

**CONDITION SURVEY**

for

**SEARS TOWER  
HARVARD COLLEGE OBSERVATORY  
CAMBRIDGE, MASSACHUSETTS**

**Prepared for:**

**HARVARD COLLEGE OBSERVATORY  
60 GARDEN STREET  
CAMBRIDGE, MASSACHUSETTS**

**May 1990  
Project #5334**



**BRIGGS**

**CONDITION SURVEY  
SEARS TOWER  
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**Introduction**

In April of 1990, Briggs Associates, Inc. performed a Condition Survey of the Sears Tower, including adjacent building sections, at the Harvard College Observatory in Cambridge, Massachusetts. The Survey was performed to ascertain the existing conditions of the following building components:

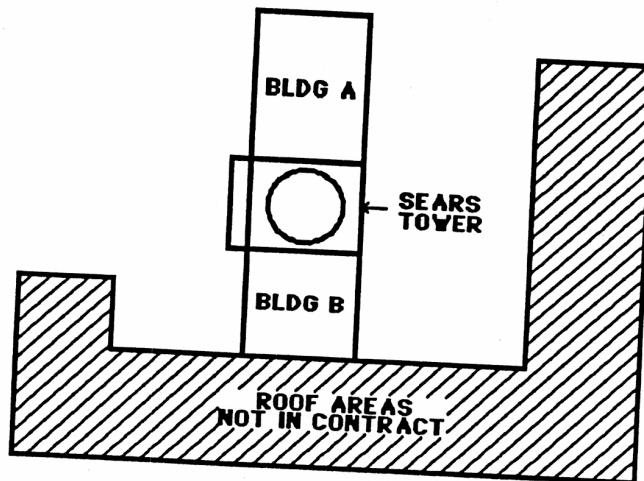
- 1) Roofing systems, including copper and built up roofing.
- 2) Exterior walls, including masonry veneers and window systems.
- 3) Sears Tower floors.

All above components were inspected where accessible. Available building plans were reviewed and structural analyses performed of structural floor components. Also, test cut samples were extracted from the existing built up roof systems to determine system composition.

Recommendations on repair and/or replacement priorities, including cost estimates will be offered. Photographic documentation of observed deficiencies is included.

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The following is a sketch of the observatory complex with the three surveyed building sections referenced as noted:



**ROOF SYSTEMS**

The existing roof systems on the three building sections vary from traditional tar and gravel roofing on the A Building, to flat seamed copper roofing on the dome. The following are descriptions of the existing roof systems:

**A Building**

The existing roof system on this building is a traditional tar and gravel roof and appears to be the building's original roof (constructed in 1954). The roof membrane and bituminous flashings are in very poor condition. The tar and gravel roof membrane is severely blistered with numerous holes and splits noted throughout the roof area.

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The extraction of a roof test cut sample revealed the roof's composition to be a 4 ply, tar and gravel roof membrane over one inch of wood fiberboard on a wood deck. A one ply vapor barrier exists between the wood roof deck and fiberboard insulation. The roof membrane is brittle and worn.

The existing bituminous flashings are also in very poor condition. Several splits exist in the bituminous strip flashings used to flash the flange of the lead coated copper gravel stop to the roof membrane, particularly at the gravel stop joints. Also, the gravel stop was not secured with a concealed hook strip; therefore, the gravel stop is loose and prone to wind damage.

Also, of note is the presence of debris from adjacent trees on the roof. This debris appears to be clogging the existing roof drains. It is important that all roofs be periodically inspected and the drains cleaned.

**Sears Tower**

The existing roof systems on the existing dome and the adjacent peaked roof are flat seamed copper roofs. This building section was constructed circa 1846. The existing roofs do not appear to be the building's original roofs. Both roof sections were surfaced with what appears to be an elastomeric, patina green, coating.

Inspection of the dome and adjacent peaked roof revealed the two roof areas to be in varying conditions. The smaller peaked roof at the rear of the building is generally in worn but functional condition. This roof section is not leaking at this time. Two items worth noting, are the conditions of the masonry chimney and the wood cornice work at the roof eaves. Several bricks are missing at the chimney cap and the paint on the exposed wood cornice is peeling thus exposing sections of the wood.

