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INFRARED THERMOGRAPHY OF BUILDINGS

Qualitative Analysis of Five Buildings at Rickenbacker Air Force Base, Columbus, Ohio

Richard H. Munis
Stephen J. Marshall

September 1977

Prepared for
301ST AIR REFUELING WING
RICKENBACKER AIR FORCE BASE, COLUMBUS, OHIO
By
CORPS OF ENGINEERS, U.S. ARMY
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A heat loss survey was performed on five typical Air Force Base buildings with an infrared camera system: two with wood frames and wood clapboards, one with wood frame and aluminum siding, and two of cinder block construction with brick veneer. A walk-through inspection was also performed on three of these buildings chosen by project monitors for retrofitting. This report presents thermograms typical of the heat loss problems in each of the five buildings along with a complete explanation of each thermogram. The purpose of the report is

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20. to serve as a basis upon which Air Force civil engineers can plan a future retrofit program for the buildings surveyed and write a set of specifications incorporating thermography. Typical thermograms show heat loss from large, single-pane, steel-frame, projected windows, which in one building account for 50% of the total wall area. Infiltration losses through framing spaces for all windows are evident. Heat patterns from precast concrete floor slabs and radiators under the windows showed up clearly. Ribs in uninsulated door panels were clearly seen as well as leakage around the doors. Heat loss through the roof of a one-story duplex was easily recorded from the ground using the infrared camera system. Thermographic comparisons between windows with storm sashes and a picture window with insulating glass were made. Heat was found escaping from slab foundation vents and gable vents.

PREFACE

This report was prepared by Dr. Richard H. Munis, Research Physicist, and Stephen J. Marshall, Physical Science Technician, of the Physical Sciences Branch, Research Division, U.S. Army Cold Regions Research and Engineering Laboratory.

This study was funded by the 301st Air Refueling Wing, Rickenbacker Air Force Base, Columbus, Ohio, under MIPR No. FQ46017073-0001, Work Unit Infrared Survey of Five (5) Selected Base Facilities.

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INDEX

QUALITATIVE ANALYSIS OF FIVE BUILDINGS AT RICKENBACKER AIR FORCE BASE, COLUMBUS, OHIO

Richard H. Munis
Stephen J. Marshall

INTRODUCTION

During the week of 25 January 1977, a heat loss survey to pinpoint locations of excess heat loss was made at Rickenbacker Air Force Base, Columbus, Ohio. Two thermographers, Dr. Richard H. Munis and Mr. Stephen J. Marshall, of the U.S. Army Cold Regions Research and Engineering Laboratory (USACRREL), performed the survey using an AGA Thermovision infrared camera system (see photograph, page 2).

At the time of the survey, Ohio was in a state of emergency due to a shortage of natural gas. Extreme cold, heavy snowfall, and wind gusts up to 35 knots hindered the survey. In addition to these difficulties, the image splitter in the main frame of the infrared camera system was completely shattered during shipping; this made it very difficult to operate the system in the usual manner. The result was that approximately twice as much time was required to perform the survey as would normally have been required.

Five buildings were inspected with the AGA system: Building 865 (Women's (WAF) Dormitory), Building 1082 (Central Security Control), Building 2035 (Capehart Duplex Housing), Building 37-38 Elm (Wherry Fourplex Housing), and Building S-1 (Wing Headquarters). Following the heat loss survey, a walk-through inspection was made of three of these buildings. After the initial survey had been completed these three buildings (S-1, #865, #1082) were chosen by the SAC project monitors, Major Steve Mugg and Mr. Ed Morgan, to be analyzed for quantitative heat losses. However, this report covers only the results of the qualitative analysis of the five buildings.

BUILDING 865
WOMEN'S (WAF) DORMITORY

Building 865 is a three-story concrete block structure with precast concrete floor slabs. It has over 100 projected steel windows consisting of single-pane glass. At the time of the heat loss survey of this building, the average interior temperature was 70°F and the exterior temperature was 21°F. It is our understanding that there is no insulation in the walls of this building. The thermographic inspection of this building indicated that the locations of major heat loss were the single-pane windows (especially those situated at the center of the building on the west face), the walls (particularly where they meet the precast concrete floor slabs) and the framing spaces of all windows. Heat losses through the window glass and around the window framing spaces seemed to be the predominant heat losses.

Inspection of the east and west faces of this building showed that, except for the middle section of the west face, there is approximately 50% glass and 50% masonry on the two faces. On the north and south sides of the building, there are no windows -- only three doors. Figure 1 shows the heat loss (arrows) above and alongside the second- and third-floor doors on the north side. Figure 2 (photograph) shows open ventilators above these doors which were responsible for some of the heat loss shown on these thermograms. However, during the heat loss survey, the third-floor door was propped open as shown in the photograph. Therefore the heat loss (shown in Figure 1) alongside this door was being transmitted directly through the open door.

