EXTERIOR MASONRY CLEANING AT SAINT THOMAS CHURCH NEW YORK, NEW YORK

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ABSTRACT

Saint Thomas Church, at 5th Avenue and 53rd Street, New York, New York, was designed by the prominent architectural firm Cram, Goodhue and Ferguson in 1914. The church is constructed primarily of Bowling Green (Kentucky) limestone in the Gothic style popular at the turn of the century. Because the presence of dark-colored soiling and residues of old "preservative" treatments marred its otherwise imposing appearance, exterior restoration was recently undertaken. An investigation of conditions was begun in April 1986.

According to church records, past preservation treatments have included application of a fluorosilicate solution (1928-1929) and of a polyester sealer (early 1970's). On-site inspection and laboratory examination of materials were used to determine the areas in which those treatments survived. Because conditions varied from location to location, chemical cleaning as well as water wash methods were recommended. Specifications for full-scale cleaning operations were based on the results of on-site tests executed in several locations. Restoration of the original appearance of exterior stonework at Saint Thomas Church is expected to be completed in the Spring of 1987.

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INTRODUCTION

Saint Thomas Church, at 5th Avenue and 53rd Street, New York, New York, was designed by the prominent architectural firm Cram, Goodhue and Ferguson Architects in 1914. Its Gothic style was popular for ecclesiastical architecture at the turn of the century. The church has an assymetrical form with a main tower at the corner and a turret at the clerestory level on the 53rd Street facade.

Because the presence of dark-colored soiling marred its otherwise imposing appearance, cleaning of exterior stonework of Saint Thomas Church was undertaken in 1984 as part of a larger restoration effort [1]. Difficulties encountered during execution of some of the preliminarywork prompted the church to initiate a complete survey of conditions in hopes of better understanding the nature of the soiling. Masonry materials were examined in the laboratory as well as in situ. Church records were also reviewed for information concerning previous preservation treatments. The research described in this paper developed as a result of this investigation [2].

MATERIAL

The principal material of Saint Thomas Church is Bowling Green limestone, an oolitic limestone quarried in Warren County, Kentucky. The predominant mineral of the stone is calcite with pyrite occasionally present. Oolites stand out conspicuously and are rounded or elongated in shape. Although Bowling Green limestone was quarried in a primitive manner from as early as 1833, the first important commercial quarry was opened in 1872. Limestone beds are generally 10-22 feet thick. Freshly quarried stone contains oil (from petroleum deposits) which gives it a murky appearance. However, upon exposure to the weather, this material evaporates leaving the stone with a white or nearly white appearance [3].

Bowling Green limestone has been called the "aristocrat of limestones" because of its color, uniformity, and strength. With perfect rift and grain, the stone is particularly well suited for delicate carving. Because it has good weathering qualities, original tool marks are often retained long after construction.

EXISTING CONDITIONS

Stonework of Saint Thomas Church is in generally good condition. As surface erosion has been moderate, carved ornamental details are still relatively crisp and arrises sharp in most locations. A notable exception is limestone of the turret at 53rd Street where weathering has been severe. The dark soiling present on exterior limestone in areas that are protected from the rinsing action of rainwater is typical for limestones. Although this condition was noted throughout, the pattern is most pronounced on the south elevation at street level. The mechanism resulting in this condition is described below.

Acidic gases absorbed from the atmosphere by rainwater cause it to be reactive with carbonate minerals. Sulfur dioxide, which (under typical atmospheric conditions) forms both sulfurous and sulfuric acids when dissolved in water, is perhaps the most destructive of these pollutant gases. In addition to the direct dissolution of calcium carbonate (calcite), the reaction of sulfur dioxide with limestone results in the formation of calcium sulfate dihydrate (gypsum) on the surface of the stone. As gypsum is more soluble in water than is calcium carbonate, the exposed surface becomes eroded when washed by the rain.