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The condition of the dome roof system varies from worn but functional at the dome portion of the roof to poor at the shelf portion (i.e., water table). The dome's water table encompasses the entire dome and includes a copper gutter to accommodate roof run off. The section of the watertable's cornice adjacent to the B Building's roof is underpinned with wood supports. The wood decking, fascias, and cornice work in this area is severely deteriorated, apparently resulting from water penetration into the water table and/or gutter. It is impossible to determine the condition of structural wood components of the shelf until the the copper roofing and flashing are removed. However, it does appear that the structure is salvageable and the severe deterioration restricted to the wood decking, fascia and cornice work.

The gutter in this area is severely deteriorated with several detached and missing support straps. The gutter seams are also in poor condition and in some cases open to water penetration. Also, all of the existing gutter downspouts are in poor condition.

According to present building maintenance personnel, a severe leak exists at the dome's retractable door. Inspection of the door revealed several past repairs to the door's flashing. The existing flashing materials are delaminating from the door and several holes and splits exist. Also, the door's running track and associated mechanisms are severely rusted.

**B Building**

The existing roof system on this building is a gravel surfaced, asphalt, built up roof and appears to be the building's original roof (constructed in 1954). The roof membrane is generally in a worn but functional condition with a few blisters and areas of exposed felts.

The roof's bituminous base flashings are generally in poor condition. Several splits exist and the several sections of the flashings are severely deteriorated.

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Inspection of the building's interior revealed a severe roof leak in the stairwell between the B Building and Sears Tower directly under an access door and adjacent exterior stairwell where the B Building abuts the Sears Tower. The wood blocking at the perimeter of the exterior stairwell is exposed and severely deteriorated and the stairwell's drain clogged with debris. Also, the door requires repainting and the installation of weatherstripping at the door's base.

It is difficult to ascertain the source of the existing leak however it appears to be related to the aforementioned exterior stairwell deficiencies.

In addition to the built up roofing on this building, sun screens exist at window head locations along the rear of the building. Fully adhered PVC (polyvinylchloride) roofing exists on the top floor's sun screen with gravel surfaced built up roofing on the second floors' sun screen and stone ballasted PVC on the first floor's sunscreen. The PVC roof membrane and flashings are in satisfactory condition and the built up roof is generally in a worn condition.

**EXTERIOR WALLS**

The exterior walls consist of brick veneer with various types of window styles. In general the brick veneer appears to be in satisfactory condition as no signs of structural duress or settlement were discovered.

The brick is painted at the Sears Tower portion of the complex and unpainted at the A and B Buildings. A few deficient mortar joints were noted and sections of the brick veneer underlying the steel balcony on the Sears Tower are rust stained.

The conditions of the existing windows vary. The wooden double hung windows at the Sears Tower are in poor condition. The paint surfacing is peeling and sections of the wood are deteriorated.

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The windows on the remaining building sections are metal framed fixed and projected units. The following deficiencies were noted:

- 1) The paint on the window frames is peeling and generally in poor condition at the A Building.
- 2) The conditions of the existing window putty varies. Several windows appear to have received new putty recently with the putty being in poor condition in areas not addressed.
- 3) The steel lintels at the B Building are rusted.

**FLOORS - SEARS TOWER**

The floor joists supporting the main floor appear to be full sized 2 x 10 members which span approximately 9 feet from the exterior walls radially to the granite block column. The ends of the joists rest in irregular pockets in the brick and against the granite column. Diagonal members span from the brick wall to approximately midspan of the first floor joists. The ends of the braces are set into a bird-mouth cut into the lower edge of the joists. The area directly below this floor is devoted to mechanical and electrical equipment, including steam and water supply pipes. Electrical conduit is hung in random patterns from the joists and braces.

The observatory floor joists span approximately 10 feet from the exterior walls to the granite column and appear to be full sized 2 x 10 members. The joists are approximately 2.5 feet on center at the exterior wall. No bridging was observed between joists. A plaster dome ceiling in the first floor lobby is suspended on diagonal braces and form-fit wood supports under framing.

The wood structural members supporting the observatory and first floor appear to be dried out and many joists have longitudinal cracks at mid-depth extending most of the length. The pockets at the exterior brick walls are irregular and offer poor support for the ends of the joists. Some joists were observed to be supported on less than 1 inch of masonry at the exterior and interior supports.

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The first floor has notches cut at mid-span to accommodate a tie in brace. This notch is detrimental to the strength of the member as it concentrated the stress and causes horizontal cracks to develop at the cut. Few or no nails were observed at these connections. It appears that many of the braces have twisted or split at this location, indicating high stress levels in these members. Many of the diagonal braces are founded on wood beams spanning approximately 8 feet across pockets in the walls of the building. These beams are split and cracked and appear to be dried out. Some of the braces are loosely founded on the beams thus providing little support for the overlying joists.

