X-RAY INVESTIGATION OF BUILDINGS

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This paper and the accompanying illustrations partially describe the author's experimental efforts to develop the X-ray process as a means of exploring invisible conditions within historic structures, and to determine its potential for conducting non-destructive physical research. The process is in its initial stages of investigation, with the assistance of the staff of the Society for the Preservation of New England Antiquities, and James H. Ballou, Architect.

The equipment used is a Picker Corp. Portashot System, which is composed of an X-ray generator, film holder, and processing unit. The entire system can be purchased for approximately $5,000.00. Polaroid ® sheet radigraphic film is used, as it can be quickly developed in the field for examination and correction of technique. The film cost is about $3.00 per shot, in addition to the equipment cost. The entire system is portable, and requires only 115 v.a.c. line current for operation. The generator weighs 13 pounds, and the processing unit weighs an additional 50 pounds (see Figure 1).

X-rays are basically a form of high energy electromagnetic radiation, capable of penetrating most materials. The radiation is absorbed to varying degrees by different building materials, and the resulting pattern appears on a film placed on the other side of a group of materials. This pattern gives a picture of the internal composition. For example, when a wall is "shot," the generator is set up approximately three feet away. The film holder is placed against the opposite side of the wall, and the exposure made. The film packet is then run through the processing unit for 45 seconds.

The results so far indicate that wood is easily penetrated, with internal conditions such as grain pattern, rotted and insect damaged areas readily determined. Iron, steel and other metals are vividly displayed in contrast to wood. Normal thicknesses of plaster are easily penetrated, but mortar, clay and stone materials are not. The presence of lead paint is usually apparent.

The following examples of X-ray techniques will illustrate the advantages and limitations encountered so far.

The first example is from the Dexter-Treadwell House, Topsfield, Mass. (c. 1741). This is an internal wall, plastered on one side and panelled on the other. The X-ray reveals stud wall construction, with early, hand-split lath, forged nails, and a recent thermostat cord (Figures 2 and 3).

The next example is taken through a ceiling in the House of the Seven Gables (John Turner House, 1679) Salem, Mass. There is a prominent crack in the plastered ceiling, which suggests a structural failure (Figure 4). The X-ray reveals a joist directly above the crack, which is being displaced downward by a partition. This would seem to account for the crack. In addition, evidence is seen of new,

regular width lath to the right of the joist, and old, hand-split lath to the left. This indicates the area of recent work on the ceiling (Figure 5).

The third example is from the Harrison-Gray-Otis House, Boston, Mass. (1796), headquarters of the Society for the Preservation of New England Antiquities. The photograph shows one side of an internal wall (Figure 6). Both sides have plaster above a chair rail. This side is plastered below its elaborate rail, while the other side (not illustrated) has wood panelling below. The X-ray reveals items hidden in the wall. Lath and plaster are seen, as well as possible plank wall construction. Carved ornament details on one of the chair rails is evident; numerous coats of paint conceal them from view on the surface (Figure 7).

The next example is a ramped side rail in the stair hall of the S.P.N.E.A.'s Codman House property in Lincoln, Mass. The staircase had been constructed in the 1790's, and had been partially remodeled in the second half of the 19th century. There is a question as to the dating of the rail (Figure 8). The wall illustrated has plaster above the rail and wood panelling below. The opposite side of the wall (not illustrated), also has plaster above a chair rail, and wood panelling below. The presence of wrought nails and uniform paint distribution is made clear by the X-ray. The evidence, therefore, suggests that the rail is of the 1790 period (Figure 9).

The fifth example is from the Edward Allen House, Salem, Mass. (1768). A summer beam spans 36 feet, at the middle of which there is a cross wall. The X-ray, taken at the door jamb in this wall, reveals an apparent six-inch wide stud. This stud evidently acts as a support. Lath and the door frame members are all attached to this stud. Note the presence of a large hand-wrought spike (Figures 10 and 11).

The advantages of field examination by X-ray are evident; the limitations so far seem to be the necessity of taking the picture straight-on to achieve clarity. There is also the difficulty of analysis caused by the lack of depth perception. It is hoped that further trials can overcome these limitations by use of stereo picture taking.

In summary, this process seems to have definite advantages in the investigation of structural conditions in historic buildings. The X-ray analysis is certainly less expensive than tearing out a section of covering materials for examination. In a scholarly sense, it permits the investigation of areas that a preservationist would not ordinarily open up, and therefore can make a significant contribution to the cause of preservation.

