

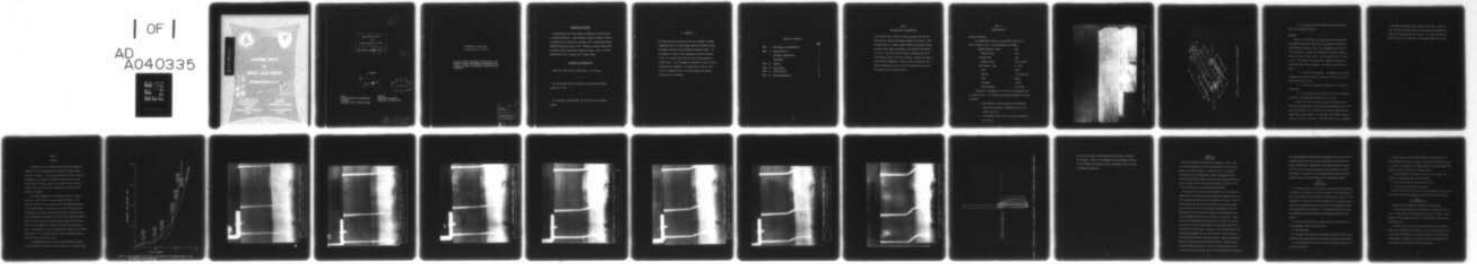
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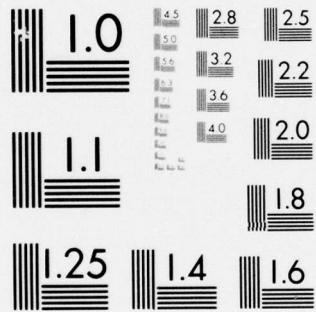
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DYNAMIC TESTS
ON
WOOD - NAIL JOINTS

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DYNAMIC TESTS
ON
WOOD-NAIL JOINTS

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INTERIM REPORT, NO. 2

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MTMC
TRANSPORTATION ENGINEERING
AGENCY
NEWPORT NEWS, VIRGINIA 23606

DARCOM
AMMUNITION CENTER
SAVANNA, ILLINOIS 61074

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DYNAMIC TESTS ON
WOOD-NAIL JOINTS

A JOINT TESTING PROGRAM CONDUCTED BY THE
MILITARY TRAFFIC MANAGEMENT COMMAND AND
US ARMY MATERIEL DEVELOPMENT AND READINESS
COMMAND.

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** ABSTRACT **

This report documents a special test that was conducted to provide supplemental data for the joint project between the Military Traffic Management Command and the DARCOM Ammunition Center. The test produced a series of X-Ray photographs to show the distortion of nails in a wood-nail joint after the joint has been exposed to dynamic forces. Seven photographs are presented to show the amount of distortion from negligible, to a double bend in each nail when the joint is exposed to forces up to and exceeding the maximum force the joint can withstand.

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PART I

BACKGROUND INFORMATION

A wood-nailed joint is difficult to analyze because there are many factors that can influence the holding capability of the joint. Some of these factors are: moisture content, density, and species of wood; nail size, finish, depth of penetration, and mechanical characteristic of the nail. With each of these variables contributing some effect on the amount of force a joint can withstand, a decision was made to produce X-Ray photographs of a joint at various intervals of a test to obtain information that could be useful in analyzing the results from the laboratory tests on wood-nail joints.