In areas where this surface is protected from the flow of rainwater, the continued transformation of calcium carbonate into calcium sulfate dihydrate results in the formation of a "crust" of gypsum. Particulate matter becomes entrapped in the network of gypsum crystals, giving the surface a blackened appearance. Thick "framboidal" crusts can be seen at window tracery, decorative moldings of the entries, and ornamental carving of the turret. Of particular note are areas where there is uneven erosion of the gypsum crust; this "scabbing" is most noticeable at the turret.

Below the carved ornament of the turret, the appearance of stonework is mottled. This condition is also noticeable at the tops of buttresses on the 53rd Street facade. The dark-colored staining on brickwork at the northwest corner suggests the presence of a coating on the stonework above. Stonework of the entries also appears to have a coating residue. In these protected locations, mottling is less apparent. There is discoloration throughout these areas with efflorescence visible above the doorway at the southeast entry.

PREVIOUS TREATMENTS

Fluorosilicate Treatment

According to church records, restoration work completed on Saint Thomas Church in 1928-29 included the application of a preservative treatment to all exterior masonry. It was thought that the "Magnesium-Silicon-Fluorite" solution described in correspondence would harden the stone and make it resistant to deterioration. Apparently, soiling and discoloration were present at the time of treatment.

The fluorosilicate or "fluate" treatment for preserving stone was first described by Jacques Louis Kessler in France in 1882 [4]. In Clermont-Ferrand, where Kessler resided, extensive deposits of fluorspar (fluorite) made possible the commercial production of "fluates". Although the fluorosilicate treatment for protecting stone gained popularity in France, it appears to have been little known in the United

States until after the turn of the century. A report from 1918 states that Kessler's method was "free from all objectionable features possessed by other methods proposed or adopted for preservation of building stones" [5]. However, as early as 1921, there were reports of difficulties experienced with the treatment. One such report described the formation of a hard surface film on treated stone that led to flaking and scaling [6].

Success of the treatment is based on the reaction of magnesium fluorosilicate with calcium carbonate (calcite) of the limestone. The reaction is said to proceed as follows:

$$H_2O + MgSiF_6 + 2CaCO_3 \rightarrow 2CaF_2 + MgF_2 + 2CO_2 + SiO_2 \cdot nH_2O$$

Because the pH of the solution is low, the evolution of carbon dioxide gas accompanies its reaction with limestone. This effervescence often results in the deposition of a superficial, spongy layer of calcium fluoride and silica. [7]. In addition, because the calcium flouride formed is not isomorphous with calcium carbonate, it has been reported that its presence can result in the formation of micro-cracks and fissures due to differential expansion and contraction [8].

Resin Treatment

During 1971-4, the Plexi-Seal Protection Corporation of Long Island City, New York, proposed application of a coating of Plexi-Seal to stonework of the Church. Although the product data is somewhat vague, it appears that the coating is a partially cross-linked polyester or acrylic material. Plexi-Seal is said to provide masonry substrates with a protective coating that will reduce damage caused by water intrusion. Correspondence indicates that the Plexi-Seal coating was applied to elements of the main tower, "frontal areas" of buttresses, and to the northwest rear wall at the third floor level. In addition, a modified acrylic latex formulation of Plex-Seal was added to mortar used in patching and repointing work [9].

Potential risks of resin treatments such as Plexi-Seal include the failure to achieve more than superficial penetration and that of the drastically reduced water vapor permeability of the substrate. With some building materials, the latter can result in damage related to the entrapment of water.

LABORATORY EXAMINATION

Following completion of the on-site inspection of conditions and the examination of church records, samples were examined in the laboratory to determine whether the previous preservative treatments have survived. In addition, an attempt was made to evaluate whether their applications have contributed to deterioration of the stonework. Core drilling samples of Bowling Green limestone were obtained from three problem areas of the church:• the northwest corner at the stair landing; the turret at the 53rd Street facade, northside; and from the clerestory wall, southside below the turret.