The floor joists have been subjected to steam and water damage caused by breaks and leaks in many of the supported pipes. The extent of the damage is unknown, but some of the joists and braces have visible areas of rot. In addition, shrinkage of the members was observed with many joints and gaps visible.

The first floor sheathing is loose and buckling in many areas, and the underlying sub floor appears to be soft and unsecured. Although the floor structure appears to generally be in satisfactory condition, many areas require repairs.

The observatory floor near the east door has several areas of loose flooring and deteriorated subfloor, apparently resulting from leakage at the exterior stairwell addressed in the roofing section of this report. The flooring appears to be warped and buckled in several other areas as well, apparently the result of leaks in the observatory dome roof.

The plaster dome ceiling in the first floor lobby was observed to be cracked in several areas apparently the result of water damage. Many of the cracks have been repaired. Because the ceiling has been painted black, the extent of the ceiling damage is unknown.

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The capacities of various members was calculated to determine if major strengthening of the floors is necessary to accommodate floor loading as required by the Massachusetts State Building Code. It was found that the floor joists appear to be able to support live loads of approximately 100 pounds per square foot, assuming that all joints were tight and that the members were not split or twisted. Since many of the members are founded on irregular bearings and are split, the actual live load capacity of the floors may be less than 100 pounds per foot.

In addition, the calculations do not take into account the effect of vibrations on supported members such as the dome ceiling in the first floor. Repairs/modifications are necessary to restore the integrity of the floor structure.

**RECOMMENDATIONS**

The Sears Tower and adjacent building sections require several repairs and/or replacements of various building envelope and structural floor components. The following items should be addressed:

**Roof Systems :**

**A Building**

The existing tar and gravel roof system is in poor condition and should be removed and replaced. It is this firm's opinion that a fully adhered PVC roof system (manufactured by Sarnafil) or a fully adhered EPDM (ethylene propylene diene monomer) roof system (manufactured by Carlisle, Firestone or equal) with new roof insulation, metal flashings, wood work, etc. be installed when reroofing is initiated. The estimated cost of reroofing this building section is approximately \$26,000.00.

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The following two items should be noted:

- 1) The removal of the existing roof top structural steel should be performed at the time of reroofing if the structure is no longer necessary.
- 2) The installation of a ladder from the adjacent copper roof to the A Building roof should be considered as access to the A Building roof is limited.

**Sears Tower**

The peaked roof is generally in satisfactory condition and can be expected to remain functional for a minimum of 3 - 7 years if it is properly maintained; however, the existing chimney should be repaired and the cornice repainted. The estimated cost of these two items is approximately \$3,500.00.

The dome roof and underlying watertable are in varying conditions. At a minimum the existing copper flashing and gutters at the water table and all deteriorated wood as well as the retractable door's cover should be removed and replaced with new matching materials. It is difficult to estimate an accurate cost for these items as the extent of deteriorated wood is unknown; however these costs may exceed \$35,000.00.

Replacement of the dome roof in conjunction with the water table should be considered. Replacement of the water table alone will require removal of all existing surfacing on the dome with the entire roof and water table recoated in order to maintain a constant color thus adding an additional \$10,000.00 to the cost of the work. Replacement of the water table without addressing the dome will result in the new copper of the water table contrasting with the existing patina green colored dome.

Replacement of the entire dome roof (including a new door cover) and the water table with new cold rolled copper materials will cost approximately \$65,000.00.

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In addition to the roof replacement, all necessary door frame and mechanism repairs and/or replacements which must be performed from the exterior should be addressed at that time.

**B Building**

The existing roof is in a worn but functional condition; however, the following items should be addressed in the immediate future.

1. Repair all edge and base flashing deficiencies.
2. Replace deteriorated wood and install new replacement flashing, repaint door, install weatherstripping, and clean drain at exterior stairwell.

The estimated cost of the above repairs is approximately \$5,000.00. Replacement of this roof should be considered if funding is available (approximate replacement cost of \$22,000.00), as the existing roof may require replacement within the next two (2) to four (4) years.

**EXTERIOR WALLS**

In general, the exterior walls are in satisfactory condition; however, the following items should be addressed in the near future:

1. Replacement of existing wooden windows at Sears Tower with new matching wooden windows.
2. Scrape, prime, and paint all window frames at A Building.
3. Removal of all defective window putty and replace with new glazing materials.
4. Scrape prime and paint all rusted window lintels at B Building.
5. Scrape, prime and paint balcony Sears Tower.