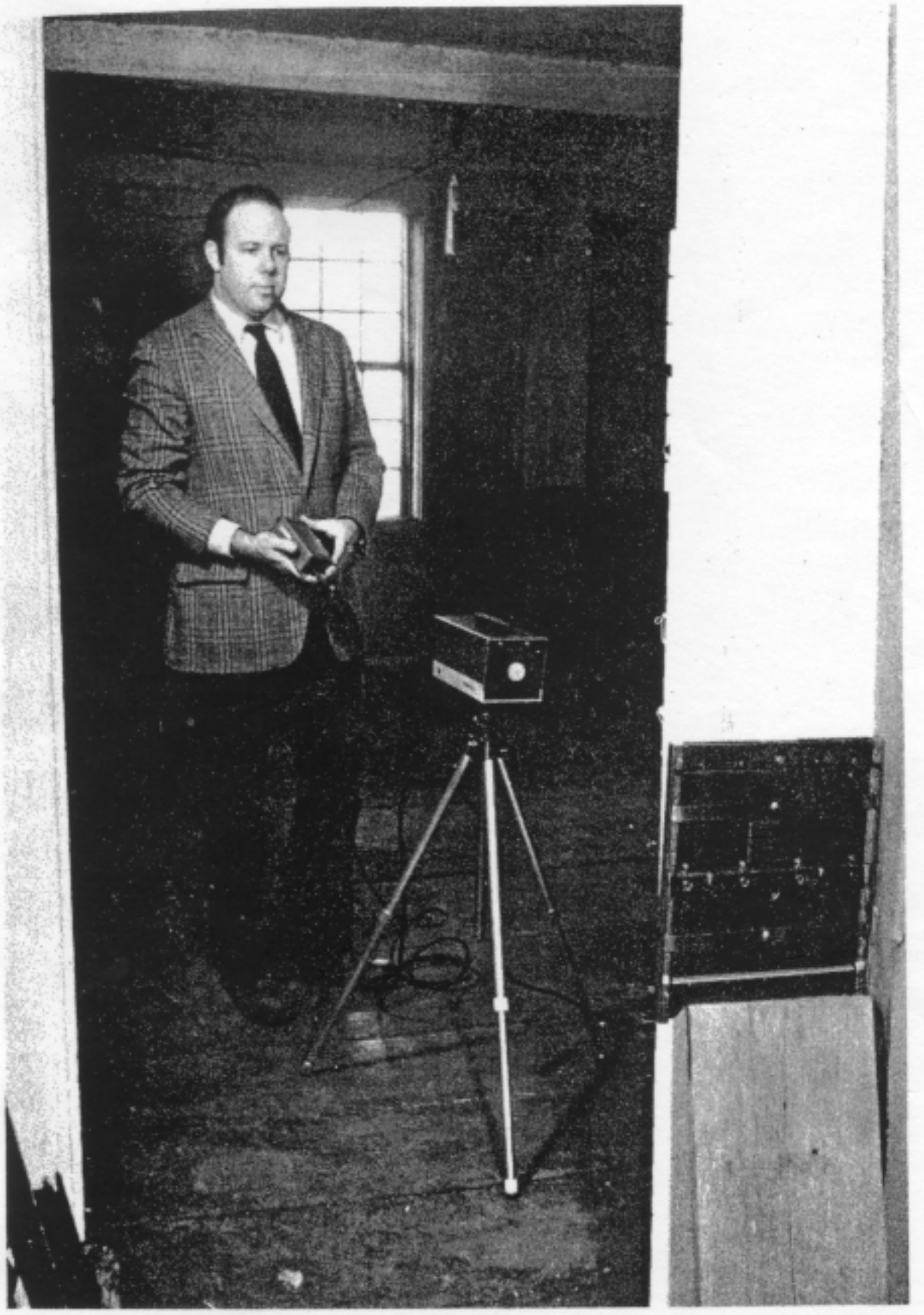

Fig. 1 Author David Hart with portable X-ray generator (on tripod) and film holder (seen on near side of doorway).

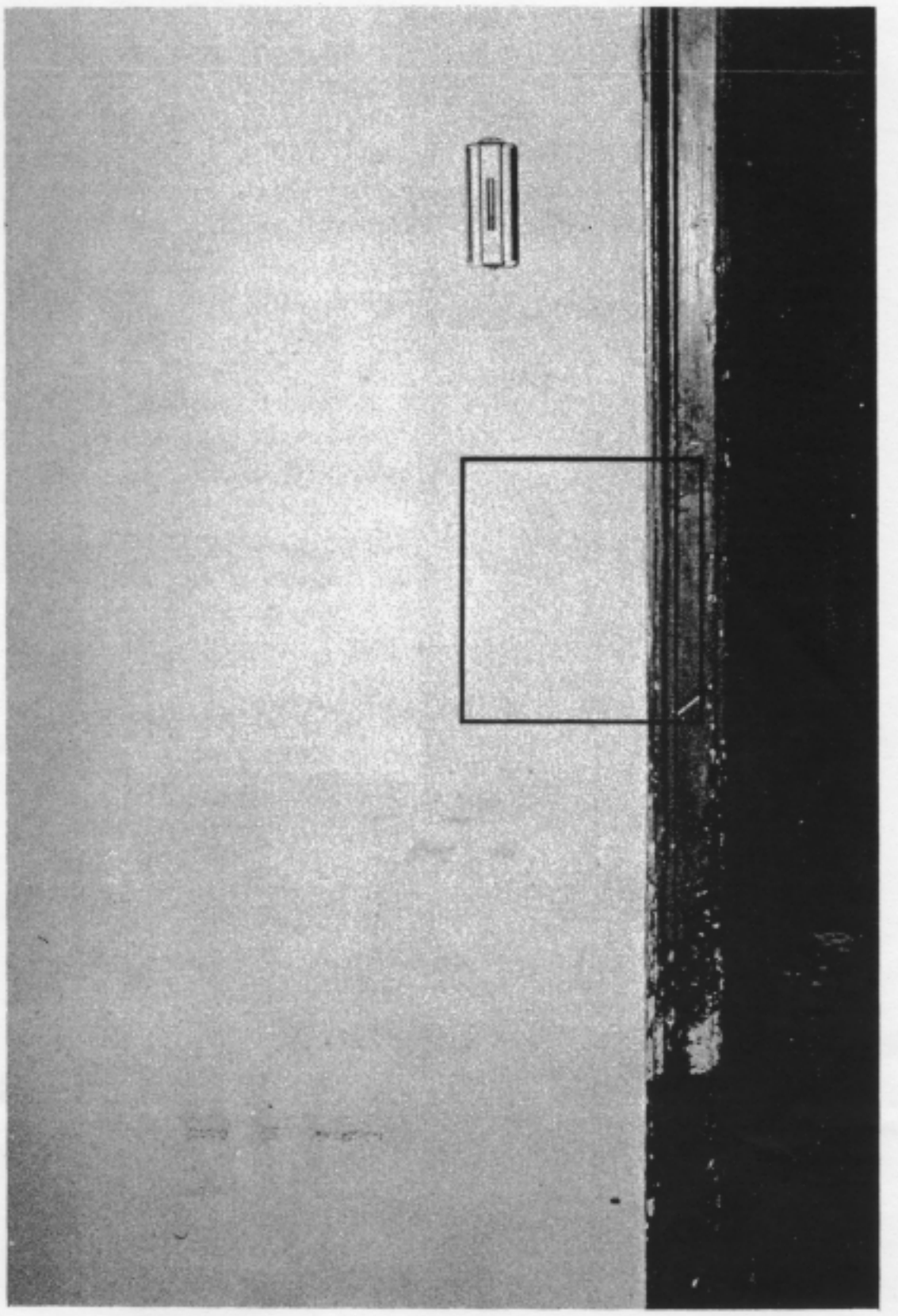

Fig. 2 Dexter-Treadwell House, Topsfield, Mass. (c. 1741). Rectangle drawn on photo near edge of door opening indicates area of X-ray seen in Figure 3. Note thermostat above.

