

APPENDIX B

1977 LETTER TO MORGAN PHILLIPS

FROM LEMESSURIER CONSULTANTS

LeMessurier Associates / SCI

1033 Massachusetts Avenue, Cambridge, Massachusetts 02138

13 January 1978

JAN 16 1978

Society for the Preservation of
New England Antiquities
141 Cambridge Street
Boston, Massachusetts 02114

Attention: Morgan Phillips

Reference: Old State House
LeM Job No. 9407

Gentlemen:

The following report outlines conditions observed during visual inspections of the Old State House building, and makes recommendations for further study or remedial action.

Inspections were carried out by the writer on 5 January 1978 accompanied by Morgan Phillips and Sarah Chase of the Society, and on 11 January 1978 accompanied by Juris Anderson of LeMessurier Associates, who had previously inspected the building in 1969 and 1973.

Inspection was limited to observing cracks in the building perimeter walls and the roof over the boiler room.

Observations

Cracks in the perimeter brick walls occur predominantly in the north wall at the northeast corner of the building and in the south wall at the southwest and southeast corners. All four corners of the building are out of plumb, leaning outwards 1-3 inches at the top, and the west end wall is noticeably bowed in plan above the second floor. Crack patterns, and the lean at the corners, suggest a stretching of the walls of the upper story relative to the foundations. The cause of such movement is difficult to determine but probably results from foundation settlements and/or movements due to expansion and contraction of the walls from thermal effects. Areas where brickwork has been repointed indicate that additional earlier cracking has taken place, which has not since reopened. Crack patterns are shown on the accompanying sketches.

Sippican Consultants International, Inc.
LeMessurier Associates
Francis Associates
Tighe & Bond

617/868-1200

The cracks are not recent in origin, but there are indications that at the southwest corner there may have been some movement since the building interior was repainted in 1975. This is evidenced by lack of paint intrusion into the cracks and Mr. Anderson's opinion that the cracking may be wider at this location than when previously inspected.

The cracks do not, however, suggest any recent drastic movements that would cause concern for the immediate stability of this corner.

The brickwork has weathered badly in many areas resulting in spalling and loss of mortar, and generally is in need of re-pointing. Water intrusion has occurred at the northeast corner at the second floor.

The roof of the boiler room under the sidewalk consists of reinforced concrete supported on concrete encased steel beams, constructed about 1907. Severe corrosion of some steel beams and reinforcing bars has occurred due to moisture penetration from the sidewalk.

Some beams and rebars have completely disintegrated due to rusting. This is in a potentially dangerous condition.

Recommendations

Movements in building walls can generally be categorized under three broad headings.

A. Seasonal and reversible movements.

B. Unidirectional but self-limiting movements.

C. Progressive and continuing movements.

Cracks produced by type C movements may, if left unchecked, eventually lead to structural distress. A program of crack width monitoring should be started to check if progressive movements are taking place. This will determine the need for, and urgency of, any structural repairs. Additionally, sealing of the exterior of the cracks should be carried out by repointing or epoxy grouting to prevent ingress of moisture leading to leakage and freeze-thaw deterioration.

Crack movements can be monitored on interior surfaces simply by drawing pencil lines across the crack at various locations and angles and taking direct but accurate measurements of offset or length change with an Engineer's steel rule. For exterior work glass telltales should be installed bridging over the crack and cemented rigidly to the brickwork on each side. The glass will crack under any slight movement. Subsequent movements can be monitored from ground level by use of binoculars. More sophisticated techniques are available using strain gauges but are not warranted in this situation.

Regardless of the outcome of these measurements, it would seem prudent, if it is seriously intended that the building should last for another century or so, that the structure be strengthened in areas that have already shown weakness. Potential methods for increasing strength and stability involve improving the connection between perimeter walls and the second and attic floor diaphragms, and installation of steel dowels in the masonry running across major crack lines. Dowels would be installed in holes drilled longitudinally through the walls at the corners and grouted into place.

Parts of the boiler room roof under the sidewalk are in a dangerous condition and may collapse if subjected to a heavy load such as from a truck wheel mounting the sidewalk. Deteriorated areas should be replaced and a waterproofing membrane installed over the structure to prevent recurrence of the problem. Further inspections are required to determine the precise areas of deterioration. This should include the chipping away of concrete from encased steel work where the concrete is badly cracked or spalled so that the condition of the steel can be seen. If it is not possible to carry out immediate repairs, temporary shoring should be installed in the deteriorated zones. We understand that there are other areas where rooms extend under the sidewalk and these should also be inspected.

Vibrations due to subway trains running directly beneath the structure are noticeable within the building. These will not by themselves cause structural deterioration but will certainly exacerbate any weakness existing from other causes. Vibrations can be drastically reduced by installing continuous welded rails in the subway in place of the existing jointed type, and setting the rails on vibration isolators. Such installation involves the use of existing and well proven railway technology, and the MBTA might be approached on this issue.

The following summarizes our recommendations:

- o Further inspect the boiler room roof and other underground areas
- o Shore rusted out areas of boiler room roof or replace defective structure

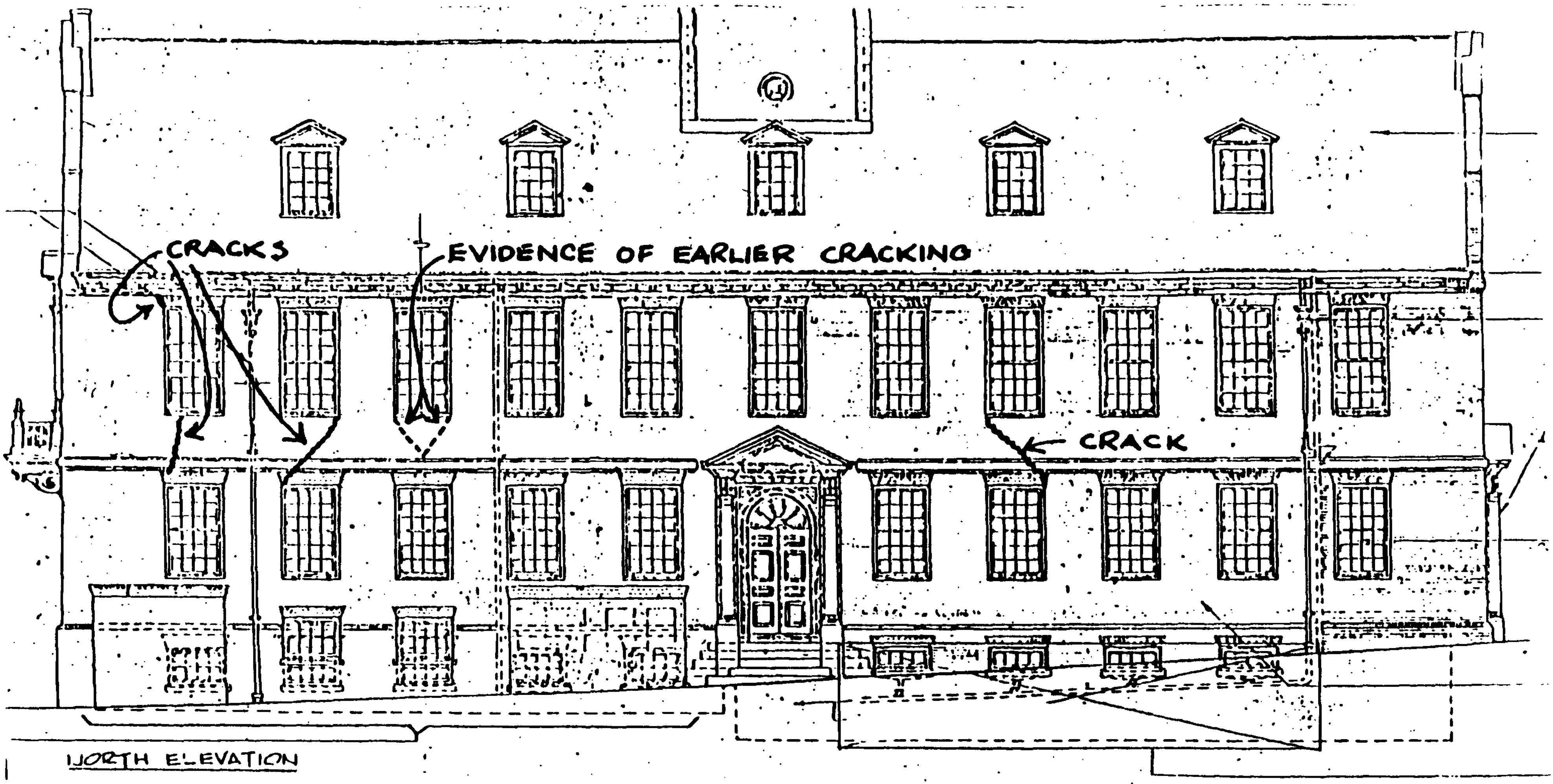
- o Repoint brickwork and seal existing cracks
- o Monitor existing cracks in walls at corners of building
- o Strengthen the building corners
- o Reduce vibrations from the subway

Very truly yours,

LeMESSURIER ASSOCIATES/SCI

John A. Coote

JAC:mt



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CRACKS SHOWN ARE DIAGRAMMATIC ONLY. NOT TO SCALE.