The estimated cost of the above items is approximately \$35,000.00. This is broken down as follows - A Building - \$18,000.00; B Building - \$12,000.00; Sears Tower - \$5,000.00.

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**FLOORS - SEARS TOWER**

The following miscellaneous repairs are recommended:

- 1) The wood structural members supporting the first and observatory floors must be reinforced with steel gusset plates such as those used on new wood trusses. These plates will maintain the members and provide a more positive load transfer. Add new joists next to severely cracked members to provide a stiffer floor system. The flooring and subflooring should be removed to provide access to the floor sheathing to allow an assessment of the condition of the top surface of the structure. Removal of all vinyl asbestos tile shall be in accordance with Massachusetts 453 CMR 6.0. A new layer of plywood tightly screwed and glued to the existing floor structure will add significant strength and stiffness to the structure. The replacement flooring should be consistent with the flooring used at the time of the building's construction (i.e., oak flooring)
- 2) Provide wood blocking under the ends of the joists to provide positive support for the joists. Use chemical anchors or expansion bolts to secure the wood to the granite or brick walls. Wedge the joists tightly against the new supports. Because of the curvature of the walls, separate members should be used for each 3 or 4 joists so that the gap between the blocking and the walls does not exceed 1 to 2 inches. Use wedges to close these gaps at the bolt locations.
- 3) Provide additional hangers and supports for the plaster dome ceiling in the first floor lobby. Provide new diagonal braces to stiffen the joists and prevent the deflection of the floor system from cracking the ceiling. After installing the new members, replaster and repaint the ceiling.
- 4) Provide steel angles to support the wood beams spanning across the pockets in the exterior walls. Securely wedge the steel angles to provide contact. Use lag screws to connect the wood braces to the beams. Provide wedges where necessary to close all gaps.

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5. Provide bridging between all joists at midspan. In addition, provide solid blocking between the ends of the joists.

The estimated cost of the aforementioned items is approximately \$35,000.00.