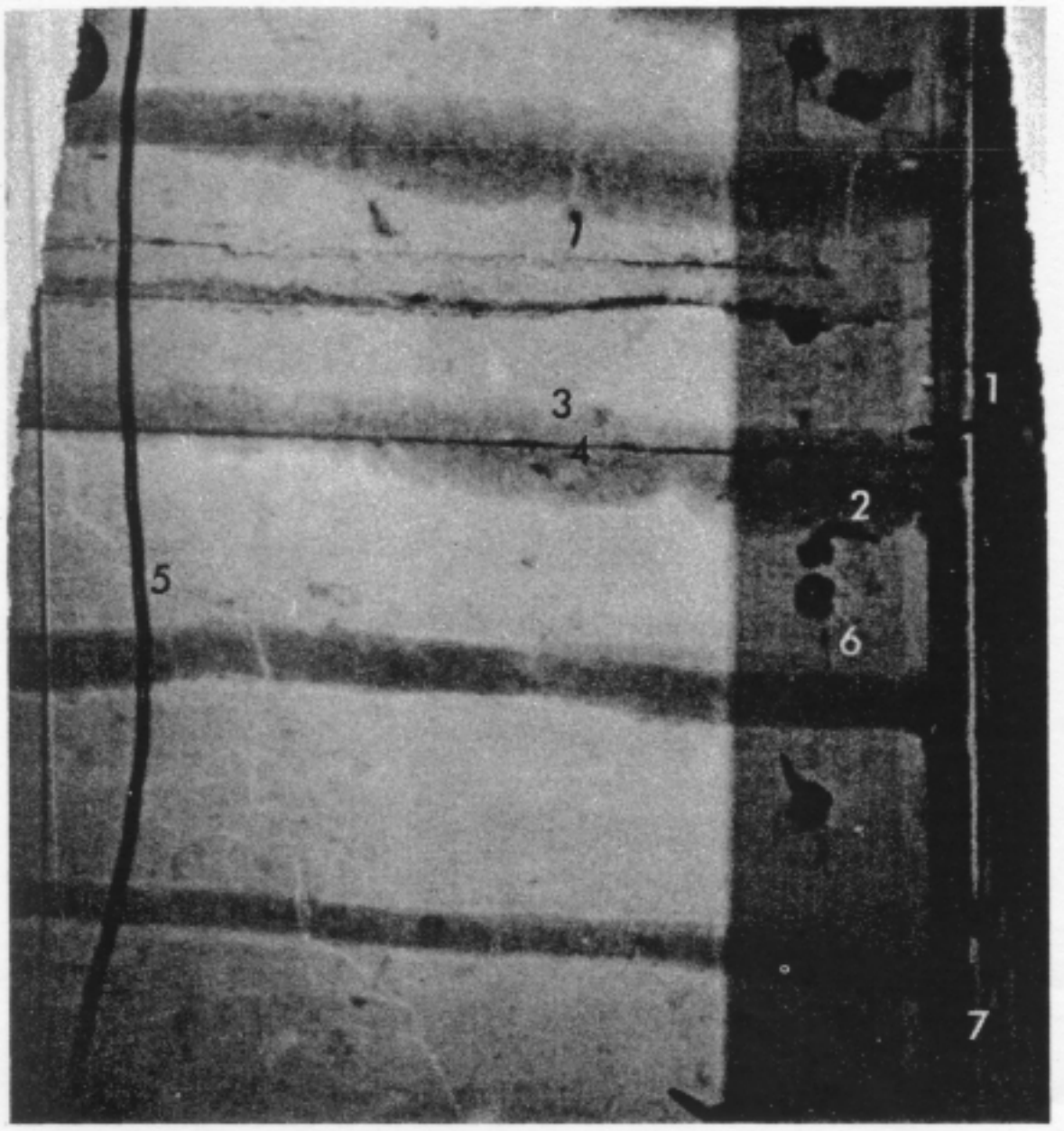

Fig. 3 Dexter-Treadwell House, Topsfield, Mass.
Key to X-ray:
1. Possible wire nail, on trim
2. Wrought nails
3. Hand-riven lath
4. Plaster Key
5. Thermostat wire
6. Wide stud (or door post)
7. Door backband moulding

Note: Incompleteness of photo is a consistent processing defect.