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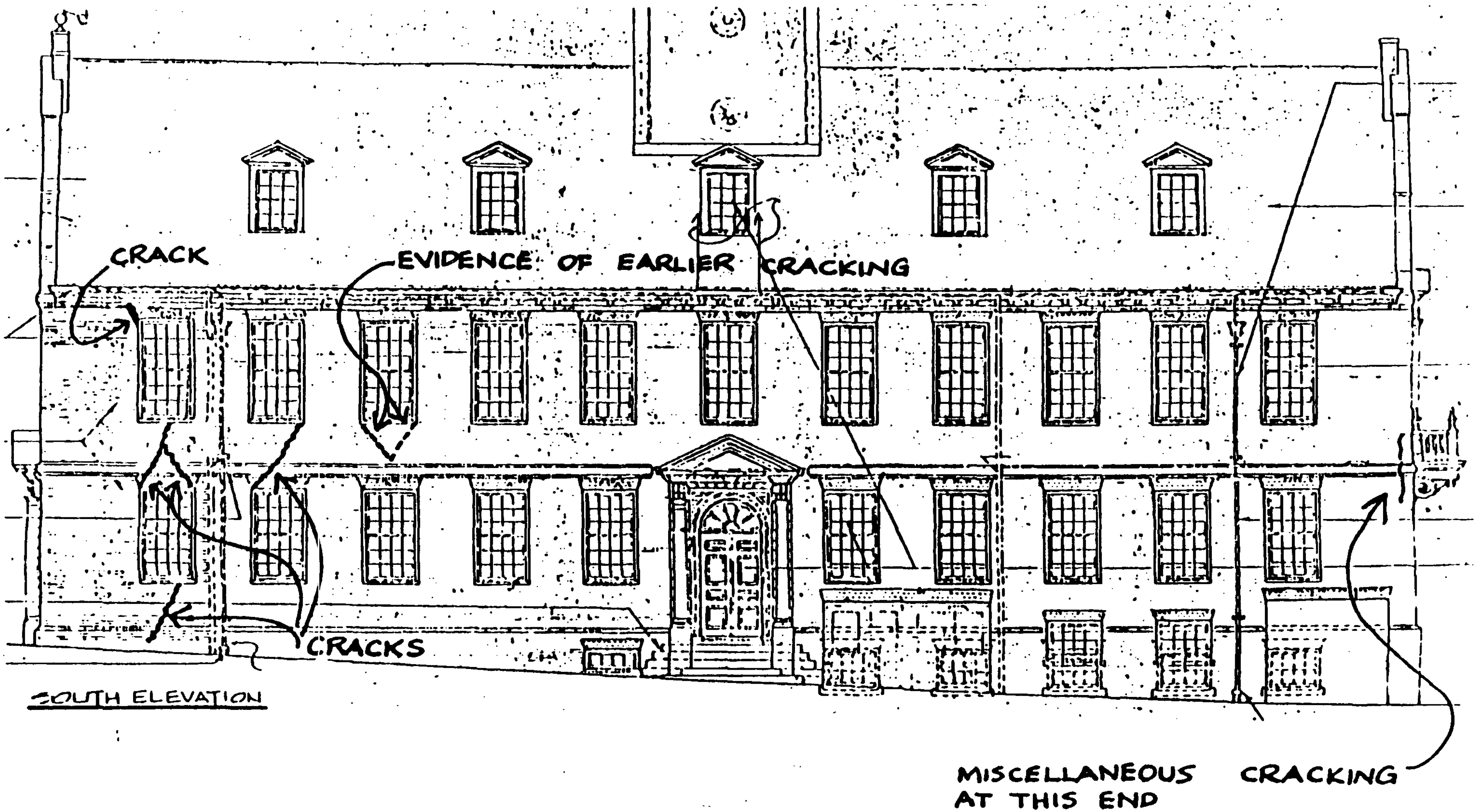
1/11/78



CRACKS SHOWN ARE DIAGRAMMATIC ONLY. NOT TO SCALE.

LeMessurier
Associates, Inc

1/11/78

APPENDIX C

1978 LETTER TO MORGAN PHILLIPS

FROM ENVIRONMENTAL DESIGN ENGINEERS

environmental
design
engineers inc.

145 PORTLAND STREET, BOSTON, MASS. 02114
Tel. (617) 742-7435

January 23, 1978

S.P.N.E.A.
141 Cambridge Street
Cambridge, Massachusetts 02114

Subject: Old State House

Attention: Mr. Morgan Phillips

Gentlemen:

As a result of a brief inspection of subject project, it is our determination that air conditioning of said project appears not to be viable for the following reasons:

A. There appears no way to provide air distribution to the First Floor Library and Display Areas from the Basement Level, since the possibility of pulling in contaminants from ground level is very great.

B. The upper level could be air conditioned, with units located in the Attic, with duct distribution provided at the exterior. However, this would require the removal of glass in 3 or 4 dormer windows, which would appear not to be in keeping with the building exterior.

Air conditioning through a ducted system was considered since control of relative humidity would be easily accomplished.

C. As an alternative to a ducted system, a two pipe fan coil system was considered. (i.e. two-pipe - either heating in winter or cooling in summer).

This system would require a hot water heating system and chilled water cooling system with the cooling system located in either Attic or Basement.

Continued.......

environmental design engineers inc.

Janaury 23, 1978
Page Two

The condensing portion of the cooling system, however, would require ducting through the Attic dormers and would impose considerable weight and potential vibration on the Attic Floor.

This system would also preclude a central control of relative humidity since such could not be built into the system.

Consequently, it is our determination that central air conditioning of the subject project does not appear feasible at this time - pending a more detailed study of the building and the Owner's specific requirements.

Very truly yours,

ENVIRONMENTAL DESIGN ENGINEERS, INC.

Daniel B. Levenson, P.E.
President

APPENDIX D

1977 PAINT ANALYSIS

Paint Analysis

Paint analysis in the Old State House was limited to scrutiny of the patterns of sequence in the paint layers, for the purpose of determining the relative dates of various elements of the building. Two areas, however, have paint layers of particular interest. Portions of the trim around the east balcony doorway bear between 57 and 60 layers of paint. This, taken with other evidence cited elsewhere in this report (see index that follows), seems to indicate clearly that the earliest layers and their substrates date from the 1748 build of the Old State House. The second paint sample of significance comes from a dentil found in the tower. The dentil, as already described, is probably part of the material installed at the time of George Clough's 1882 restoration.

The east balcony-area paint sample was taken from the neck molding of the pilaster on the north side of the doorway (Ill. 84, 21). The paint chip (Ill. 64) shows six to seven generally ocher- and earth-pigment hues adjacent to the substrate. The layer indicated by "A" is a light gray, and clearly has grains of sand embedded in it. A letter written in 1773 describes the Old State House as freshly refurbished, with "The whole of the outside (being) painted of a stone color." Evidently the paint was not only of a color resembling stone, but also of a stone texture.

Illustration 65 shows the underside of this paint chip from the pilaster neck molding on the east end of the Old State House, and displays the unpolished appearance of the paint layers. It should be noted that the small red "dot" to the left is a foreign intrusion — possibly a drop of paint from some higher surface.

Paint layers on the dentil (Ill. 66) indicate that the dentil probably was not on the building before 1882.

The earliest layers are a dark chocolate brown, very probably applied in 1881-82. Weathering makes this sample more difficult to read than those from the pilasters and other elements of wood trim around the east balcony.

An index to selected references in the text of the report is as follows:

ILLUSTRATION 64: OLD STATE HOUSE: PAINT SAMPLE FROM NECK MOLDING, NORTH PILASTER, BALCONY DOORWAY, 1977.