**COST ESTIMATE SUMMARY**

**Roofs**

**A. Buildings - Roof Replacement** **\$26,000.00**

**Sears Tower -**

**Peaked Roof Chimney/Cornice Repairs** **\$3,500.00**

**Watertable Replacement**

**\$35,000.00**

**Recoating Dome Watertable**

**\$10,000.00**

**or**

**Replace Dome and Watertable**

**\$65,000.00**

**Building B -**

**Repairs** **\$5,000.00**

**or**

**Replacement**

**\$22,000.00**

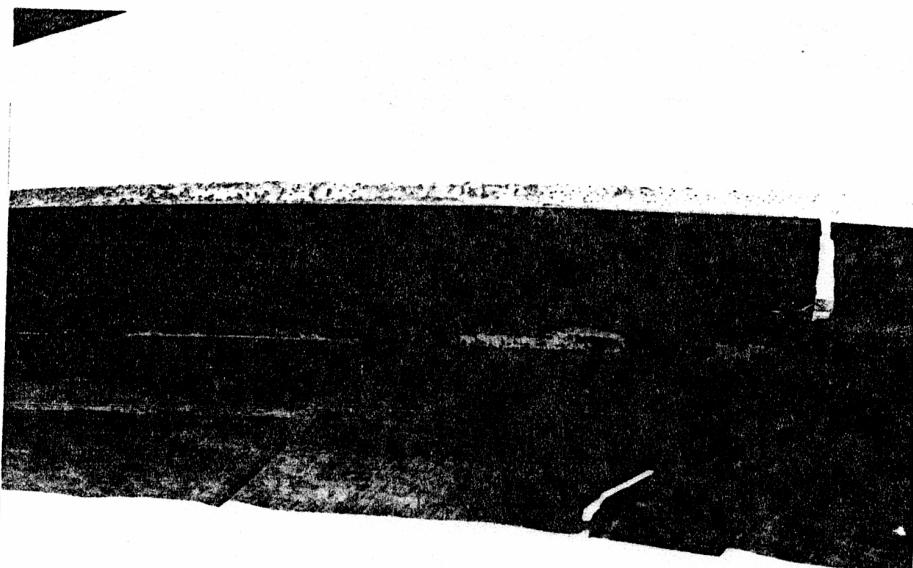
**Exterior Walls**

**Miscellaneous Repairs/Replacements** **\$35,000.00**

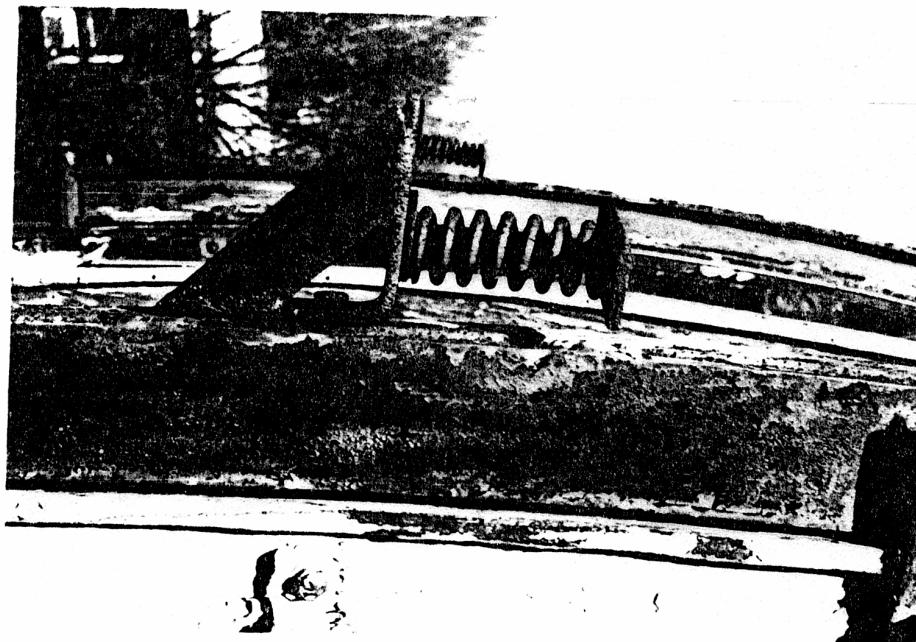
**Floors - Sears Tower**

**\$35,000.00**

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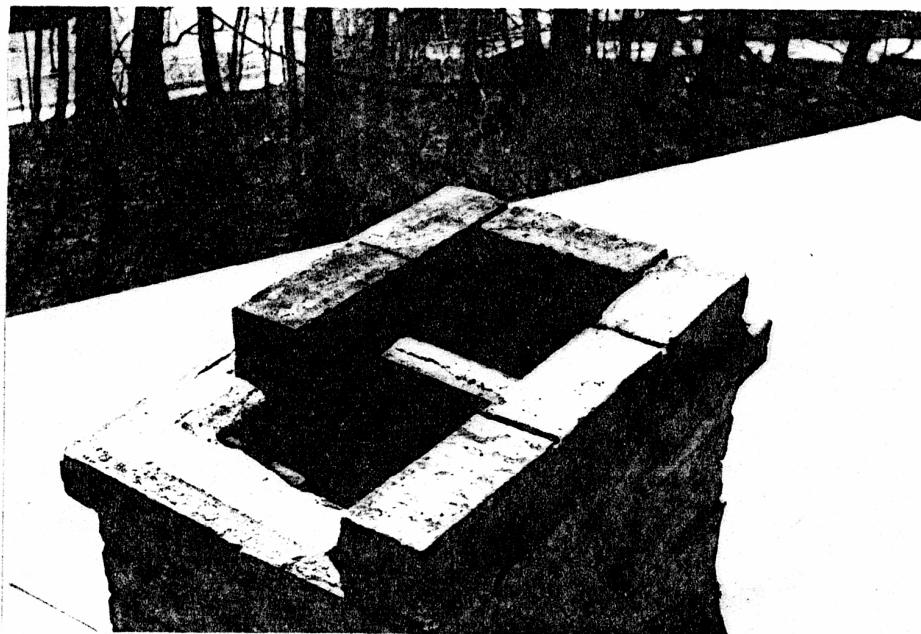