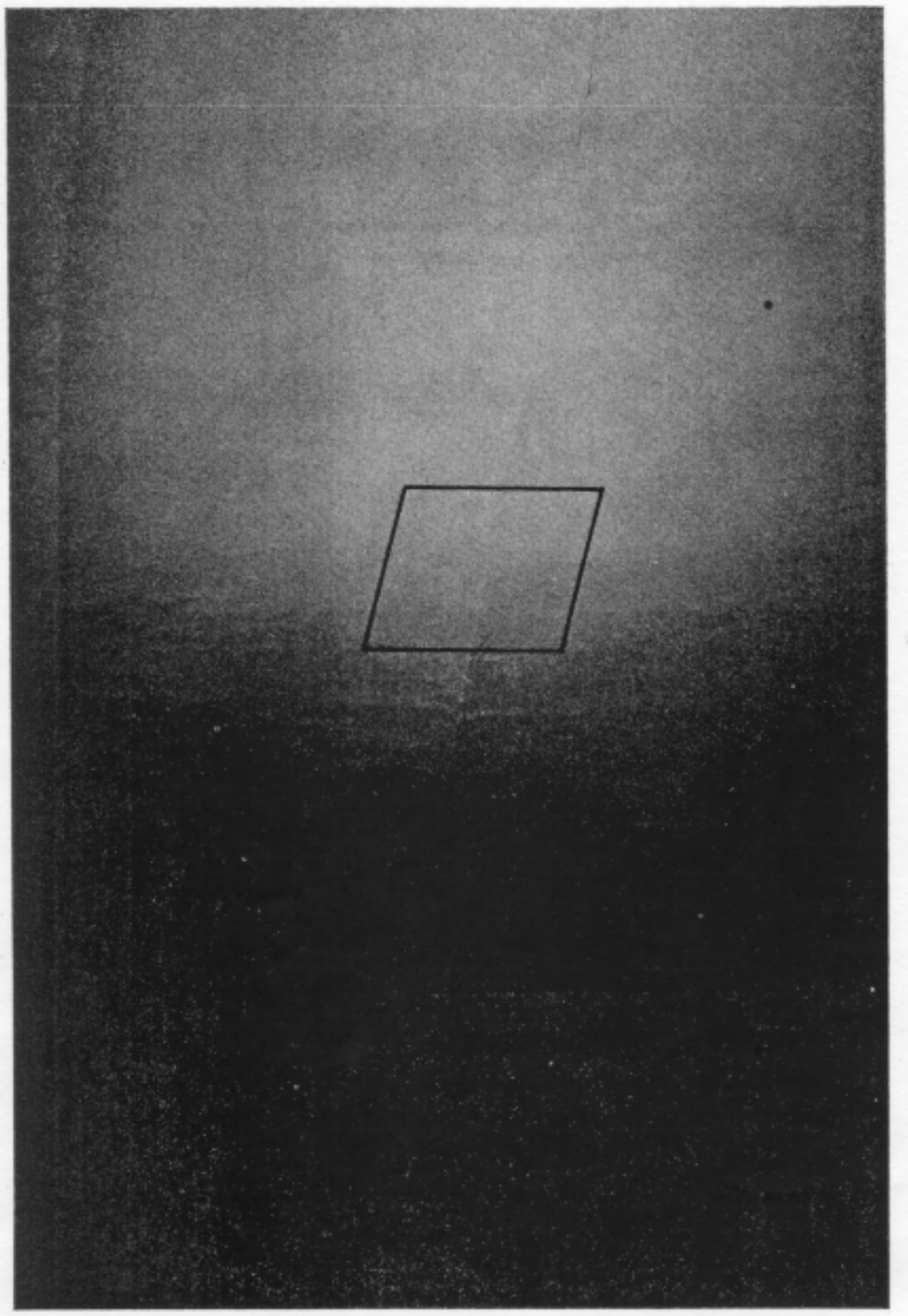

Fig. 4 House of the Seven Gables (John Turner House), Salem, Mass. Rectangle drawn on photo of ceiling indicates area of X-ray seen in Figure 5. Note crack in the plastered ceiling, which suggested a structural displacement or alteration.

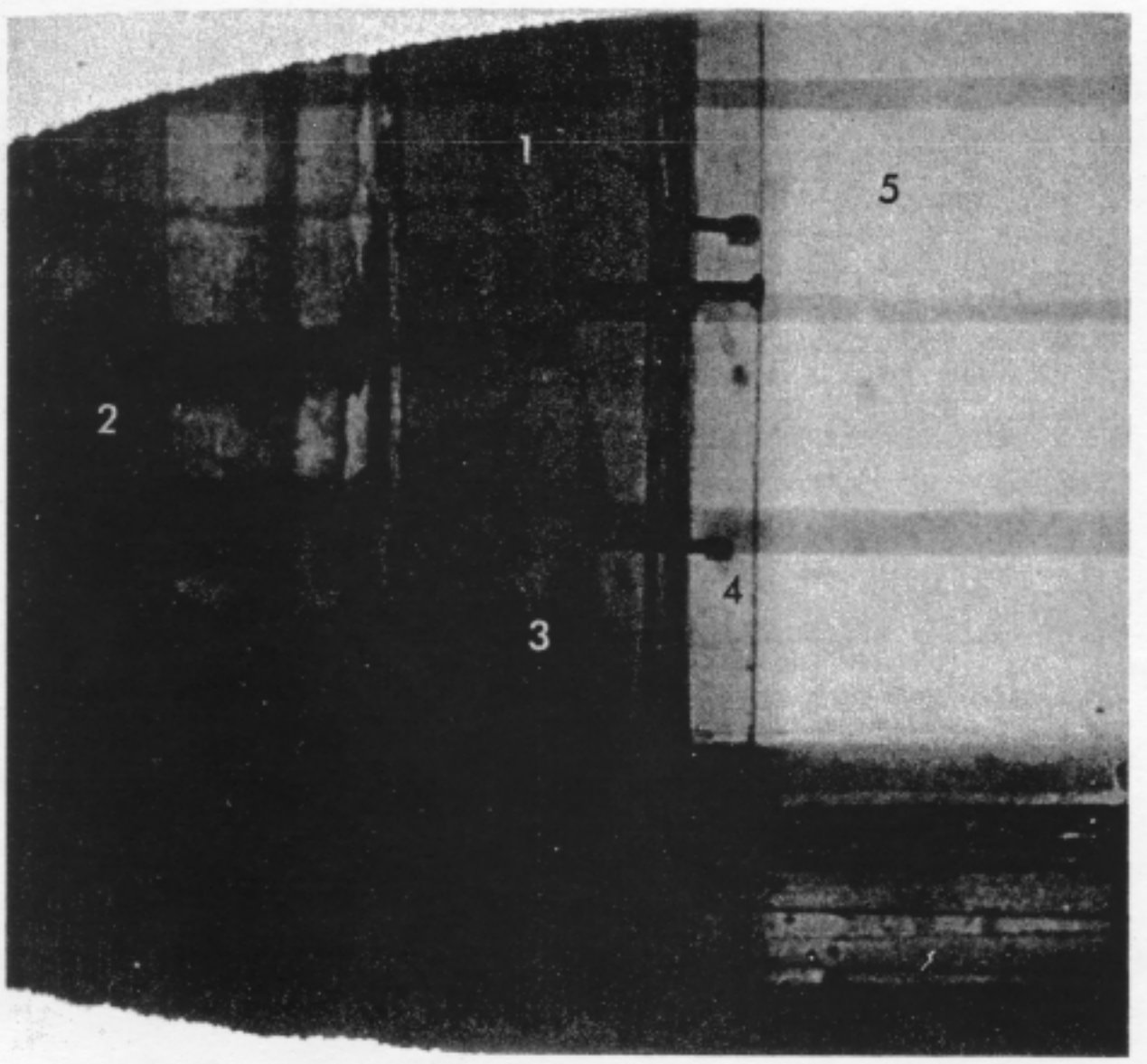

Fig. 5 House of the Seven Gables, Salem, Mass.
Key to X-ray: 1. Wrought nail
2. Hand-riven lath
3. Joist
4. Cut nail
5. Sawn lath
Note: Incompleteness of photo is a consistent processing defect.