Figure 3 shows dramatic evidence of heat leakage (arrows) around the second- and third-floor projected steel windows on the east side of this building. Figure 4 shows infiltration losses (arrows) around first-, second- and third-floor windows on the east face of the building, while Figure 5 shows infiltration losses around windows on the west side of the building. The bright zones under some of the windows in Figures 4 and 5 indicate heat leakage from radiators through the walls.

Figures 6 and 7 show an interesting heat loss pattern. Thermograms show essentially two large white areas on each floor at this point. The one large white, well-defined zone shows heat loss (horizontal arrows) from the west-facing windows located in the central section of the building. The other three white zones show heat loss (vertical arrows) from the windows that abut this section and the north face of this west-facing section, which is all masonry. Even in these two figures we see evidence of heat leakage (white arrows) around the projected windows on the main part of the west face of the building.

Figure 1

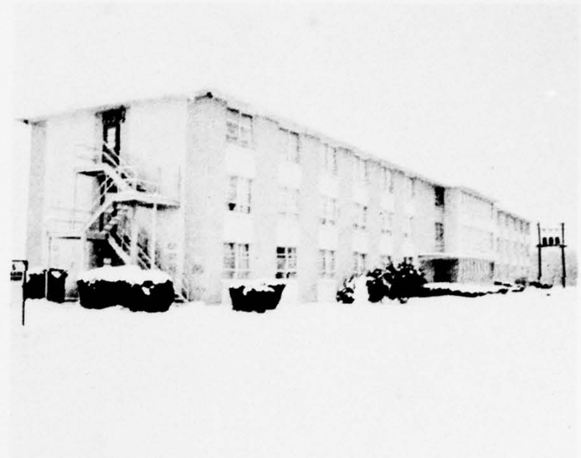


Figure 2

Figure 3

Figure 4

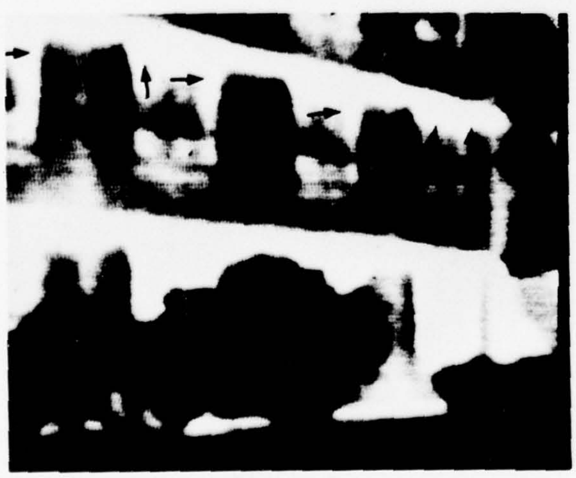


Figure 5

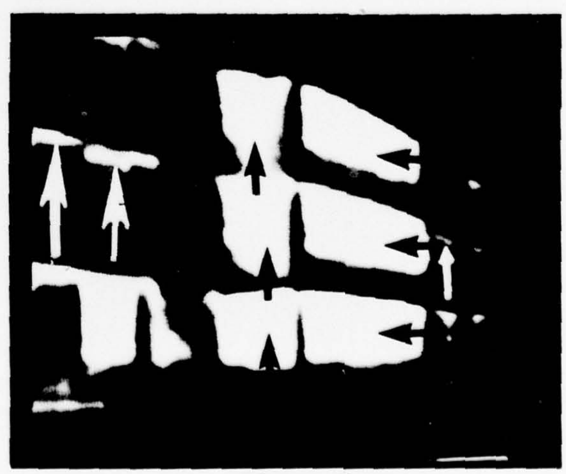


Figure 6

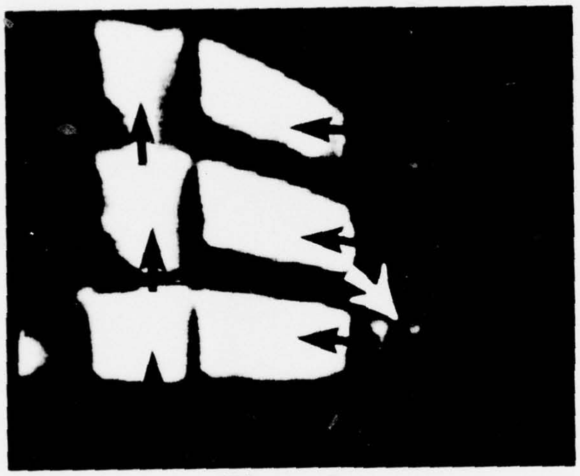


Figure 7

BUILDING 1082
CENTRAL SECURITY CONTROL

Building 1082 is a one-story concrete block structure with brick facing. The drawings show that there is 1 in. of rigid insulation in the walls. The windows are projected. This building does not contain many windows; however, most of the windows it does contain are fairly large. If there is 1 in. of rigid insulation in the walls, it does not seem sufficient.