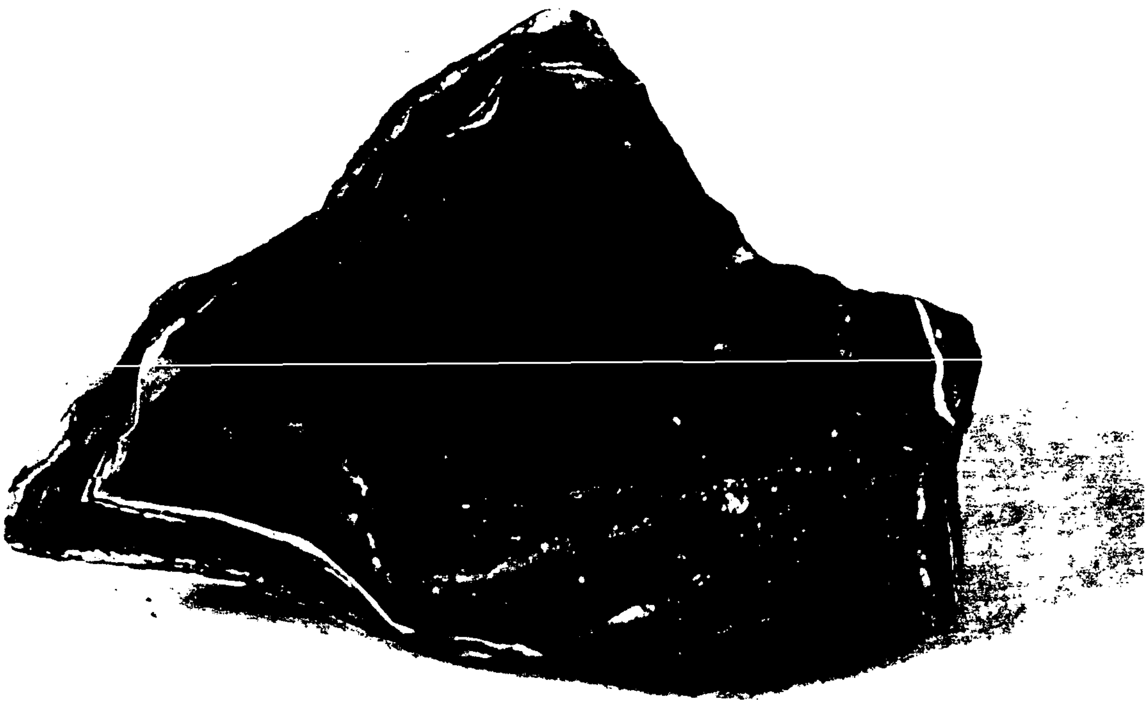


ILLUSTRATION 65: OLD STATE HOUSE: UNPOLISHED PAINT SAMPLE FROM NECK MOLDING, NORTH PILASTER, BALCONY DOORWAY, 1977.

ILLUSTRATION 66: OLD STATE HOUSE: LAYERS OF PAINT ON DENTIL FROM TOWER CORNICE, 1977.

ILLUSTRATION 67: OLD STATE HOUSE: EAST WALL, UPPER PORTION, AND 1957 SUNDIAL, 1977.

APPENDIX E

1987 WOOD IDENTIFICATION

WOOD IDENTIFICATION

SAMPLE NO.	SOURCE/LOCATION	WOOD SPECIES	REMARKS
1.	TRUSS TOP CHORD OLD STATE HOUSE - BOSTON NHP	Pine of the white pine group probably eastern white pine (*Pinus strobus*)	
2	TRUSS SUPPLEMENTARY TOP CHORD OLD STATE HOUSE - BOSTON NHP	Oak (*Quercus*) of the white oak group	
3	TRUSS KING POST OLD STATE HOUSE - BOSTON NHP	Same as #1	
4	TRUSS BOTTOM CHORD OLD STATE HOUSE - BOSTON NHP	Same as #1	
5	ROOF TRUSS GENERATION BUILDING WPTC / C&O CANAL NHP	Douglas-fir. (*Pseudotsuga menziesii*)	
		Identified by Donna J. Christensen Center for Wood Anatomy Research U. S. Forest Products Laboratory Madison, WI 53705	12-12-86

APPENDIX F

OCCUPATIONAL HELATH AND SAFETY

ASBESTOS REGULATIONS

(29 CFR 1910.1001)

§ 1910.1001 Asbestos.

(a) *Definitions*. For the purpose of this section, (1) "Asbestos" includes chrysotile, amosite, crocidolite, tremolite, anthophyllite, and actinolite.

(2) "Asbestos fibers" means asbestos fibers longer than 5 micrometers.

(b) *Permissible exposure to airborne concentrations of asbestos fibers*—(1) *Standard effective July 7, 1972*. The 8-hour time-weighted average airborne concentrations of asbestos fibers to which any employee may be exposed shall not exceed five fibers, longer than 5 micrometers, per cubic centimeter of air, as determined by the method prescribed in paragraph (e) of this section.

(2) *Standard effective July 1, 1976*. The 8-hour time-weighted average airborne concentrations of asbestos fibers to which any employee may be exposed shall not exceed two fibers, longer than 5 micrometers, per cubic centimeter of air, as determined by the method prescribed in paragraph (e) of this section.

(3) *Ceiling concentration*. No employee shall be exposed at any time to airborne concentrations of asbestos fibers in excess of 10 fibers, longer than 5 micrometers, per cubic centimeter of air, as determined by the method prescribed in paragraph (e) of this section.

(c) *Methods of compliance*—(1) *Engineering methods*. (i) *Engineering controls*. Engineering controls, such as, but not limited to, isolation, enclosure, exhaust ventilation, and dust collection, shall be used to meet the exposure limits prescribed in paragraph (b) of this section.

(ii) *Local exhaust ventilation*. (*a*) Local exhaust ventilation and dust collection systems shall be designed, constructed, installed, and maintained in accordance with the American National Standard Fundamentals Governing the Design and Operation of Local Exhaust Systems, ANSI Z9.2-1971, which is incorporated by reference herein.

(*b*) See § 1910.6 concerning the availability of ANSI Z9.2-1971, and the maintenance of a historic file in connection therewith. The address of the American National Standards Institute is given in § 1910.100.

(iii) *Particular tools*. All hand-operated and power-operated tools which may produce or release asbestos fibers in excess of the exposure limits prescribed in paragraph (b) of this section, such as, but not limited to, saws, scorers, abrasive wheels, and drills, shall be provided with local exhaust ventilation systems in accordance with subdivision (ii) of this subparagraph.

(2) *Work practices*—(i) *Wet methods*. Insofar as practicable, asbestos shall be handled, mixed, applied, removed, cut, scored, or otherwise worked in a wet state sufficient to prevent the emission of airborne fibers in excess of the exposure limits prescribed in paragraph (b) of this section, unless the usefulness of the product would be diminished thereby.

(ii) *Particular products and operations*. No asbestos cement, mortar, coating, grout, plaster, or similar material containing asbestos shall be removed from bags, cartons, or other containers in which they are shipped, without being either wetted, or enclosed, or ventilated so as to prevent effectively the release of airborne asbestos fibers in excess of the limits prescribed in paragraph (b) of this section.

(iii) *Spraying, demolition, or removal*. Employees engaged in the spraying of asbestos, the removal, or demolition of pipes, structures, or equipment covered or insulated with asbestos, and in the removal or demolition of asbestos insulation or coverings shall be provided with respiratory equipment in accordance with paragraph (d)(2)(iii) of this section and with special clothing in accordance with paragraph (d)(3) of this section.

(d) *Personal protective equipment*—(1) Compliance with the exposure limits prescribed by paragraph (b) of this section may not be achieved by the use of respirators or shift rotation of employees, except:

(i) During the time period necessary to install the engineering controls and to institute the work practices required by paragraph (c) of this section;

(ii) In work situations in which the methods prescribed in paragraph (c) of this section are either technically not feasible or feasible to an extent insufficient to reduce the airborne concentrations of asbestos fibers below the limits prescribed by paragraph (b) of this section; or

(iii) In emergencies.

(iv) Where both respirators and personnel rotation are allowed by paragraphs (d)(1) (i), (ii), or (iii) of this section, and both are practicable, personnel rotation shall be preferred and used.

(2) Where a respirator is permitted by paragraph (d)(1) of this section, it shall be selected from among those approved by the Bureau of Mines, Department of the Interior, or the National Institute for Occupational Safety and Health, Department of

Health, Education, and Welfare, under the provisions of 30 CFR Part 11 (37 FR 6244, Mar. 25, 1972), and shall be used in accordance with subdivisions (i), (ii), (iii), and (iv) of this subparagraph.

(i) *Air purifying respirators.* A reusable or single use air purifying respirator, or a respirator described in paragraph (d)(2) (ii) or (iii) of this section, shall be used to reduce the concentrations of airborne asbestos fibers in the respirator below the exposure limits prescribed in paragraph (b) of this section, when the ceiling or the 8-hour time-weighted average airborne concentrations of asbestos fibers are reasonably expected to exceed no more than 10 times those limits.

(ii) *Powered air purifying respirators.* A full facepiece powered air purifying respirator, or a powered air purifying respirator, or a respirator described in paragraph (d)(2)(iii) of this section, shall be used to reduce the concentrations of airborne asbestos fibers in the respirator below the exposure limits prescribed in paragraph (b) of this section, when the ceiling or the 8-hour time-weighted average concentrations of asbestos fibers are reasonably expected to exceed 10 times, but not 100 times, those limits.

(iii) *Type "C" supplied-air respirators, continuous flow or pressure-demand class.* A type "C" continuous flow or pressure-demand, supplied-air respirator shall be used to reduce the concentrations of airborne asbestos fibers in the respirator below the exposure limits prescribed in paragraph (b) of this section, when the ceiling or the 8-hour time-weighted average airborne concentrations of asbestos fibers are reasonably expected to exceed 100 times those limits.