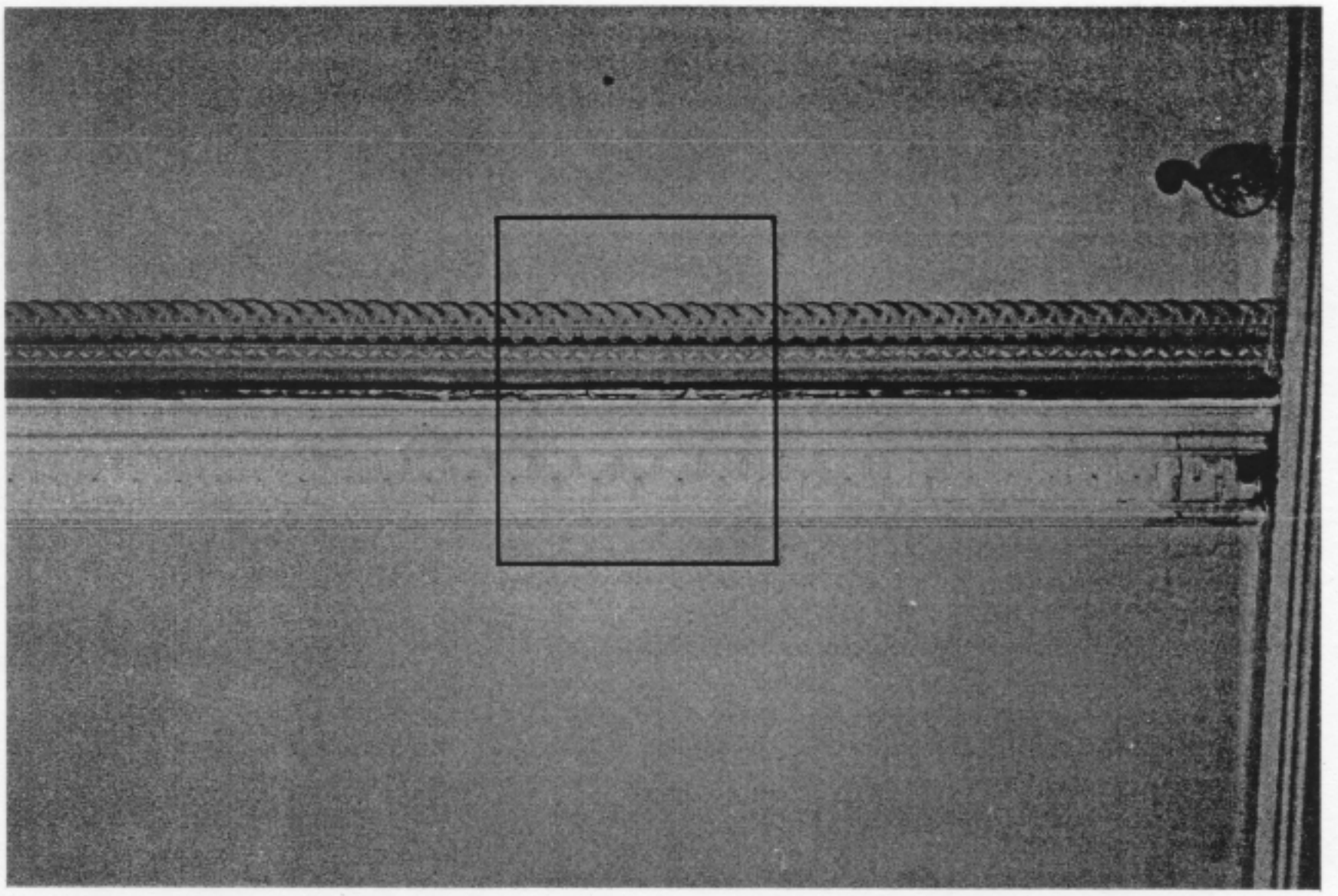

Fig. 6 Harrison Gray Otis House, Boston, Mass. Rectangle drawn across photo of chair rail indicates area of X-ray seen in Figure 7.