Figure 1 shows significant wall heat losses occurring (arrows) from the northwest corner of the building, while Figure 2 shows wall heat losses occurring (arrows) from the northeast corner. Figures 3, 4 and 5 show wall heat losses occurring (arrows) from the east face of the building. Figures 6 and 7 show the wall heat losses near the south-facing door. Figures 6 and 7 show air leakage underneath the window (vertical arrows) to the left of the door on the north side of the building. They also show considerable leakage around the jambs of the door on the south side of the building, as well as the wood panel above the door.

Figure 8 shows evidence of window leakage around the framing space and around the mullions of two windows near the southeast corner of the building. Figure 9 shows a thermogram of an east-facing window covered by a drape; however, the arrows point to infiltration losses around the mullion and the framing space. Figure 10 shows heat loss (arrows) occurring around the framing space of an east-facing window. Figure 11 indicates heat escaping (arrows) through an open vent on the east side of the building.

Figure 12 shows more heat loss from the single-pane glass above the two doors on the east face than from the single-pane glass in the two doors. Figures 13 and 14 show the same effect as shown in Figures 6 and 7 at the door on the north side of the building. Figures 15 and 16 show leakage around individual sash units. Figure 17 is a photograph of the south and east sides of this building.

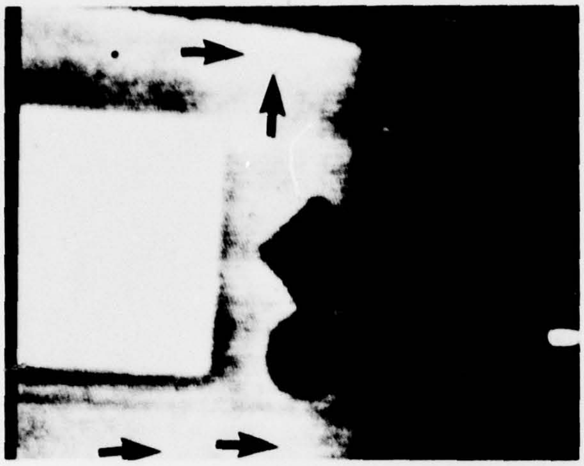


Figure 1

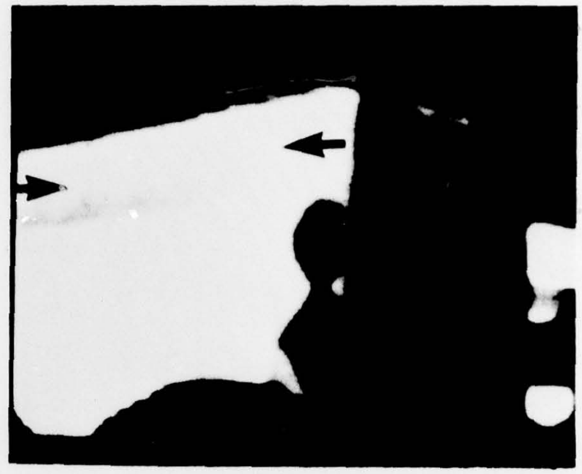


Figure 2

Figure 3

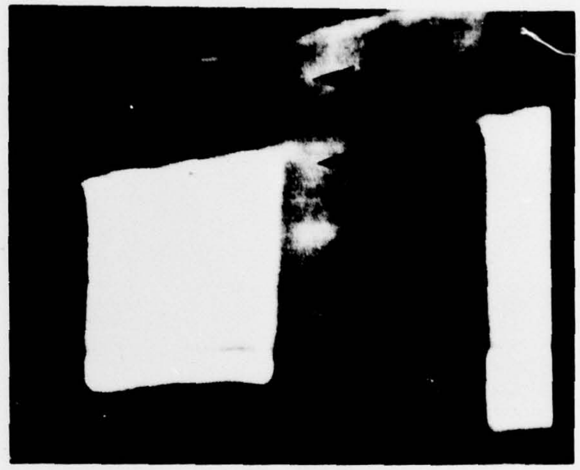
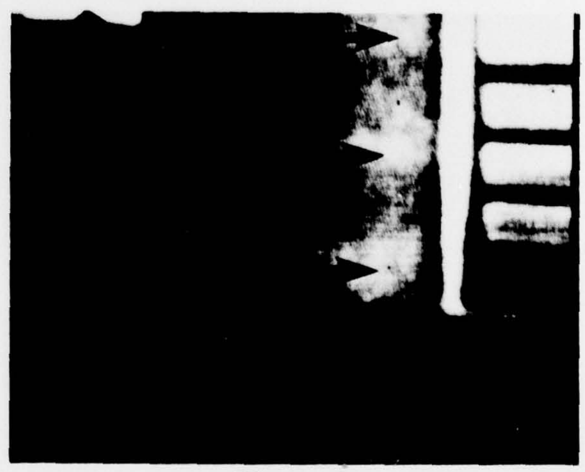