(iv) *Establishment of a respirator program.* (*a*) The employer shall establish a respirator program in accordance with the requirements of the American National Standards Practices for Respiratory Protection, ANSI Z88.2-1969, which is incorporated by reference herein.

(*b*) See § 1910.6 concerning the availability of ANSI Z88.2-1969 and the maintenance of a historic file in connection therewith. The address of the American National Standards Institute is given in § 1910.100.

(*c*) No employee shall be assigned to tasks requiring the use of respirators if, based upon his most recent examination, an examining physician determines that the employee will be unable to function normally wearing a respirator, or that the safety or health of the employee or other employees will be impaired by his use of a respirator. Such employee shall be rotated to another job or given the opportunity to transfer to a different position whose duties he is able to perform with the same employer, in the same geographical area and with the same seniority, status, and rate of pay he had just prior to such transfer, if such a different position is available.

(3) Special clothing: The employer shall provide, and require the use of, special clothing, such as coveralls or similar whole body clothing, head coverings, gloves, and foot coverings for any employee exposed to airborne concentrations of asbestos fibers, which exceed the ceiling level prescribed in paragraph (b) of this section.

(4) Change rooms: (i) At any fixed place of employment exposed to airborne concentrations of asbestos fibers in excess of the exposure limits prescribed in paragraph (b) of this section, the employer shall provide change rooms for employees working regularly at the place.

(ii) Clothes lockers: The employer shall provide two separate lockers or containers for each employee, so separated or isolated as to prevent contamination of the employee's street clothes from his work clothes.

(iii) Laundering: (*a*) Laundering of asbestos contaminated clothing shall be done so as to prevent the release of air-borne asbestos fibers in excess of the exposure limits prescribed in paragraph (b) of this section.

(*b*) Any employer who gives asbestos-contaminated clothing to another person for laundering shall inform such person of the requirement in paragraph (d)(4)(iii)(*a*) of this section to effectively prevent the release of airborne asbestos fibers in excess of the exposure limits prescribed in paragraph (b) of this section.

(c) Contaminated clothing shall be transported in sealed impermeable bags, or other closed, impermeable containers, and labeled in accordance with paragraph (g) of this section.

(e) *Method of measurement.* All determinations of airborne concentrations of asbestos fibers shall be made by the membrane filter method at 400-450 × (magnification) (4 millimeter objective) with phase contrast illumination.

(f) *Monitoring*—(1) *Initial determinations.* Within 6 months of the publication of this section, every employer shall cause every place of employment where asbestos fibers are released to be monitored in such a way as to determine whether every employee's exposure to asbestos fibers is below the limits prescribed in paragraph (b) of this section. If the limits are exceeded, the employer shall immediately undertake a compliance program in accordance with paragraph (c) of this section.

(2) *Personal monitoring*—(i) Samples shall be collected from within the breathing zone of the employees, on membrane filters of 0.8 micrometer porosity mounted in an open-face filter holder. Samples shall be taken for the determination of the 8-hour time-weighted average airborne concentrations and of the ceiling concentrations of asbestos fibers.

(ii) Sampling frequency and patterns. After the initial determinations required by paragraph (f)(1) of this section, samples shall be of such frequency and pattern as to represent with reasonable accuracy the levels of exposure of employees. In no case shall the sampling be done at intervals greater than 6 months for employees whose exposure to asbestos may reasonably be foreseen to exceed the limits prescribed by paragraph (b) of this section.

(3) *Environmental monitoring.* (i) Samples shall be collected from areas of a work environment which are representative of the airborne concentrations of asbestos fibers which may reach the breathing zone of employees. Samples shall be collected on a membrane filter of 0.8 micrometer porosity mounted in an open-face filter holder. Samples shall be taken for the determination of the 8-hour time-weighted average airborne concentrations and of the ceiling concentrations of asbestos fibers.

(ii) *Sampling frequency and patterns.* After the initial determinations required by paragraph (f)(1) of this section, samples shall be of such frequency and pattern as to represent with reasonable accuracy the levels of exposure of the employees. In no case shall sampling be at intervals greater than 6 months for employees whose exposures to asbestos may reasonably be foreseen to exceed the exposure limits prescribed in paragraph (b) of this section.

(4) *Employee observation of monitoring.* Affected employees, or their representatives, shall be given a reasonable opportunity to observe any monitoring required by this paragraph and shall have access to the records thereof.

(g) *Caution signs and labels*—(1) *Caution signs*—(i) *Posting.* Caution signs shall be provided and displayed at each location where airborne concentrations of asbestos fibers may be in excess of the exposure limits prescribed in paragraph (b) of this section. Signs shall be posted at such a distance from such a location so that an employee may read the signs and take necessary protective steps before entering the area marked by the signs. Signs shall be posted at all approaches to areas containing excessive concentrations of airborne asbestos fibers.

(ii) *Sign specifications.* The warning signs required by paragraph (g)(1)(i) of this section shall conform to the requirements of 20″ × 14″ vertical format signs specified in § 1910.145(d)(4), and to this subdivision. The signs shall display the following legend in the lower panel, with letter sizes and styles of a visibility at least equal to that specified in this subdivision.

Legend	Notation
Asbestos	1″ Sans Serif, Gothic or Block.
Dust Hazard	¾″ Sans Serif, Gothic or Block.
Avoid Breathing Dust	¼″ Gothic.
Wear Assigned Protective Equipment.	¼″ Gothic.

Legend	Notation
Do Not Remain In Area Unless Your Work Requires It.	¼" Gothic.
Breathing Asbestos Dust May Be Hazardous To Your Health.	14 point Gothic.

Spacing between lines shall be at least equal to the height of the upper of any two lines.

(2) *Caution labels*—(i) *Labeling.* Caution labels shall be affixed to all raw materials, mixtures, scrap, waste, debris, and other products containing asbestos fibers, or to their containers, except that no label is required where asbestos fibers have been modified by a bonding agent, coating, binder, or other material so that during any reasonably foreseeable use, handling, storage, disposal, processing, or transportation, no airborne concentrations of asbestos fibers in excess of the exposure limits prescribed in paragraph (b) of this section will be released.

(ii) *Label specifications.* The caution labels required by paragraph (g)(2)(i) of this section shall be printed in letters of sufficient size and contrast as to be readily visible and legible. The label shall state:

Caution

Contains Asbestos Fibers

Avoid Creating Dust

Breathing Asbestos Dust May Cause Serious Bodily Harm

(h) *Housekeeping*—(1) *Cleaning.* All external surfaces in any place of employment shall be maintained free of accumulations of asbestos fibers if, with their dispersion, there would be an excessive concentration.

(2) *Waste disposal.* Asbestos waste, scrap, debris, bags, containers, equipment, and asbestos-contaminated clothing, consigned for disposal, which may produce in any reasonably foreseeable use, handling, storage, processing, disposal, or transportation airborne concentrations of asbestos fibers in excess of the exposure limits prescribed in paragraph (b) of this section shall be collected and disposed of in sealed impermeable bags, or other closed, impermeable containers.

(i) *Recordkeeping*—(1) *Exposure records.* Every employer shall maintain records of any personal or environmental monitoring required by this section. Records shall be maintained for a period of at least 20 years and shall be made available upon request to the Assistant Secretary of Labor for Occupational Safety and Health, the Director of the National Institute for Occupational Safety and Health, and to authorized representatives of either.

(2) *Access.* Employee exposure records required by this paragraph shall be provided upon request to employees, designated representatives, and the Assistant Secretary in accordance with 29 CFR 1910.20 (a)-(e) and (g)-(i).

(3) *Employee notification.* Any employee found to have been exposed at any time to airborne concentrations of asbestos fibers in excess of the limits prescribed in paragraph (b) of this section shall be notified in writing of the exposure as soon as practicable but not later than 5 days of the finding. The employee shall also be timely notified of the corrective action being taken.

(j) *Medical examinations*—(1) *General.* The employer shall provide or make available at his cost, medical examinations relative to exposure to asbestos required by this paragraph.

(2) *Preplacement.* The employer shall provide or make available to each of his employees, within 30 calendar days following his first employment in an occupation exposed to airborne concentrations of asbestos fibers, a comprehensive medical examination, which shall include, as a minimum, a chest roentgenogram (posterior-anterior 14 × 17 inches), a history to elicit symptomatology of respiratory disease, and pulmonary function tests to include forced vital capacity (FVC) and forced expiratory volume at 1 second ($FEV_{1.0}$).

(3) *Annual examinations.* On or before January 31, 1973, and at least annually thereafter, every employer shall provide, or make available, comprehensive medical examinations to each of his employees engaged in occupations exposed to airborne concentrations of asbestos fibers. Such annual examination shall include, as a minimum, a chest roentgenogram (posteri-

or-anterior 14 × 17 inches), a history to elicit symptomatology of respiratory disease, and pulmonary function tests to include forced vital capacity (FVC) and forced expiratory volume at 1 second ($FEV_{1.0}$).