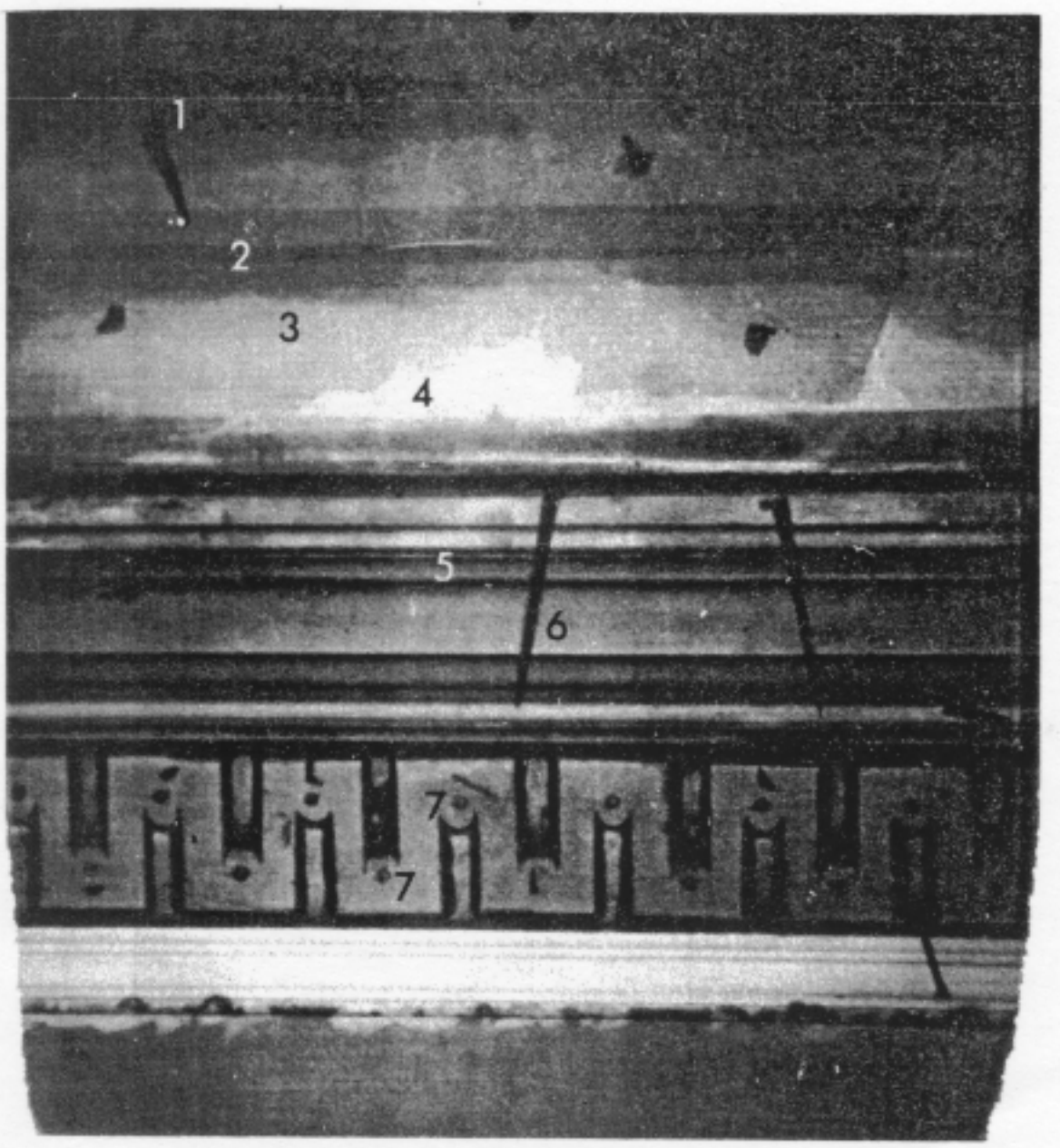

Fig. 7 Harrison Gray Otis House, Boston, Mass.
Key to X-ray:
1. Wrought nails
2. Plaster Key
3. Lath
4. Lead paint chipped away
5. Chair rail
6. Possible cut nails
7. "I" dentil drill holes not visible on surface due to paint build-up

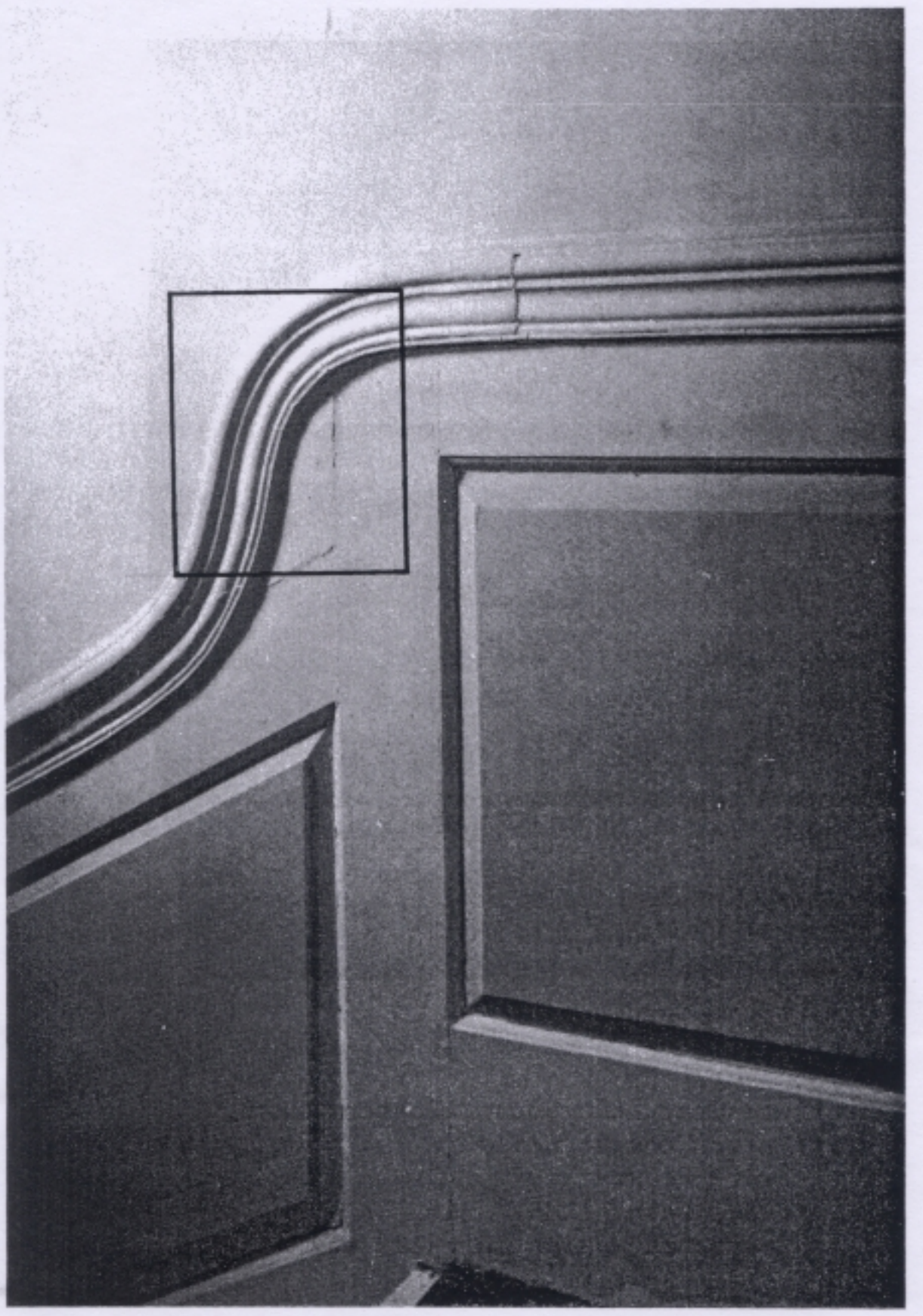

Fig. 8 Codman House, Lincoln, Mass. Rectangle drawn across photo of staircase dado rail indicates area of X-ray seen on Figure 9.