Figure 4

Figure 5



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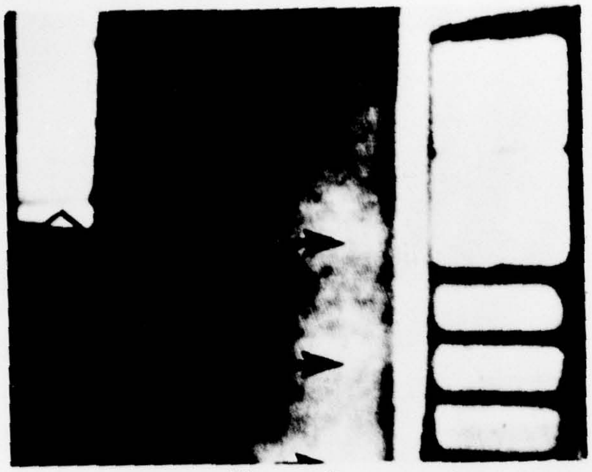


Figure 7

Figure 8

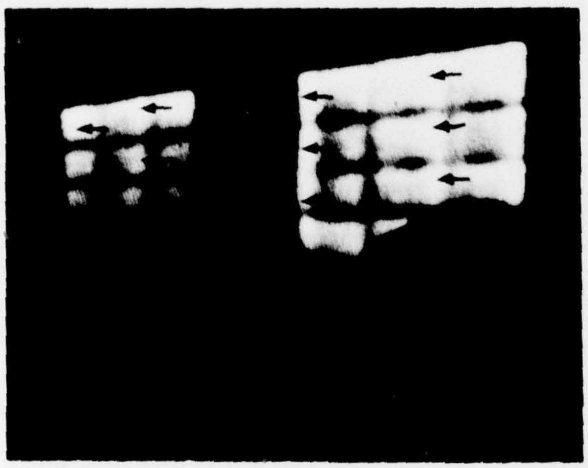


Figure 9

Figure 10

Figure 11

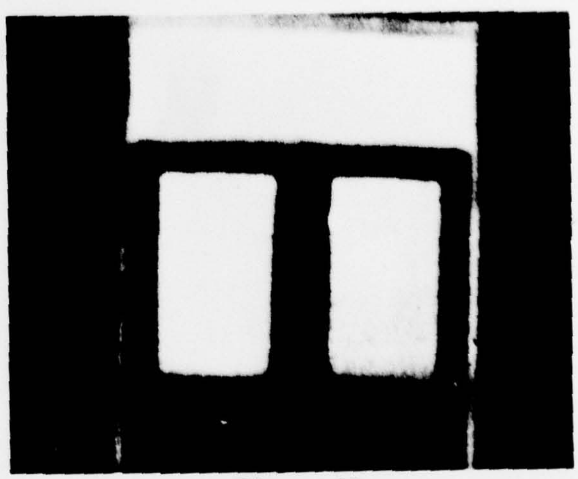


Figure 12

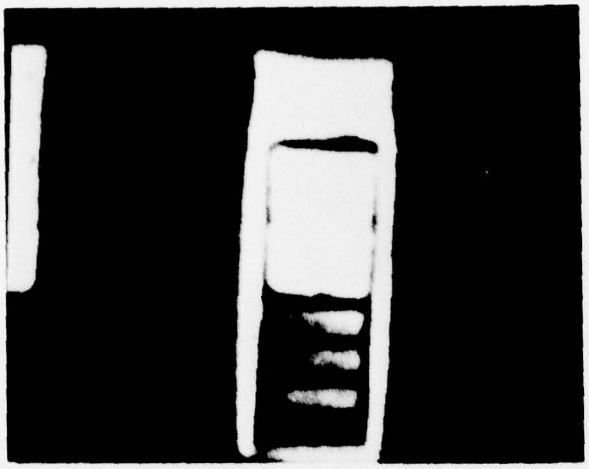


Figure 13

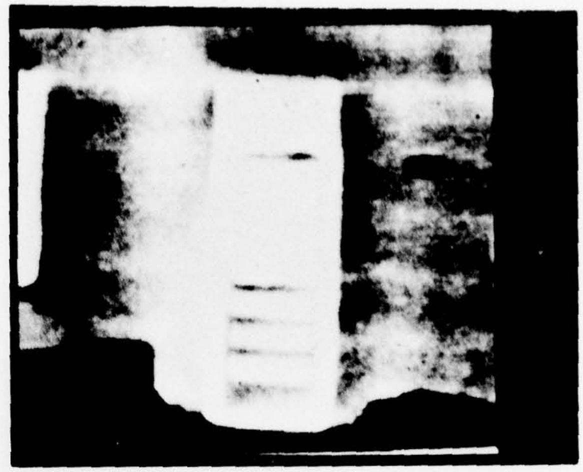
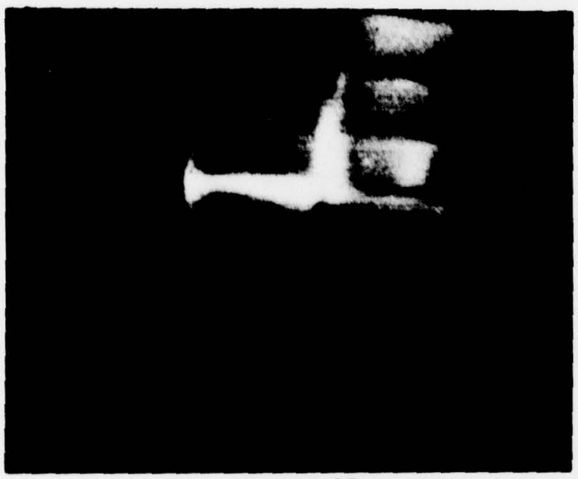