PART II
METHODOLOGY

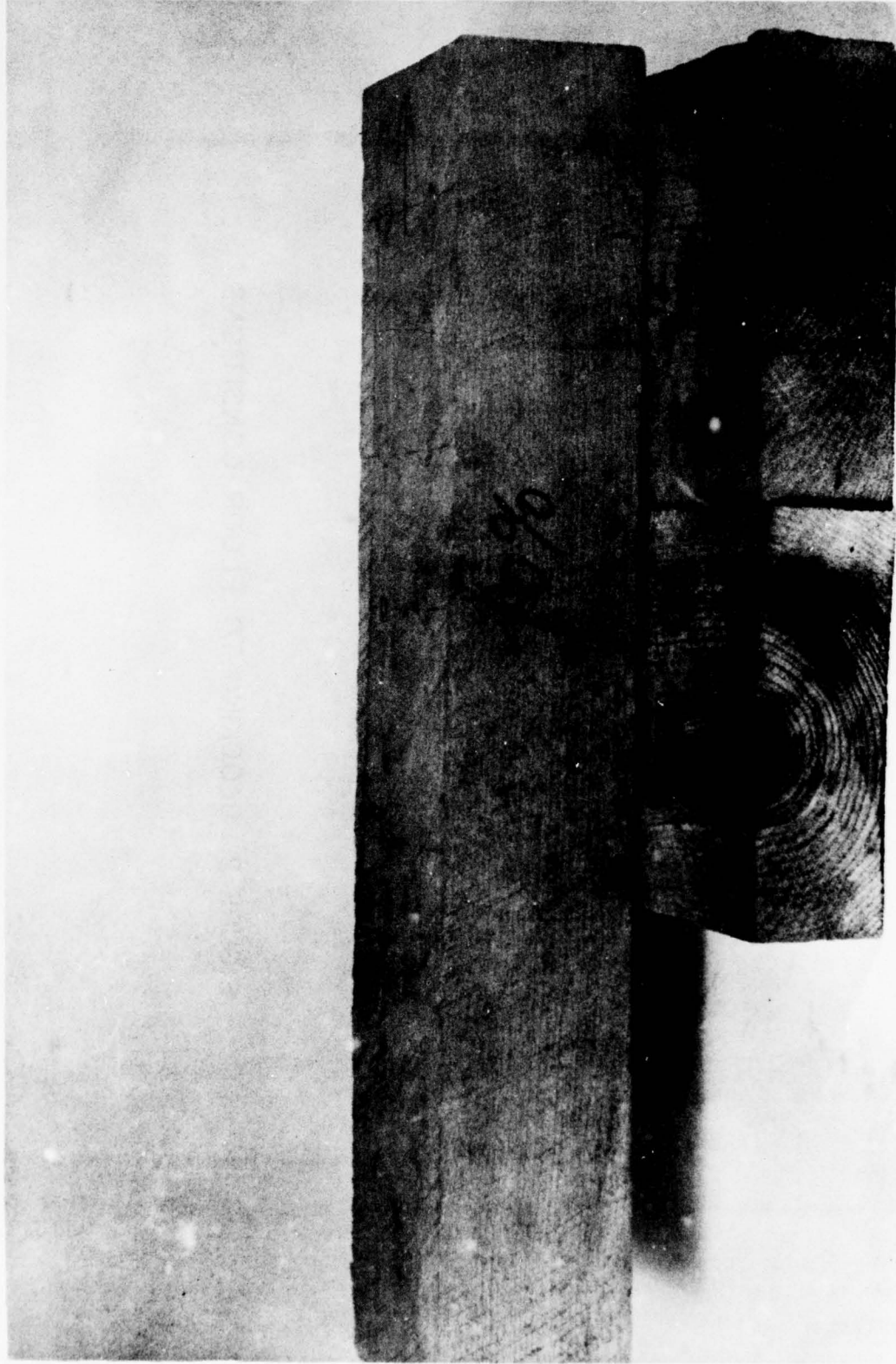
Specimen Description:

The configuration selected for the sequential X-ray test is shown in Figures 1 and 2. Other information is as follows:

Blocking Material or Cleat	Oak
Moisture content	10%
Simulated Floor	Oak
Moisture content	8.5%, 8.25%
Nail Quantity - Size	3 - 50d
Shank	Plain
Material	Low carbon steel
Finish	Bright
Orientation	Vertical
Floor penetration	2-1/4 inch

The specimen is compatible with test 2-14 of the laboratory tests on wood-nail joints. This configuration was selected based on the following factors:

1. The orientation with the wood grain of the blocking normal to the floor grain is probably one of the most common used joints.
2. Oak blocking with oak floor is the basic combination in the test plan.