(4) *Termination of employment.* The employer shall provide, or make available, within 30 calendar days before or after the termination of employment of any employee engaged in an occupation exposed to airborne concentrations of asbestos fibers, a comprehensive medical examination which shall include, as a minimum, a chest roentgenogram (posterior-anterior 14 × 17 inches), a history to elicit symptomatology of respiratory disease, and pulmonary function tests to include forced vital capacity (FVC) and forced expiratory volume at 1 second ($FEV_{1.0}$).

(5) *Recent examinations.* No medical examination is required of any employee, if adequate records show that the employee has been examined in accordance with this paragraph within the past 1-year period.

(6) *Medical records*—(i) *Maintenance.* Employers of employees examined pursuant to this paragraph shall cause to be maintained complete and accurate records of all such medical examinations. Records shall be retained by employers for at least 20 years.

(ii) *Access.* Records of the medical examinations required by this paragraph shall be provided upon request to employees, designated representatives, and the Assistant Secretary in accordance with 29 CFR 1910.20 (a)-(e) and (g)-(i). These records shall also be provided upon the request to the Director of NIOSH. Any physician who conducts a medical examination required by this paragraph shall furnish to the employer of the examined employee all the information specifically required by this paragraph, and any other medical information related to occupational exposure to asbestos fibers.

APPENDIX G

REPORT OF STAIR LOAD TEST

LeMessurier Consultants

'033 Massachusetts Avenue, Cambridge, MA 02238
617/868-1200 Telex: 710-320-7699 SCI CAM

OLD STATE HOUSE

BOSTON NATIONAL HISTORICAL PARK

BOSTON, MASSACHUSETTS

Report of Stair Load Test

Prepared for:

U.S. Department of the Interior

National Park Service

Denver, Colorado

LeM File No. 87137

April 1988

INTRODUCTION

On February 23 and 24, 1988 a load test was carried out on the circular wooden staircase between the first and second floors of the Old State House.

The need for such testing is indicated in the "Structural Engineering Report" for the building prepared for the National Park Service by Goody Clancy Associates, Inc. Architects (GCA) and LeMessurier Consultants Inc., Structural Engineers (LCI) and issued in December 1987.

Establishment of load capacity by testing was recommended because precise details of the construction of the stair are unknown, thus ruling out the determination of safe load capacity by analysis.

CODE REQUIREMENTS

The Commonwealth of Massachusetts State Building Code requires egress stairs in new construction to have a safe load carrying capacity of 100 pounds per square foot. Chapter 436 of the Code however allows a reduced load capacity to be accepted in historic buildings, subject to posting of such loading.

The Code also allows testing to be used as a means of establishing load capacity where design by engineering analysis is not possible, and gives requirements for testing procedures and acceptable performance under test. Relevant sections of the code covering testing requirements are given in

Appendix A of this report. These are summarized below:

1. Added test load to be 150 percent of design live load.
2. No damage shall be visible other than hairline cracking.
3. Deflection recovery within 24 hours of removal of test load shall be 75 percent of the maximum deflection.
4. Deflection at design live load to be less than one two hundred and fortieth of the span (unplastered construction).

THE LOAD TEST

Testing was carried out by A.and J.Conti, Inc., under full-time supervision of Protze Materials Engineering and Testing Co. (PMET). A report by PMET of the testing is included in Appendix B. Inspections during the test were carried out by GCA and LCI personnel.

Loads were added to the stair treads using steel weights up to a maximum load equivalent to 425 pounds on each tread. The test load was designed to simulate the most likely maximum load that could be applied to the stair during service, of one person standing on each stair riser adjacent to the outside rail, and one person standing on every other riser next to the inside rail, i.e., an average of 1-1/2 persons per tread. Stair tread dimensions are 5 inches at the inside rail, 19 inches at the outside rail by 44 inches between rails giving a useable tread area of 3.67 square feet. This arrangement is illustrated in Figure 1.

Assuming an average weight per person of 175 pounds, the maximum anticipated service load amounts to 175 x 1.5 per tread = 262 pounds. The average equivalent uniform load is therefore 262 ÷ 3.67 = 71.5 pounds per square foot. The maximum test load of 425 pounds per tread is 1.62 times the maximum anticipated service load, thus exceeding the 150 percent requirement for test load over design load given in the Code.

The test load was applied in three equal increments and deflection of the stair was recorded at mid span of each stringer and at level 2. Deflections are plotted in Figure 2.

As noted in the PMET report, slight cracking of the stair soffit was noticed after the full load had been in place for 3 hours. The cracks worsened slightly with time but never were more than hairline width.

After 24 hours of full loading, the load was removed and recovery measured. Recovery is included in Figure 2.

The performance of the stair under test was consistent with requirements of the Code.

CONCLUSIONS

The stair has satisfactorily withstood a test load equal to 1.5 times the maximum anticipated likely load that would be placed on the stair in service.

This maximum anticipated load represents two lines of persons, one standing adjacent to the outside rail on each step and one standing adjacent to the inside rail on every other step.

This loading represents an equivalent uniform load of about 70 pounds per square foot of stair tread area, which is less than the Code requirements for egress stairs in new construction.

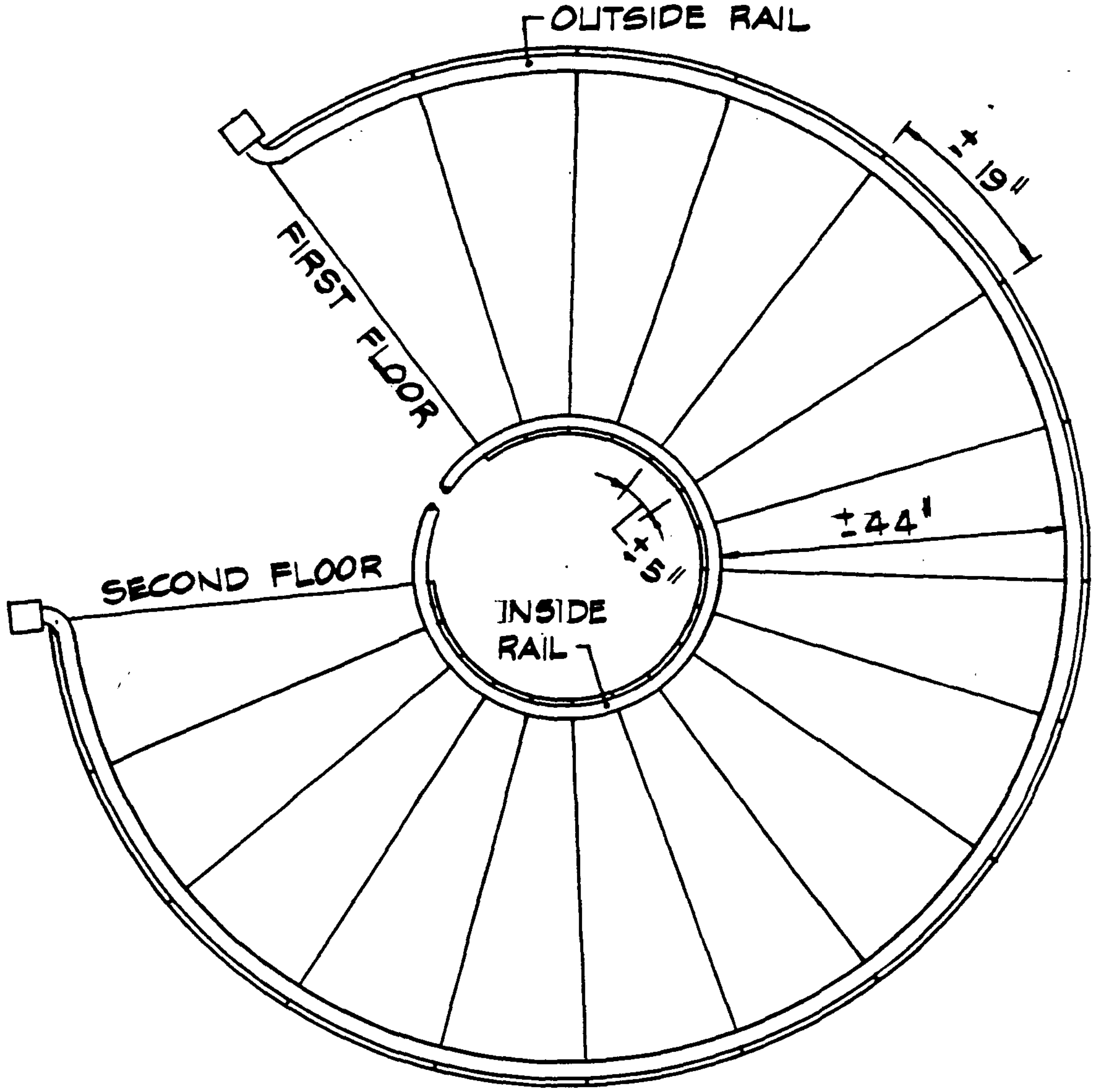
We recommend that the stair be posted in accordance with Chapter 436 of the Code, and that no more than 27 persons be allowed on the 18 stair treads at any one time.