Figure 14



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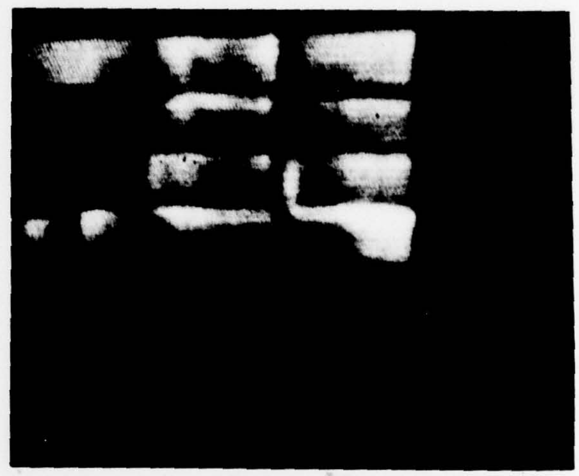

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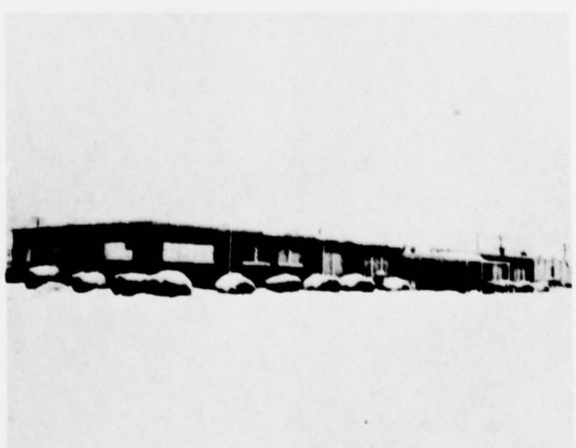


Figure 17

BUILDING 2035
CAPEHART HOUSING UNIT

The Capehart Housing Unit is a combination of face brick and stucco exterior finish (Fig. 4b). It is a one-story building with subgrade insulation and attic insulation, but according to the drawings there is no wall insulation. Exterior wall materials are either stucco or face brick followed by sheathing 25/32 in. thick and on the inside aluminum foil-backed dry wall. The Capehart structure is built on a concrete slab. This particular Capehart unit has storm sashes on all windows except the south-facing picture window which is fitted with insulating glass.

Figure 1 shows heat loss (arrows) through the wall under a north-facing window. Figure 2 shows heat loss through the east-facing laundry room wall. Figure 3 shows heat loss (arrows) through the south-facing laundry room wall. Figure 3 also shows heat loss through the foundation of the laundry room. Figure 4a shows heat loss (arrows) from the wall under a window on the west face of the west wing of this structure. Figure 4b (photograph) of the west face of the Capehart structure shows roof heat loss by virtue of the fact that there is no snow on the roof located above four of the north-facing windows. Most of the rest of the roof is covered with snow. However, the photograph shows that the joists are outlined with snow, but that in between the joists there is no snow.

Figures 5, 6 and 7 indicate air leakage (arrows) around the south-facing picture window. Figure 8 shows heat escaping from foundation vents. Figures 9 and 10 show heat loss (arrows) from the gable vents from either end of this housing unit. Figure 11 shows heat loss from the roof of the unit. At the time these thermograms were taken, there was only a small amount of snow on the roof. The location of the snow is marked by those areas which are black.