**Rusted I Beam Running Track for Dome's Retractable Door**

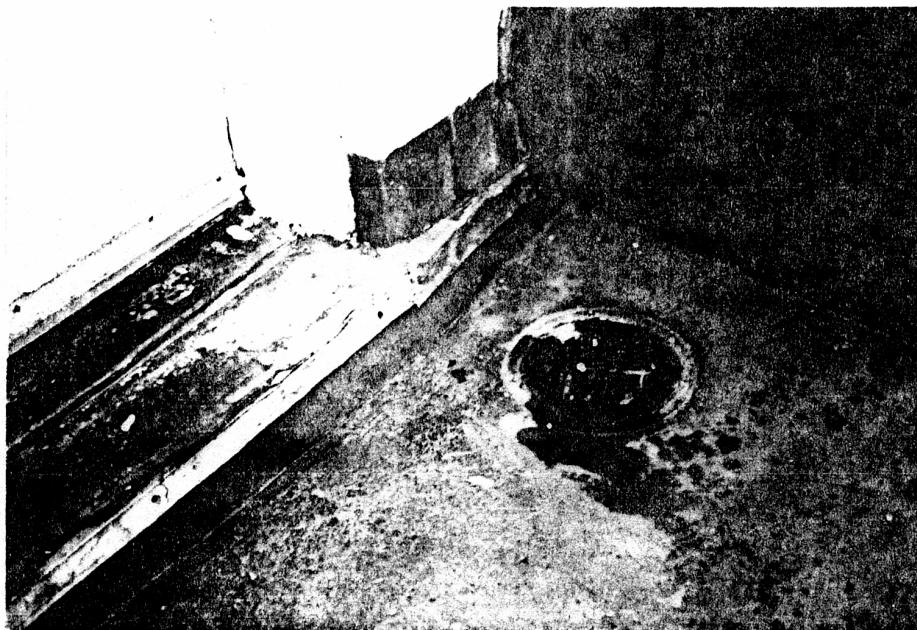


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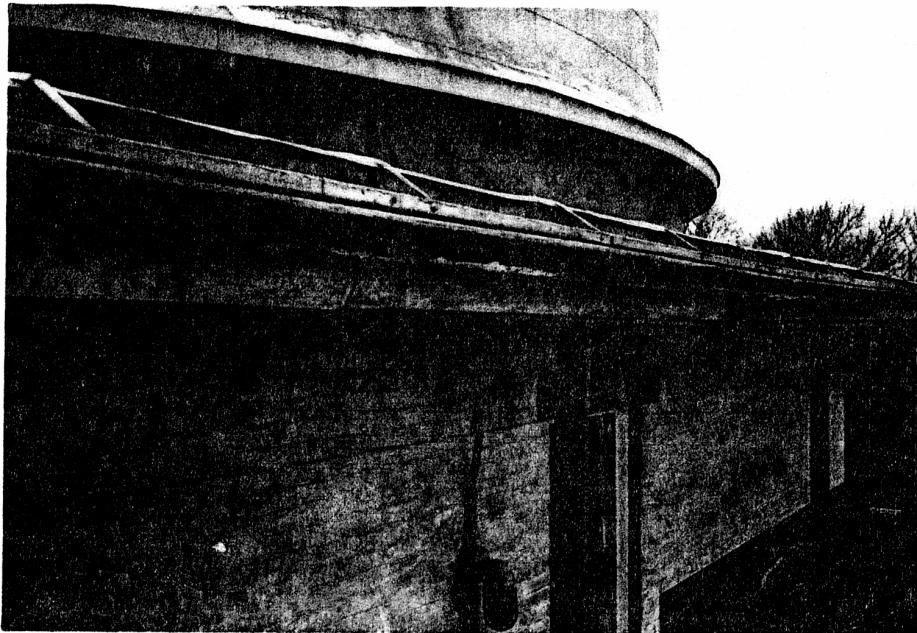