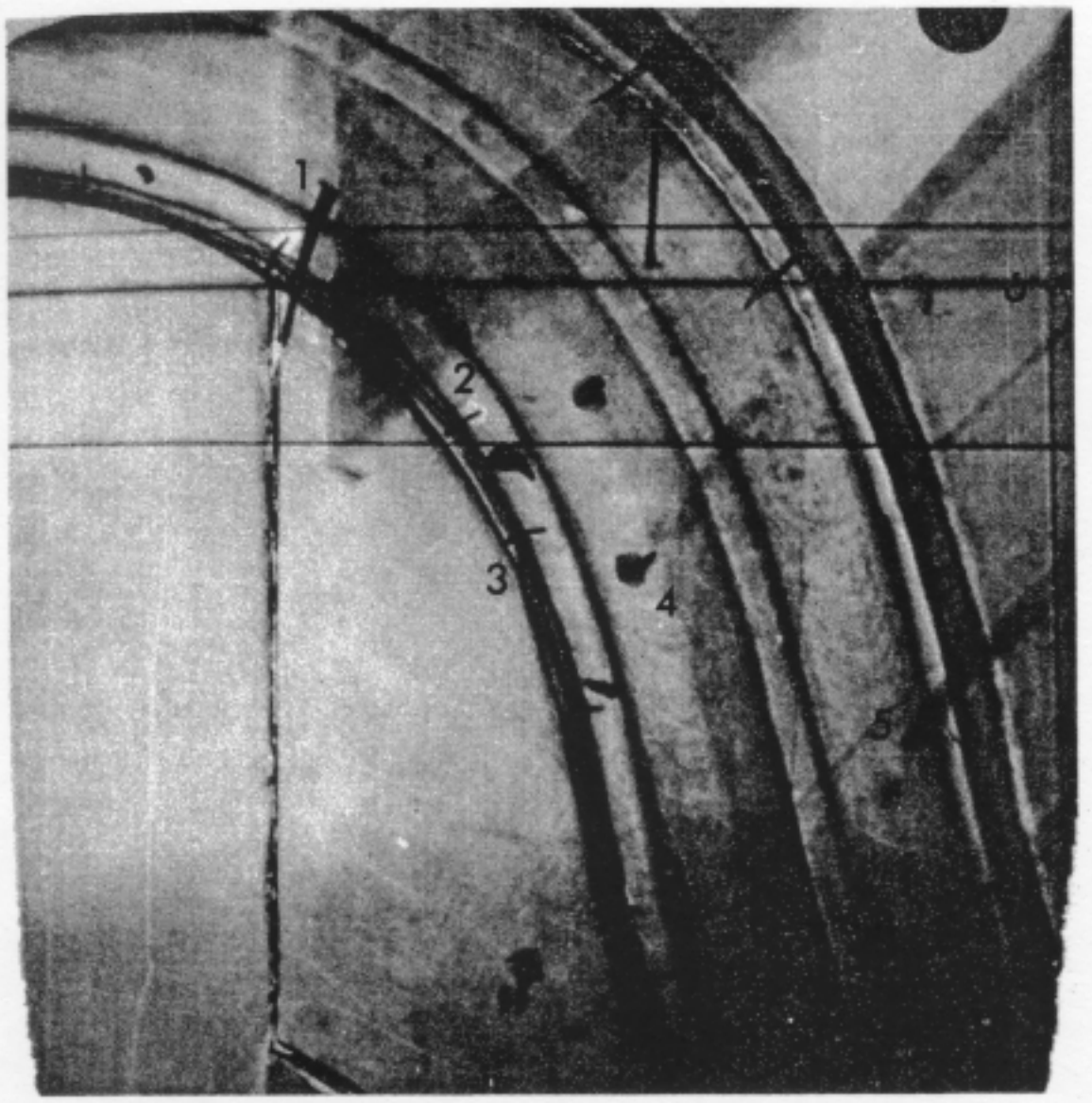

Fig. 9 Codman House, Lincoln, Mass.
Key to X-ray: 1. Possible cut nail
2. Lead paint chipped by staple
3. Telephone cable
4. Wrought nail
5. Half rail of dado
6. Hand-riven lath
Note: This X-ray is a reverse view of dado rail seen in Figure 8.