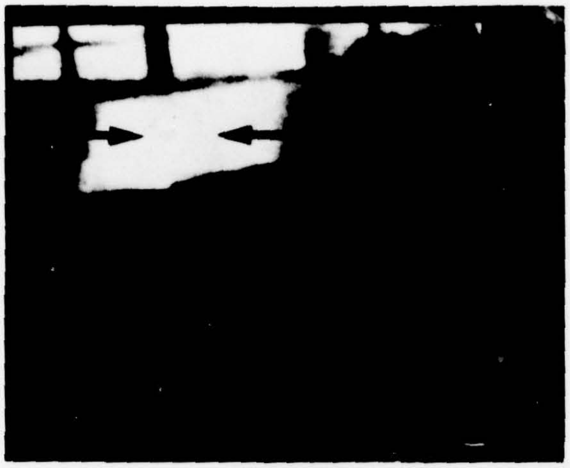


Figure 1

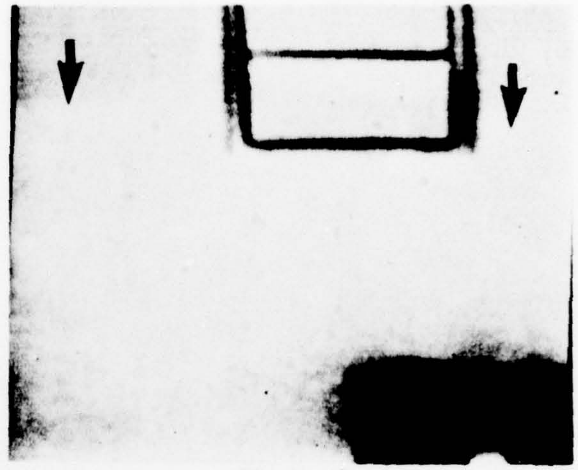


Figure 2

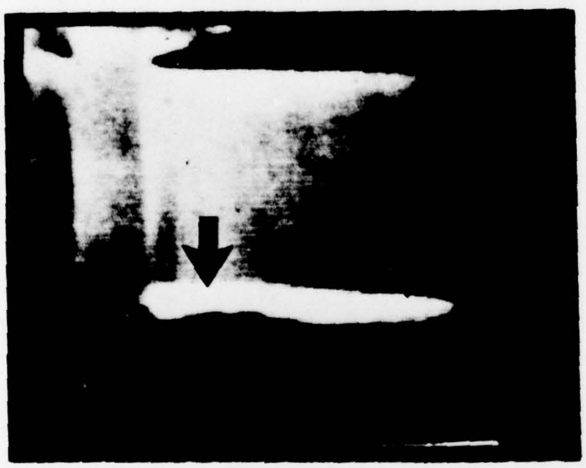


Figure 3

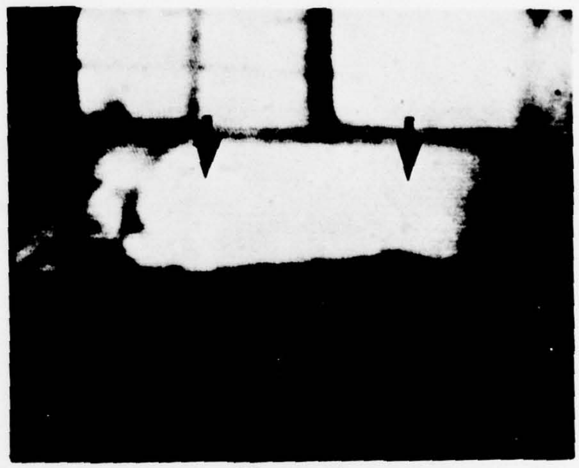


Figure 4a

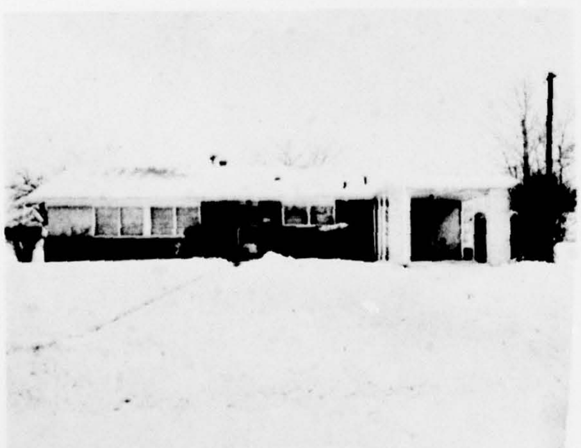
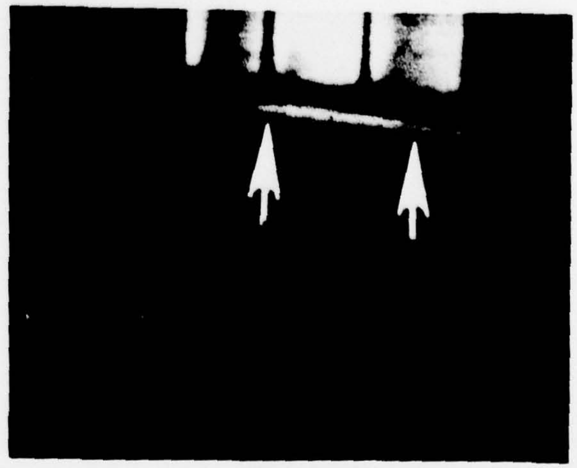


Figure 4b



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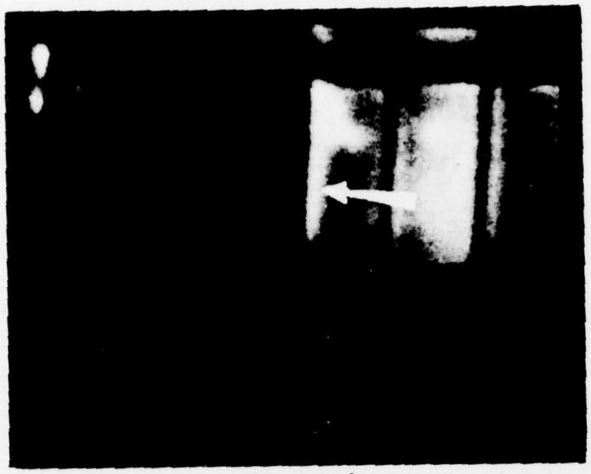