These cores were sub-sampled to allow a cross-sectional view of the exterior and interior of each piece. Samples were mounted on aluminum pin-type stubs, or on carbon stubs, and coated with either 10nm of spectroscopically pure carbon for energy dispersive x-ray analysis (EDS) in an Edwards 505 vacuum evaporator or 10 nm of Au in a Polaron E5150 sputter coater for examination by scanning electron microscopy (SEM). EDS and SEM analyses were performed in an AMray 1600 T equivalent SEM with attached Kevex 7000 EDS at 10, 20, or 30 kV.

Residue of the fluorosilicate treatment was found in all areas as evidenced by the spongy SiO_2 masses resulting from the treatment (fig. 2), and the CaF_2 deposits on the calcite crystals (fig. 3). These types of deposits have been described in other studies [10] as being characteristic of the fluorosilicate treatment of limestone.

In one area sampled, a black gypsum crust, typical of a limestone exposed to acidic air pollutants, was observed. The crust was covered with amorphous masses of silica and calcium fluoride crystals (fig. 4), indicating that the crust was not removed before application of the fluorosilicate treatment. Fly ash particles were also found on top of this layer (fig. 5). It is anticipated that there may be problems in cleaning areas of the church that have a black crust because it appears that, in some areas, the crust may be locked under the fluorosilicate treatment. Where this is the case, water washing may only remove surface dirt and fly ash.

Of the three locations examined for evidence of previous treatments, the polyester/acrylic residue was found in only one area (fig. 6). Here the surface film is apparently holding gypsum crystals in place. That the organic resin has not protected the stone beneath is evidenced by the gypsum crystals seen underneath the film. This factor and the absence of resin in other areas indicates that the treatment was not applied evenly or properly to the stone to create a protective layer. In the long run, however, the poor application of this resin may have been fortuitous: if it had sealed the surface completely, condensation might have occurred beneath it resulting in massive flaking of the surface. This application might have resulted in considerably more damage to the substrate [11].

ON-SITE TESTS

Water Wash

Water washing is generally thought to be a safe and relatively simple method for removing general soiling (gypsum crust) from limestones [12]. The effectivenes of the method relies on the fact that the gypsum crust in which the dirt is incorporated is several times more water soluble than is calcium carbonate. Thus, by partial dissolution, water loosens the gypsum crust and the material trapped within the network.

Water washing was tested in cleaning stonework at the southeast corner of the clerestory level and at the passageway below the turret of the 53rd Street facade. A perforated garden hose using water at city pressure was aimed at the soiling for approximately 24 hours. Although the dark-colored soiling was removed from the limestone in both areas, some mottling was apparent in the passageway after drying was complete.

The success of the water washing tests supports the theory that the fluorosilicate treatment was probably applied to a weathered and soiled surface. Fortunately, water washing appears to be able to penetrate the superficial crust of any surviving fluorosilicate treatment residue, solubilizing the gypsum below.

Chemical Cleaning

Tests to remove coating residues were carried out on stonework of the entries where evidence of this condition was noted during the preliminary inspection. Commerical products tested included two alkaline prewashes and an alkaline paint stripper (each used in conjunction with an acidic afterwash) and a solvent-based paint stripper [13]. Each product was applied according to the manufacturer's instructions. Dwell times were approximately one hour. Best results were obtained using the alkaline prewash/acidic afterwash cleaning products.

FULL-SCALE CLEANING

Based on the results of on-site tests, it was concluded that general soiling can be removed from stonework of most areas by water washing. Chemical cleaning was recommended as a supplement to water washing and for the removal of coating residues. Specifications were developed by the office of Gerald Allen and Associates and the contract for full-scale work awarded to Nicholson and Galloway, Inc.

Water wash equipment includes manifolds, hoses and sprinkler heads capable of delivering a fine mist of water to all soiled surfaces. Equipment is set up horizontally, parallel to the topmost area of the wall (fig. 7). When washing is completed, the equipment is lowered in a straight line to the lowest point. During on-site tests conducted by the contractor, it was determined that an 8-10 hour time period was required to remove general soiling. After completion of the washing cycle, low pressure rinsing or, alternatively, light brushing with natural bristled brushes was used to complete the cleaning operation.