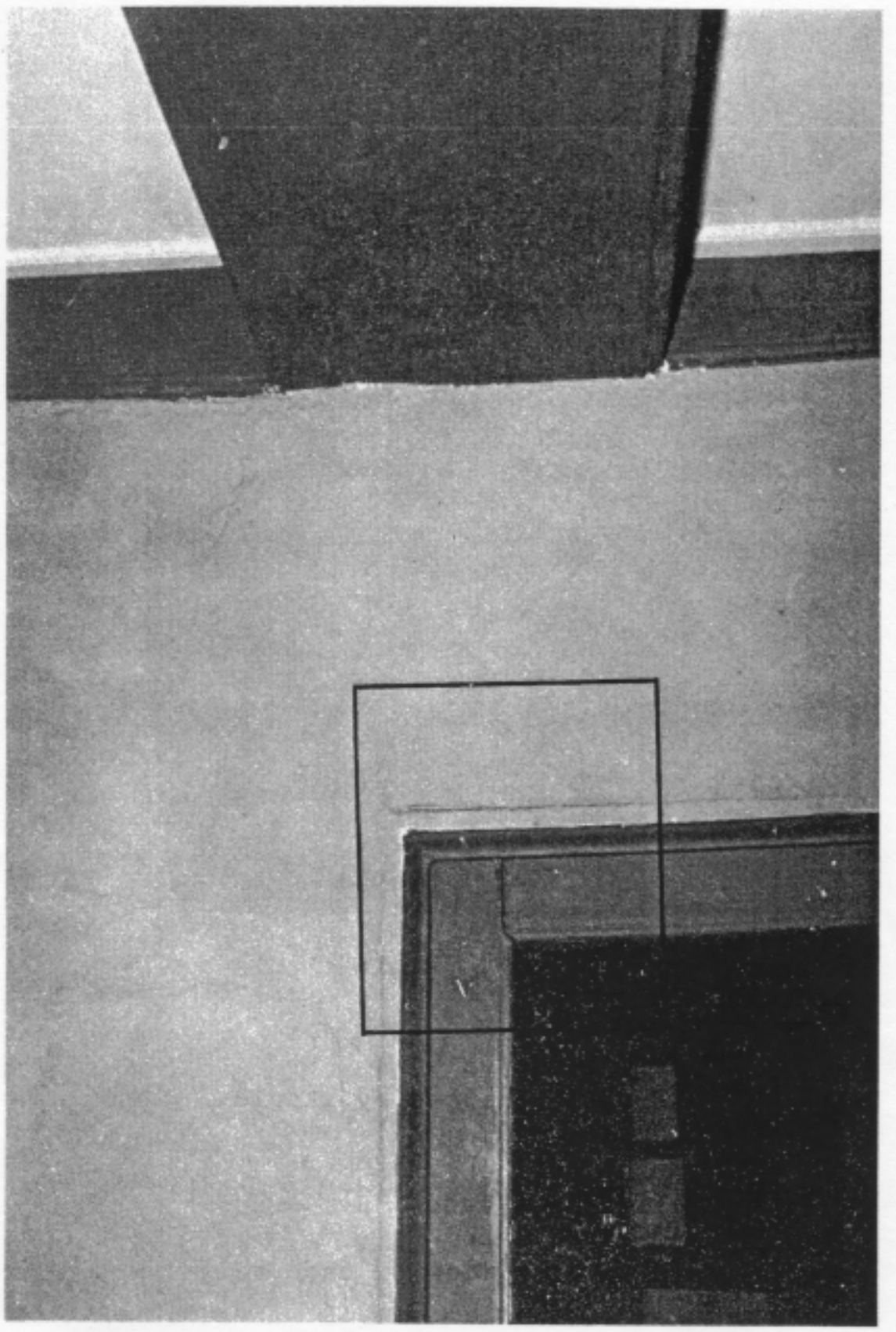

Fig. 10 Edward Allen House, Salem, Mass. Rectangle drawn on photo across upper corner of doorway indicates area of X-ray seen on Figure 11.

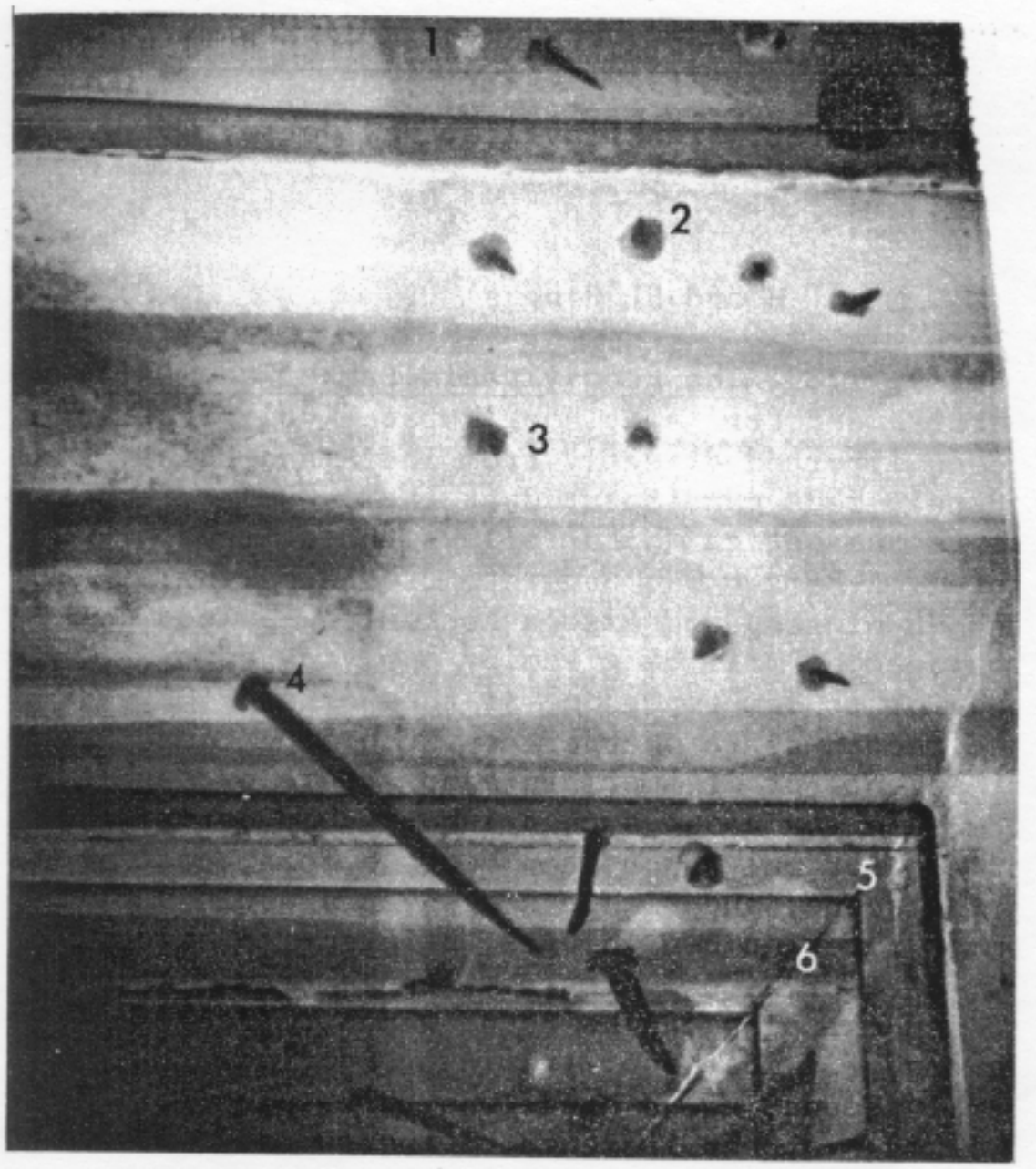

Fig. 11 Edward Allen House, Salem, Mass.
X-ray taken from opposite side of wall seen in Figure 10.

Key to X-ray:
1. Wide shadow of door stud (or post)
2. Wrought nails
3. Hand-riven lath
4. Large wrought nail
5. Wooden pin
6. Doorway architrave backband