W.L. Thoen

John A. Coote

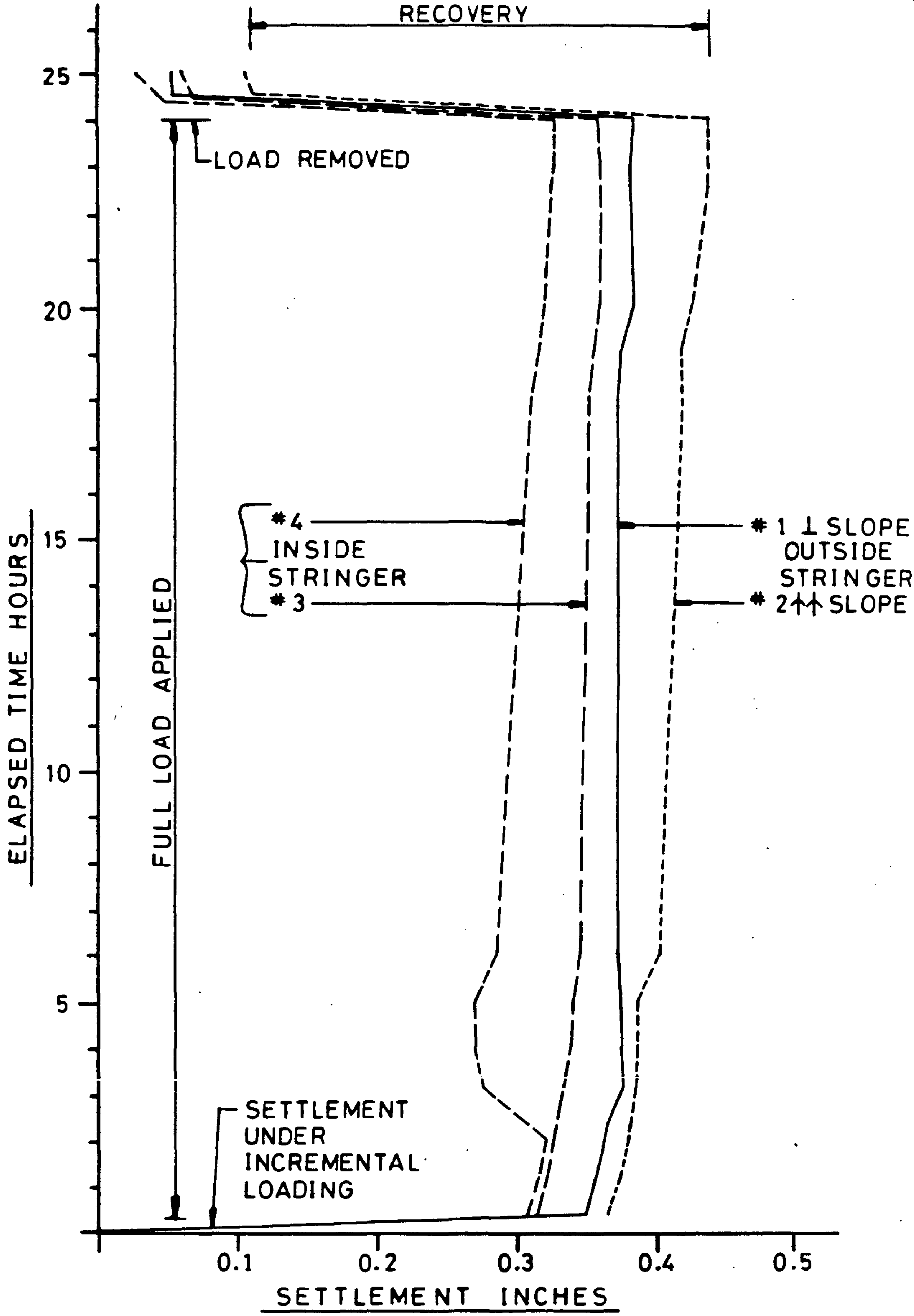
LeMESSURIER CONSULTANTS, INC.

26 April 1988



PLAN OF STAIR BETWEEN FLOORS 1 & 2

FIGURE 1



PLOT OF STRINGER DEFLECTION

FIGURE 2

ARTICLE 7

STRUCTURAL AND FOUNDATION LOADS AND STRESSES

SECTION 700.0 GENERAL

700.1 Scope: The provisions of this article shall control the structural design of all structures, and their foundations, hereafter erected to insure adequate strength of all parts thereof for the safe support of all superimposed live and special loads in addition to their own dead load, without exceeding the design capabilities. The loads specified herein are the minimum suitable for use with stresses and load factors prescribed in this code or in accepted engineering practice.

SECTION 701.0 DESIGN SAFE LOAD

701.1 Structural analysis: The safe load for any structural member or system of construction shall be determined by accepted engineering analysis except as provided in Sections 702.0 and 803.0 for tests of assemblies not capable of analysis.

701.2 Check tests: When there is reasonable doubt as to the design capacity of any structural unit or assembly, the building official may require that tests be made of such unit or assembly under the supervision of a qualified registered professional engineer. Such tests shall be made by an approved testing facility and personnel, and the procedures and results of such tests shall be signed and stamped by the said designated qualified registered professional engineer.

SECTION 702.0 TEST SAFE LOAD

702.1 When required: When not capable of being accurately analyzed, any system of construction or structural unit and its connections shall be subjected to tests prescribed in Article 8 or in the test standards listed in Appendices D and E, or to such other tests which may be certified by a qualified registered professional engineer as being acceptable for providing the information required. Any tests performed shall be conducted as required by the provisions of Section 701.2 for testing.

702.2 Test load: The test load shall be subject to the provisions of Section 803.2 and, where applicable, deflections shall be limited as provided in Section 803.3.

SECTION 703.0 DESIGN LIVE LOAD

703.1 Required live load: The live loads to be assumed in the design of buildings and structures shall be the greatest load produced by the intended use and occupancy, but not less than the minimum uniformly distributed unit loads required in Section 706.0 for specific uses.

Appendix A

800.6 Used materials and equipment: Used materials, equipment and devices which meet the minimum requirements of this code for new materials materials, equipment and devices shall be permitted; the building official may require satisfactory proof that such materials, equipment and devices have been reconditioned, tested, and/or placed in good and proper working condition prior to approval.

800.7 Equivalent materials or systems: Materials or systems which are subjected to tests determined by the Commission to be equivalent to those tests required by this code shall be accepted as meeting the requirements of this code.

SECTION 801.0 BASIC CLASSIFICATION OF CONSTRUCTION MATERIALS

801.1 General: All materials and methods used in the design and construction of buildings and structures shall be classified as controlled materials and ordinary materials as defined in Sections 201.0 and 719.0. The design and construction shall be based on the assumptions, limitations, and methods of stress determination of recognized design procedures.

SECTION 802.0 TESTS

802.1 Test standards: All structural units and assemblies shall be tested in accordance with the standards listed in Appendices D, E and F. In the absence of test procedures governing any specific material or method of construction, the building official shall accept authenticated reports from recognized authoritative sources which meet the requirements of this code.

802.2 Strength tests: To determine the safe uniformly distributed working load, when not capable of design by accepted engineering analysis, or to check the adequacy of the structural design of an assembly when there is reasonable doubt as to its strength or stability, every system of construction, sub-assembly or assembled unit and its connections shall be subjected to strength tests prescribed in this code, or to such other tests acceptable to the building official that simulate the loads and conditions of application that the completed structure will be subjected to in normal use. Structural load determinations shall include transverse floor and roof, wall compression and racking, concentrated load, plaster bond, puncture penetration and soil tests.

802.2.1 Strength tests for glass: The working strength of glass for any location in which it is required to withstand wind or impact loads shall be determined according to the following design procedure and criteria:

1. Design for wind loads by Section 857.5.4.

2. Design for impact loads of fully tempered, laminated and wired glass

shall comply with the requirements of the standard listed in Appendix B.

802.3 Deleted

802.4 Deleted

802.5 Performance test: Whenever there is sufficient evidence that the stability or structural safety of a completed building or structure or part thereof is inadequate for the intended use, the building official may require a load test of the building unit or portion of the structure in question. Such existing structure shall be subjected to a superimposed load equal to two (2) times the design live load. The test load shall be left in place for a period of twenty-four (24) hours. If during the test, or upon removal of the test load, the structure shows evidence of failure, the building official shall order such reinforcement or modifications deemed necessary to insure adequacy of the structure for the rated capacity; or in lieu thereof, he may specify a reduced working load to which the structure shall be limited. The structure shall be considered to have successfully met the test requirements if the total deflection does not exceed the theoretical deflection computed by accepted engineering formulae. When the total deflection is greater than such theoretical value, the structure shall be considered safe for the design load, if it recovers seventy-five (75) per cent of the maximum deflection within twenty-four (24) hours after removal of the test load.