As the water wash method necessitates the use of a considerable amount of water, it is important to guard against its intrusion to the interior of the church. The contractor inspected all interior spaces before general cleaning began and inserted cloths into window areas where gaps were seen. Conditions of materials were monitored by frequent interior inspection throughout full-scale operations.

In those areas where general soiling is incompletely removed by water washing, or where the appearance of cleaned stonework is somewhat mottled, supplemental chemical cleaning may be necessary. This work will be performed once general cleaning is completed. It will also be necessary to supplement water washing with chemical and/or mechanical methods in order to remove the framboidal crusts that have developed in some protected areas. Blunt masonry chisels will be used to perform mechanical removal, with care taken to avoid damaging adjacent masonry surfaces.

CONCLUSION

Full-scale cleaning of exterior masonry materials at Saint Thomas Church was begun in early September 1986 and continued until the onset of cold weather. Determination of the survival of preservation treatment residues made through on-site and laboratory examination of materials facilitated the development of appropriate cleaning materials and techniques. The remainder of the general cleaning work, scheduled to begin in the spring of 1987, will restore the original appearance of exterior stonework of the church.

NOTES

1. This work was made possible by a generous gift to the church from Mr. and Mrs. Lawrence A. Wien.

2. The authors wish to thank James E. Marlow, Director of Administration at Saint Thomas Church, for providing support and encouragement throughout the project.

3. Information about Bowling Green limestone was obtained from The Building Stones of Kentucky by Charles Henry Richardson (Frankfort, Kentucky: The Kentucky Geological Society, 1923) and "Physical properties of the principal commercial limestones used for building construction in the United States" by D.W. Kessler and W.H. Sligh (Technologic Papers of the Bureau of Standards, 21, No. 349, 497-590, July 23, 1927).

4. Kessler's 1884 application for United States patent rights described his improved process for treating natural and artificial stone using derivatives of fluorine followed by application of a wax. The former was intended to harden the stone, the latter to provide waterproofing.

5. Cecil H. Desch, "The Preservation of Building Stone", J. Soc. Chem. Ind. 37 (April 30, 1918): 118T.

6. Noel Heaton, "The Preservation of Stone", J. Roy. Soc. Arts 70 (1921): 124-39.

7. T. Stambolov and J.R.J. van Asperen de Boer, eds. The Deterioration and Conservation of Porous Building Materials in Monuments. (Rome: International Centre for Conservation, 1976) p. 47.

8. Seymour Z. Lewin and Norbert S. Baer, "The Replacement of Calcite by Fluorite: A Kinetic Study", American Mineralogist 55 (March–April, 1970): 466–476.

9. The cementitious material used to patch a number of vertical and diagonal cracks noted along the water table of the church is now considerably darker than the surrounding masonry. Discoloration of repairs to limestone blocks was also noted at the clerestory level. This discoloration strongly suggests that the modified acrylic latex formulation used in this work was not resistant to ultraviolet radiation.

10. Stambolov and van Asperen de Boer, op. cit.

11. Statements contained herein are the opinions and beliefs of the authors. Any comments concerning proprietary products are not intended directly or indirectly as statements of fact about any product, person, or company.

12. Problems associated with this method include the intrusion of water into interior spaces, "brown" staining when iron-containing minerals are present, and the encouragement of biological growth.

13. Commercial products tested in these areas were manufactured by ProSoCo, Inc., 755 Minnesota Avenue, Kansas City, KS 66117. Included were Limestone Prewash, 766 Masonry Prewash, Sure Klean Heavy Duty Paint Stripper, Limestone Afterwash, and 509 Paint Stripper.