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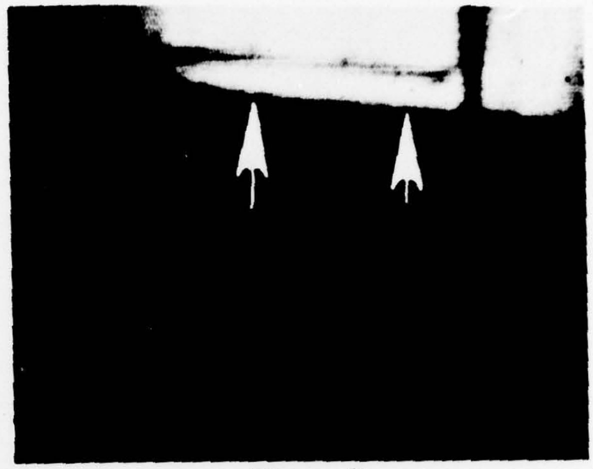

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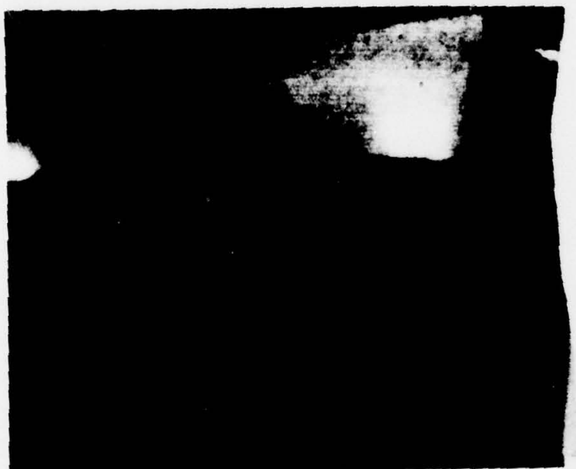

Figure 8

Figure 9

Figure 10

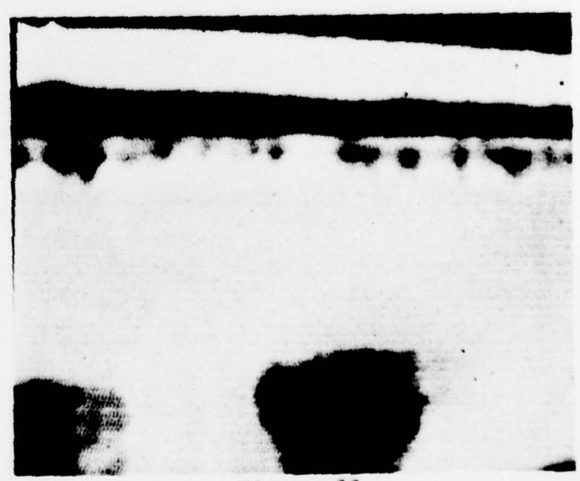

Figure 11

WHERRY HOUSING UNITS

The architectural drawings indicate that there are five types of Wherry Housing Units. These units are a combination of one- and two-story structures, utilizing brick and stucco as the basic exterior wall finish. The walls that have stucco finish have no brick underneath the stucco. In other words, the stucco is installed directly on the sheathing. A typical wall section for a Wherry housing unit has the following materials: stucco on lath; 1/2-in. waterproof-insulating sheathing; batt insulation and 1/2-in. foil-backed gypsum board. In certain housing units brick is used instead of stucco. The thickness of the insulation in all of the walls, according to the drawings, is 1 in. The drawings specify that the thermal resistance of this insulation is 7 per 1-in. thickness. However, this is an error; it should be 3.7 per 1-in. thickness. The drawing of a typical wall section of a Wherry housing unit does not show brick as an exterior finish. That raises a question as to whether the insulation is the same in this situation as it is where the exterior wall finish is stucco.

Figure 1 is a thermogram of a type-one Wherry housing unit. Figure 1 shows excess heat loss (arrows) through the brick veneer, while there seems to be minimal heat loss through the stucco. Generally speaking, in most of the thermograms of the Wherry housing units, the brick veneer appears to be warmer than the stucco. If there are no differences in the thickness of insulation behind the stucco and the brick, it is not clear why there is such a contrast in the thermal patterns of these two materials.

Although these housing units have storm windows, many of them are not being used properly; that is, the lower section was in the top position. This shows on the thermograms as excess heat loss through the lower part of the window.

Figures 2 and 3 are thermograms of the housing unit at 38 Elm. The stucco in this unit does not exhibit the same type of thermal pattern that it does in the unit shown in Figure 1. Figure 2 shows two sets of two windows. Notice that in each set the lower windows are warmer than the upper windows. In addition, the lower windows on the left are warmer than those on the right, indicating that the room on the left is at a higher temperature. Figure 3 also shows excess heat coming from the lower sash.