**Missing Bricks at Chimney on Small Copper Roof  
Adjacent to Dome Roof**

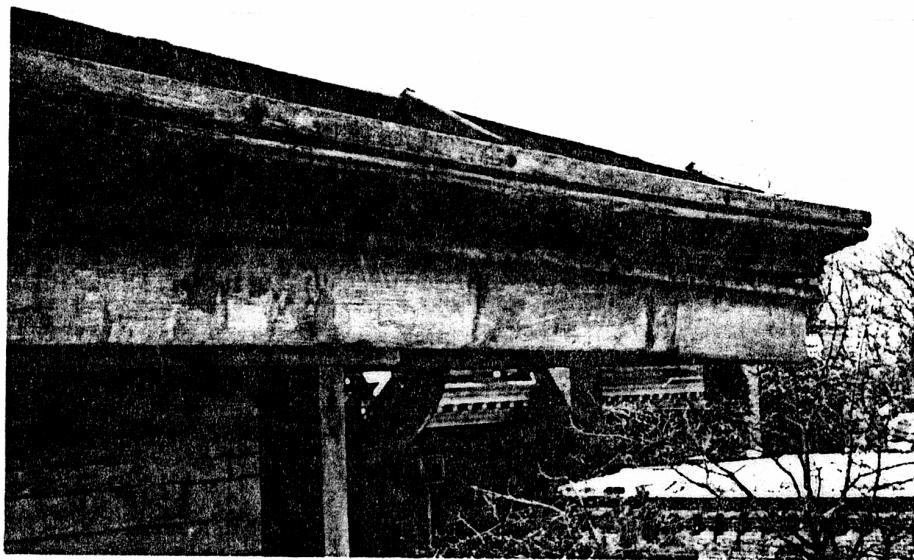


**Clogged Drain at Roof Top Stairwell**

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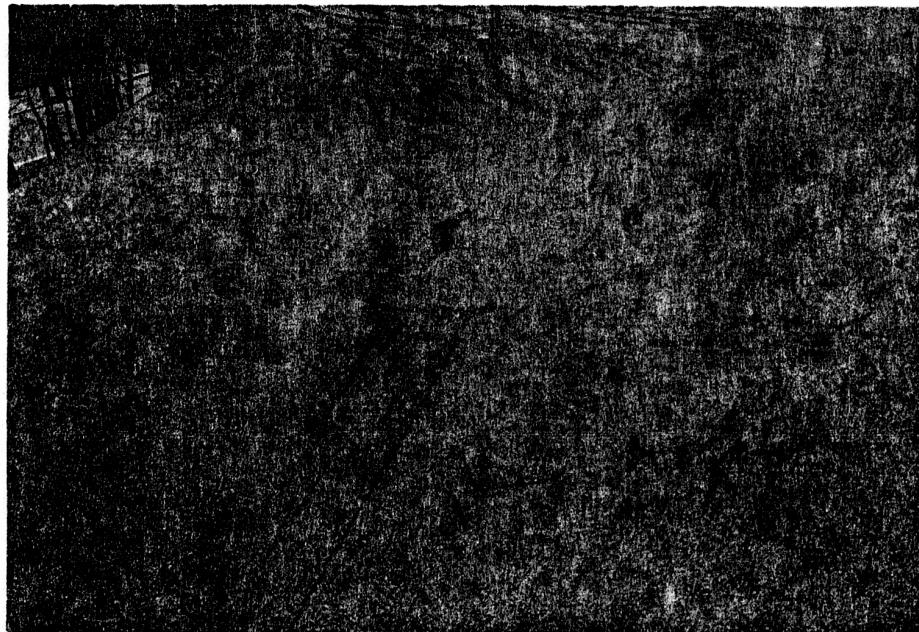