Fig. 1

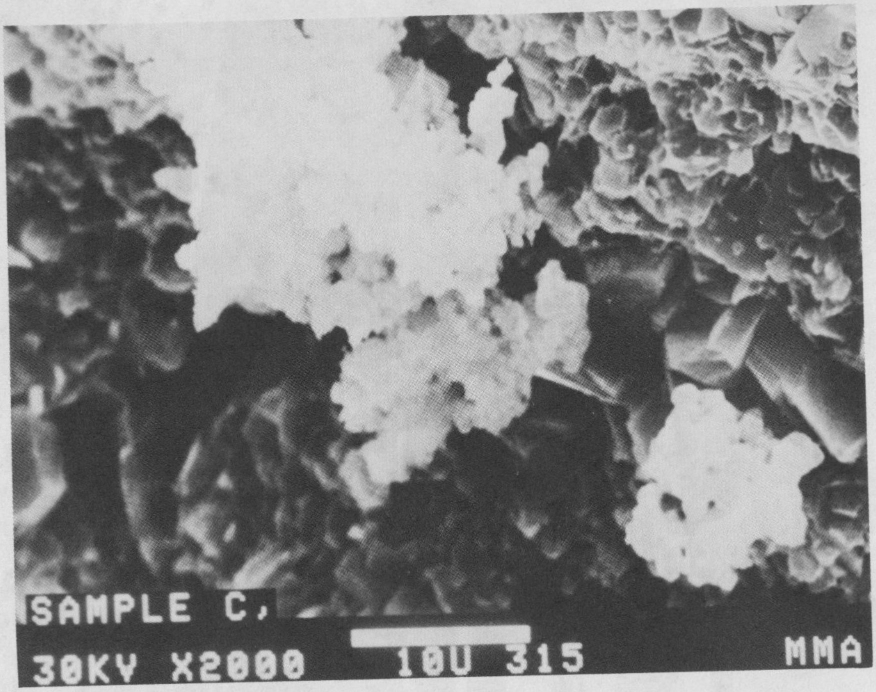
SAMPLE C,
30KV X2000
10U 315
MMA

Fig. 2


SAMPLE C,
30KV X10000
1U 303
MMA

Fig. 3

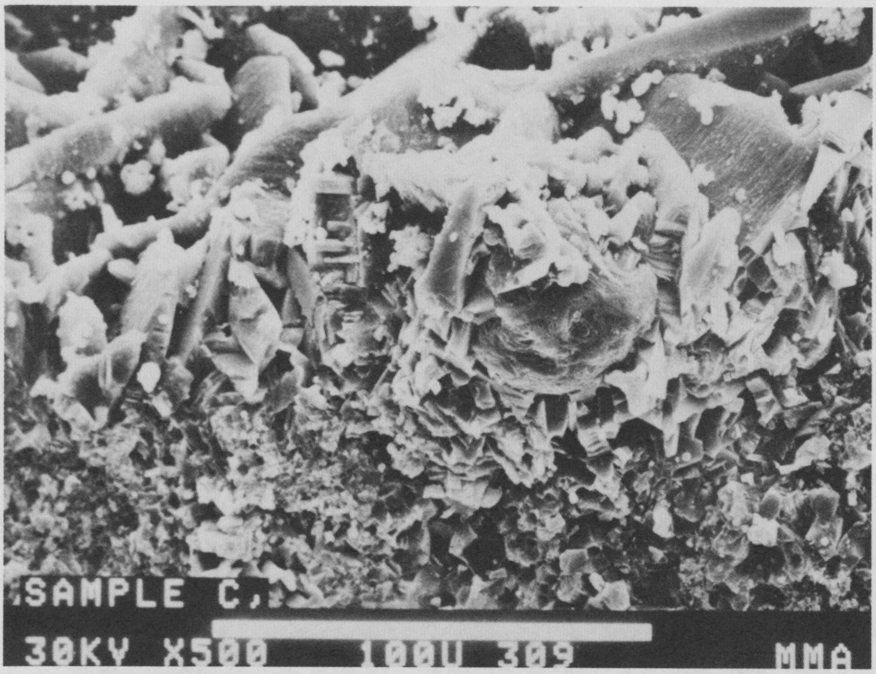
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Fig. 4