802.6 Tests of service equipment and devices: Tests of service equipment and accessories shall include proscenium curtain and stage ventilation, Section 417.7; structural load tests, Section 702.0; flues and chimneys, Section 1002.0; boilers, the mechanical code listed in Appendix B; electric installations, Article 15; moving stairways, elevator interlocks and safety devices, Article 16; refrigerating equipment, and other mechanical and plumbing systems and devices as required by the mechanical code and the plumbing code listed in Appendix B and all other service tests required by the approved rules.

802.7 Fire tests: In the determination of flash points, combustibility, flameresistance and fireresistance rating of construction materials and methods, all tests shall be conducted in conformity to Sections 902.0, 903.0 and 904.0 and the applicable standards listed in Appendices G and I.

802.8 Prefabricated construction tests: Prefabricated assemblies or sub-assemblies not capable of design by accepted engineering analysis, shall meet all the requirements and tests for at-site construction. The floor panels and other prefabricated units shall be assembled to form an integrated test specimen constructed as in practice, of not less than three (3) units in width with two (2) longitudinal joints; and when designed on the assumption of a simple span, such units shall be tested with flat end supports.

802.9 Test specimens: The selection and construction of all test specimens and the details of test procedure herein required shall conform to the recognized test procedures listed in the appendices. All test specimens and constructions shall be truly representative of the materials, workmanship and details to be normally applied in practice.

Note: Test procedures. Test requirements constitute fundamental performance standards and therefore come within the scope of this code. The detail test specifications and procedures are formulated and defined in the approved rules or by reference to accepted test standards of authoritative test agencies and organizations. Details of test procedures have been omitted from this code, except for essential basic requirements when deemed necessary.

SECTION 803.0 CONDITIONS OF ACCEPTANCE

803.1 General: In evaluating the physical properties of materials and methods of construction when not subject to design by accepted engineering analysis, the structural requirements shall be based on the criteria established by the provisions of the following Sections 803.2 through 803.7.

803.2 Test load factor

803.2.1 Loading: The test specimen shall sustain for a period of twenty-four (24) hours, without visible damage other than hairline cracks, its own weight, plus a superimposed test load equal to the dead load to be added at the site plus one hundred fifty (150) per cent of the design live load.

803.2.2 Allowed deflection: After completion of the test required by Section 803.2.1 and removal of all superimposed loads, the recovery of deflection within twenty-four (24) hours shall be at least seventy-five (75) per cent of the deflection due to the superimposed loads.

803.2.3 Failure loading: The test specimen shall sustain without collapse its own weight, plus a superimposed test load equal to fifty (50) per cent of its weight plus one hundred fifty (150) per cent of the dead load to be added at the site, plus two hundred fifty (250) per cent of the design live load.

803.3 Working load deflection: Under the approved working load, the deflection of floor and roof assemblies shall not be greater than one three-hundred-sixtieth (1/360) of the span for plastered construction; one two-hundred-fortieth (1/240) of the span for unplastered floor construction; and one one-hundred-eightieth (1/180) of the span for unplastered roof construction.

803.4 Wall and partition assemblies: Bearing wall and partition assemblies shall sustain the load test both with and without window framing.

PMET Protze Materials Engineering & Testing Company
36 JACONNET STREET, NEWTON HIGHLANDS, MA 02161 (617) 332-8460
RD9, BOX 610, OLD ROUTE 66, GREENSBURG, PA 15601 (412) 837-5030

March 1, 1988

LeMessurier Consultants
1033 Massachusetts Avenue
Cambridge, Massachusetts 02238

Att: Mr. John Coote

Re: Load Test of Circular Stairway
Old State House, Boston, Mass.

Gentlemen:

On Feburary 22, 23 and 24, 1988 we performed a proof-loading-test on the circular wooden stairway between the Entrance Leval and the floor above (Council Chamber Level) involving 18 stair treads as shown in drawings supplied by you, entitled "Floor, 2nd Stage-Tower" (an elevation), "First Floor Plan" and "Second Floor Plan". The work was carried out in general conformity with the LeMessurier File No. 87137 memorandum regarding the site meeting of February 17, 1988 and the Goody Clancy letter of January 26, 1988 addressed to the National Park Service.

Shores were installed under the stair soffit at the middle of the stair rise and at the upper landing. They were a self-supported system under, but not quite touching the stair soffit, close enough that if the stair were to subside excessively under load, blocking or wedges could be installed to arrest the trend. The lower first floor landing was shored to prevent any deflection at that location, which became the zero reference.

Ames dial gages reading directly on 0.001" were installed to measure deflection of the stair under successive increments of load and then to measure recovery from maximum deflections after unloading. The gages were located as follows:

- No. 1 Mid-length of outside stringer of stair perpendicular to slope of the soffit at that point to measure deflection in that perpendicular direction.
- No. 2 Same location, parallel with slope of the soffit, to measure movement in that direction. Soffit slope 16° with horizontal.
- No. 3 Mid-length of the inside stringer of the stair in vertical direction to measure downward deflection.
- No. 4 Same location, horizontal, to measure lateral movement in that direction.
- No. 5 On ceiling at upper end of stair near inside stringer anchorage, to measure vertical deflection of second floor landing.
- No. 6 Ditto near outside stringer.

Flat steel weights approximately 1¼ x 9 x 18" in size weighing approximately 55 pounds each were used to load the stairs. (The actual average weight of the pieces was 56.6 pounds, as determined by weighing random units.)

The test load was applied in essentially three equal increments and finally totaled 7640 lbs. (or approximately 425 lbs. on each tread). The loads were arranged so that 2/3 of the plates were on the wide part (outside) of the tread and approximately 1/3 of the plates were on the narrow (inside) part of each tread. There were a few minor variations to accommodate the averaging each test increment.

The Ames Indicator gages were read at zero load, before and after placement of each increment with approximately an hour wait between loadings. Full load readings were recorded hourly after full load to 7:00PM then resumed at 7:00AM until end of 24 hours under full load application. At this time the stairs were unloaded and rebound readings were taken immediately and one hour later. The test was terminated with consent of the Engineer when all gages indicated more than 75% recovery from total deflections. The tabulation of gage readings and deflections is presented herewith.

The stair facias, the soffit of the stair and the upper ceiling were examined before and during the test with the following observations noted:

Start of Test	No visible cracks.
2/3 Load	No visible distress.
Full load on 3 Hrs	Cracks in soffit at upper end of stair. Ends of cracks were marked. Spalled plaster at lower end of stair, inside stringer landing and indication of strain in stringer facia.
Full load on 5 Hrs	Two more cracks in plaster at upper end; show displacement in the plane of the soffit.
Full load on 18 Hrs	No further cracks. Cracks at upper end extended moderately in length.
End of Test	A previously unnoticed void seen in soffit between newel post and outer stringer after shore braces were removed.

The test was successful showing at least 75% recovery at all gages in all directions. The following photographs will clarify the test procedure.

The actual physical test was under the direction of the writer. A.J. Conti Inc., and Staff installed bracing, cribbing, supports, etc., and applied the loads. Herman G. Protze checked the test procedure and readings at three intervals. Messrs. Coote, Banning, Tolbert and Others visited the test regularly.

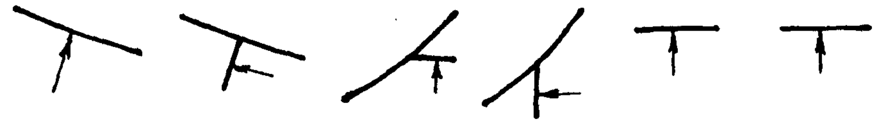
Yours very truly,

Edgar S. Van Buren

Ref. No. 88C-413

Edgar S. Van Buren, P.E.

5-LeM



Date & Time	Elapsed Hours	°F	Load	#1 Out ⊥ Slope	#2 Out ∥ Slope	#3 In Vertical	#4 In Horiz	#5 In Top Ceil	#6 Out Top Ceil
				Dial Readings in Inches *					
2/23 10:30A	Zero	70	Zero	0.000	0.000	0.000	0.000	0.000	0.000
10:50	0:20	70	1/3	.100	.110	.089	.112	.014	.027
11:45	0:55	72	"	.100	.109	.091	.110	.014	.028
12:10P	0:25	72	2/3	.203	.236	.188	.235	.039	.056
12:40	0:30	72	"	.206	.239	.190	.240	.038	.056
1:00	0:20	71	Full	.347	.363	.314	.310	.085	.089
2:10	1:10	71	"	.356	.371	.322	.320	.085	.091
3:00	2:00	71	"	.362	.379	.326	.323	.084	.090
3:20	2:20	71	"	.364	.379	-	-	-	-
4:10	3:10	70	"	.374	.384	.336	.275	.087	.090
5:00	4:00	70	"	.373	.384	.339	.270	.086	.090
6:00	5:00	72	"	.372	.386	.341	.270	.087	.090
7:00	6:00	71	"	.372	.403	.346	.285	.086	.090
2/24 7:00A	18:00	70	"	.372	.419	.351	.310	.076	.082
8:00	19:00	70	"	.374	.419	.351	.318	.076	.081
9:00	20:00	72	"	.384	.424	.356	.330	.077	.082
11:30	22:30	70	"	.382	.433	.360	.322	.077	.082
12:00N	23:00	70	"	.381	.434	.359	.328	.076	.081
1:00P	24:00	70	"	.384	.436	.360	.329	.075	.080
1:30	0:30	68	Zero	.053	.109	.067	.040	+.013	+.005
2:30	1:00	71	"	.052	.103	.059	.027	+.012	+.005
Rebound from Maximum				87%	76%	84%	92%	114%	106%