**Severely Deteriorated Gutter and Cornice at Dome Eave**

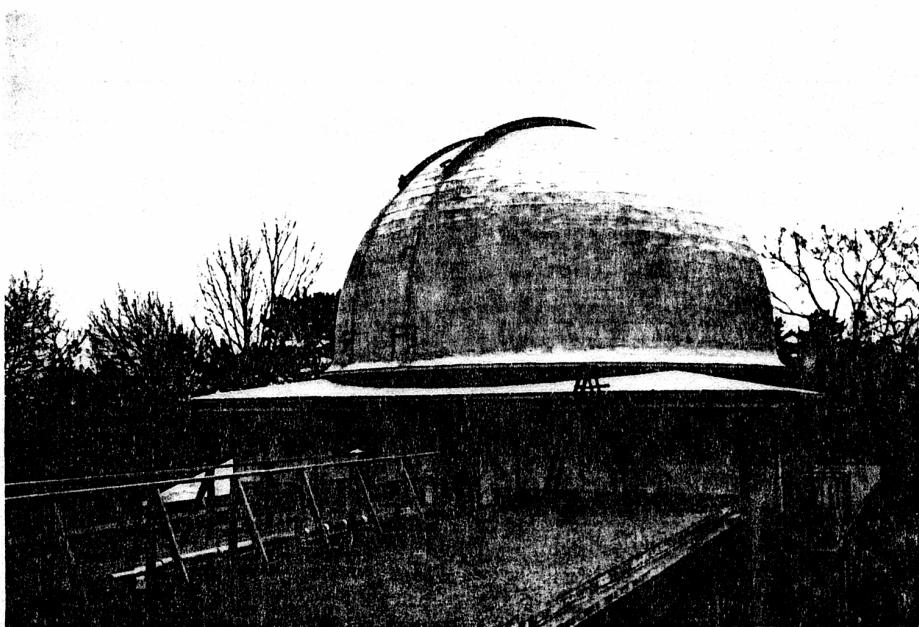


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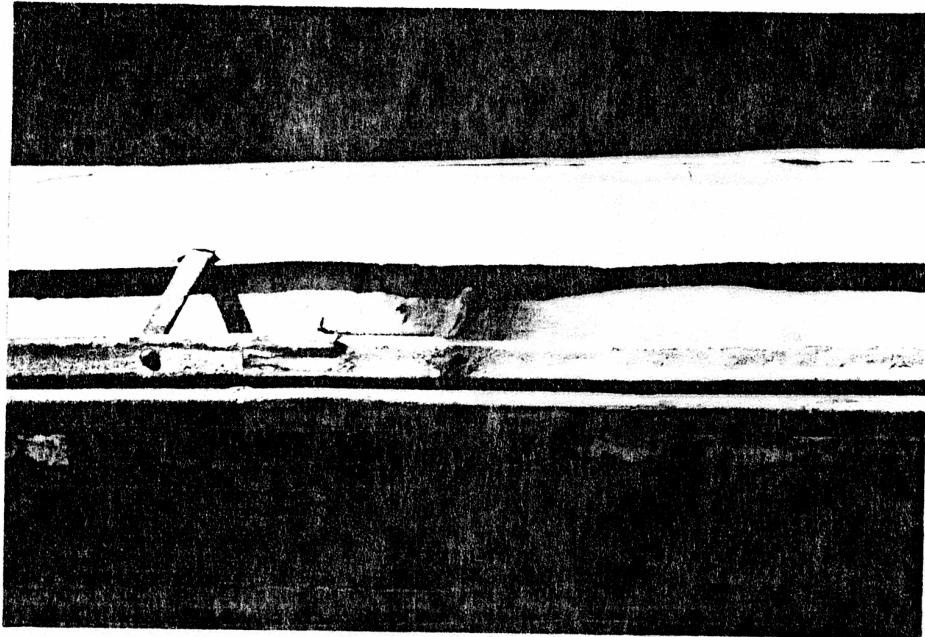


**Severely Blistered Roof at A Building**

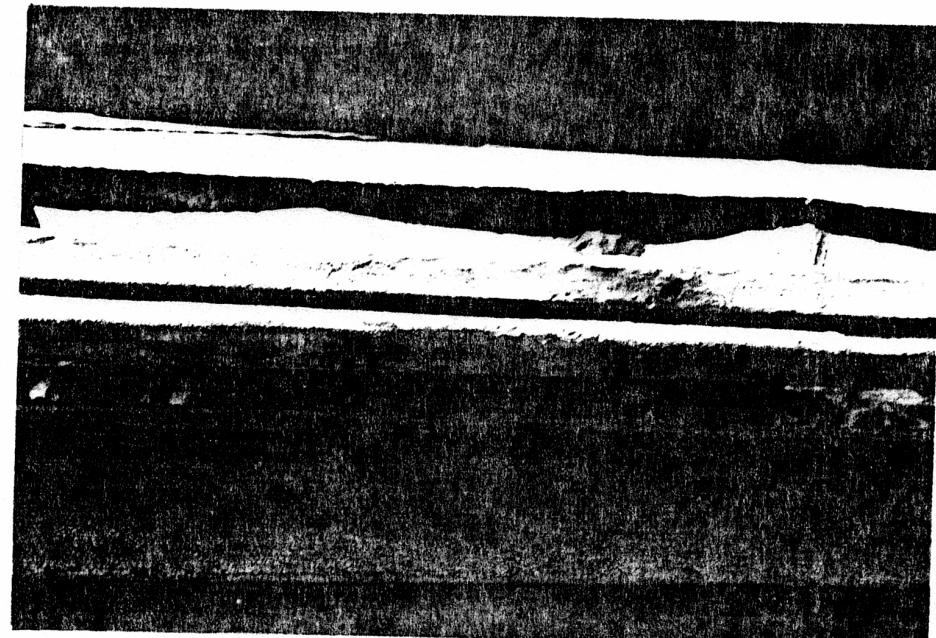


**Section of Dome Cornice Underpinned to Prevent Collapse**

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**Severely Deteriorated Gutter and Cornice at Dome Eave**



**Severely Deteriorated Gutter and Cornice at Dome Eave**



**Repairs at Dome's Retractable Door**  
**Note: Delamination of Door Flashing**



**Repairs at Dome's Retractable Door**