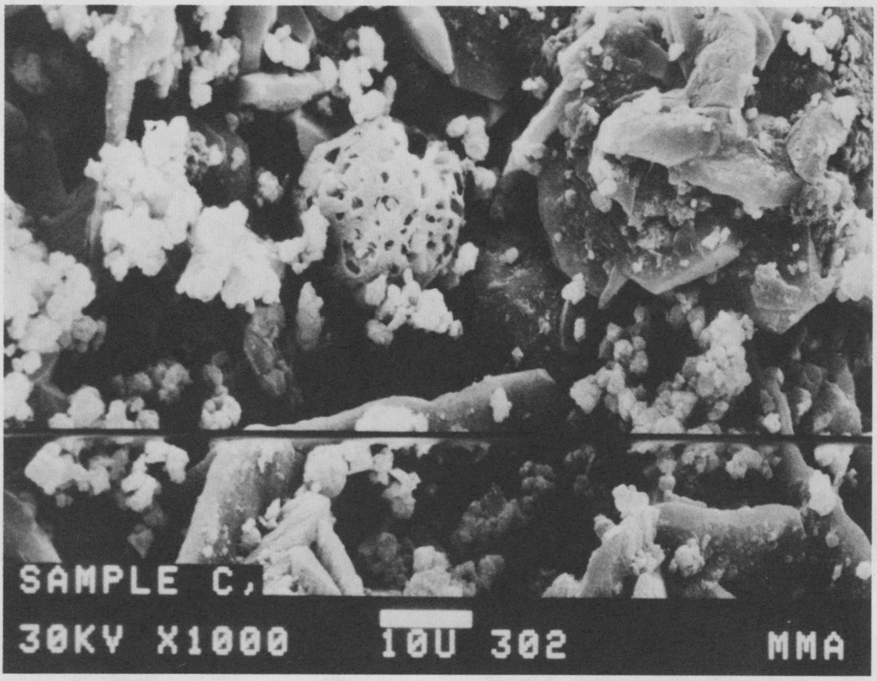
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Fig. 5