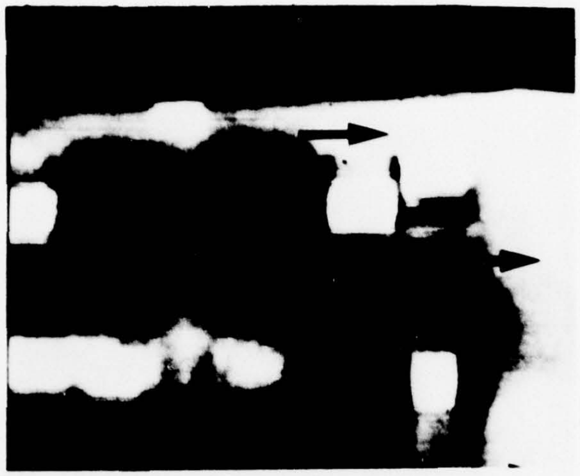

Figure 1

Figure 2

Figure 3

BUILDING S-1
WING HEADQUARTERS

Building S-1 is a one-story frame building with aluminum siding (Fig. 5). A typical wall section in this building consists of aluminum siding with 1/2-in. foam backing, frame siding, 1-in. sheathing, no insulation in the wall cavity, and finally, 1/2-in. insulation board.

During the thermographic survey of this building, we noticed that there was not much temperature contrast across any given wall in this building. However, the thermograms in Figures 1 and 2 do show some contrast. Also, Figure 2 is interesting in that there are a number of randomly spaced black spots on the east face at the north corner. Immediately adjacent to the left window in Figure 2 is a large, dark zone. This dark zone is located to the right of the top part of the window and extends almost the length of the top part of this window. Further to the right of this window can be seen two dark stripes that are approximately the same length as the one immediately adjacent to the window. However, they are not as clearly defined and are not quite as wide. An initial impression of the two dark stripes is that they could possibly be a partial thermal profile of studs. However, all these dark areas could also be attributable to moisture trapped in the siding or sheathing. Since, generally, the thermal profile of the studs could not be seen over the walls of this building, we must assume that the foam-backed aluminum siding is retarding the heat flow through these studs.

Note in Figure 2 the infiltration loss around the top and sides of the window (arrows). Infiltration losses can also be seen in Figures 3 and 4. Those losses, however, are located where the glass meets the frame of the window, whereas in Figure 2, the losses that have been described are around the framing space of the window. Figure 5 is a photograph of the east section of the north face.

Due to the low emissivity of the aluminum siding (with its characteristics of high reflectance), it was difficult to obtain the true heat loss characteristics of this structure. From this standpoint, it would have been more desirable to perform the heat loss survey from the inside of this structure. This would have allowed us to observe the thermal integrity of the insulation board and see whether or not cold air was moving through the wall cavity, or even whether cold air was being conducted through the studs. However, due to the size of this structure and the problems of security and moving furniture, the survey had to be performed from the outside.

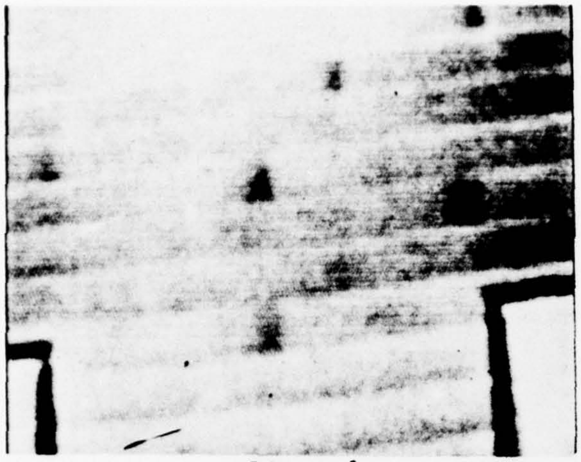

Figure 1

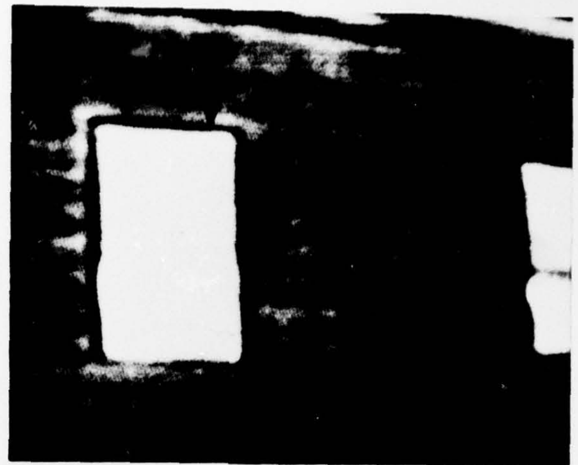

Figure 2

Figure 3

Figure 4

Figure 5