* #1 Dial on "outside of Spiral" at midspan reads movement perpendicular to slope
#2 " " " " " " " " " parallel with slope
#3 " " inside " " " " " vertical movement
#4 " " " " " " " " horizontal movement
#5 " " ceiling at top step is near inside of spiral
#6 " " " " " " " " outside of spiral

PHOTO A

Stairway on Entrance Level
Showing Full Load Applied
Left is designated "Outside"
Right is designated "Inside"
#5 Dial shown at Ceiling

PHOTO B

Stairway Looking Down
Showing Full Load Applied

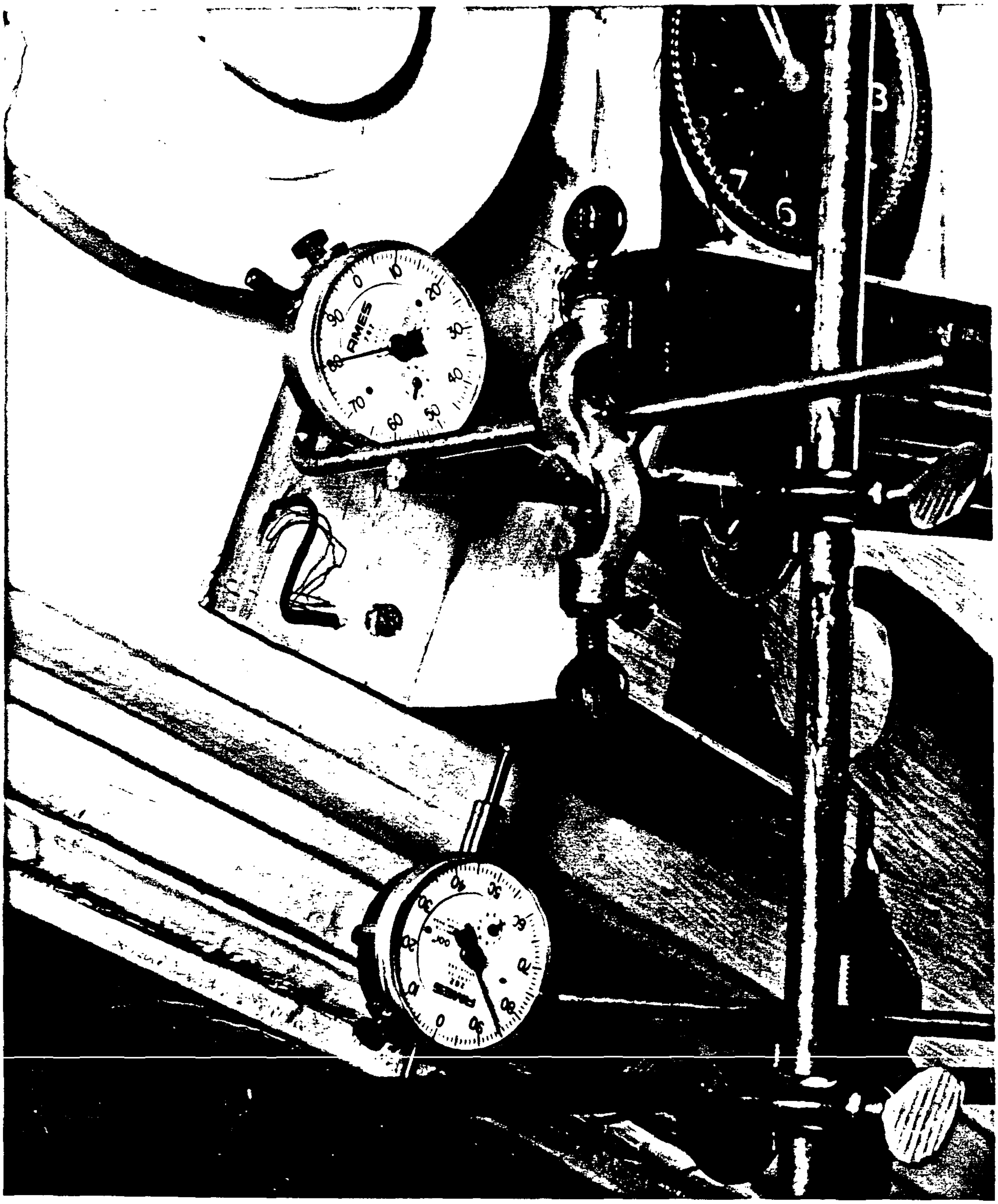


PHOTO C

Dial #1 $\perp$ to Slope
Dial #2 $\parallel$ with Slope
Soffit Slope 16° with Hor.

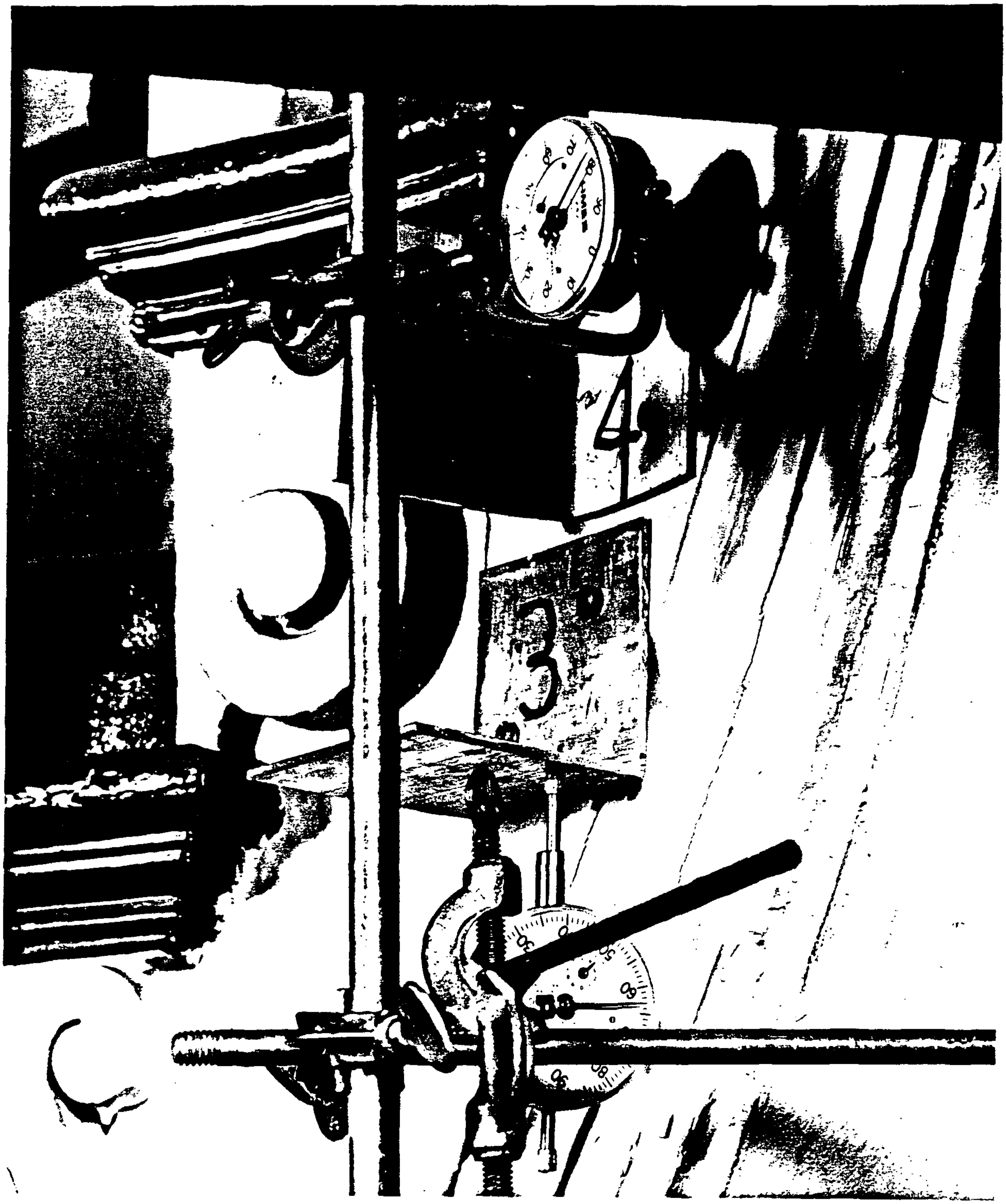


PHOTO D

Dial #3 Vertical
Dial #4 Horizontal

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