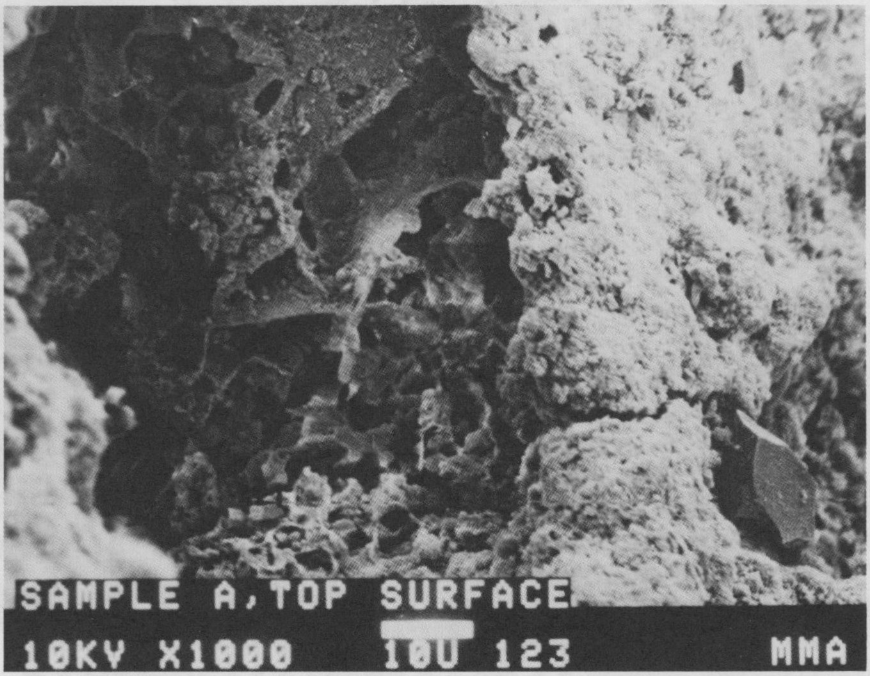

Fig. 6

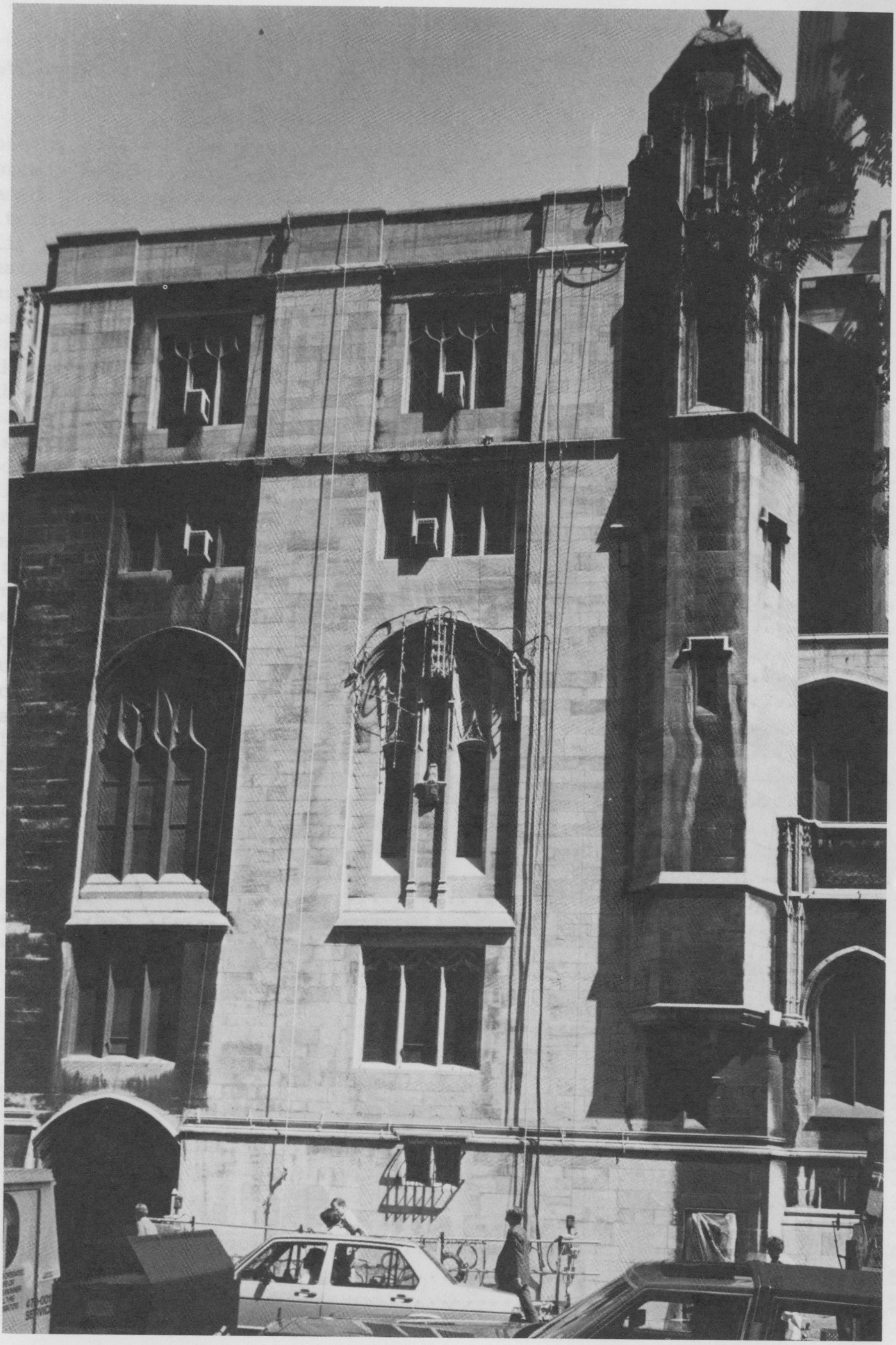

Fig. 7