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Figure 1

This floor-nail-cleat assembly was used in the X-Ray Test.

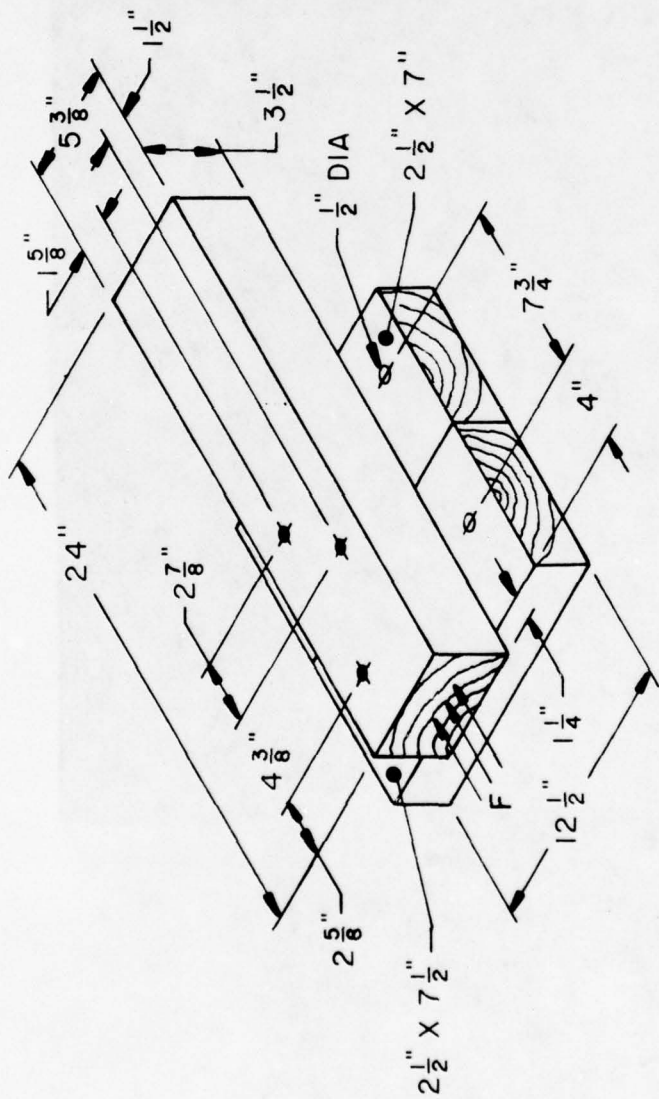


FIGURE 2. BLOCKING TO FLOOR CONDITIONS

3. Low carbon nail with a bright finish would also correspond with a commonly used joint.

Procedure:

One test was performed on the sample using the usual procedure (See DARCOM Ammunition Center Report "Transportability Criteria for Cargo Restraints" dated July 1974). The oscillograph record from that test was analyzed to determine the relationship of permanent displacement with increase in impact number, which is equivalent to an increase in force. This relationship would provide a guideline in selecting the intervals for taking X-Ray photographs. The intervals were selected as follows:

1. At 0.03 inch displacement. This position would provide a photograph after the slack has been removed from the joint and it would show the nails prior to yield.
2. A 0.05 inch displacement corresponds to the yield point for the joint.
3. The remaining intervals would be at 0.1 inch displacement and each 0.1 inch displacement thereafter up to 0.6 inch.

At each of the above intervals the sample was removed from the dolly by removing the bolts and disconnecting the displacement gage. The gage mounting bracket that was located on the sample remained with the sample during X-Ray procedures. A description of the X-Ray facility is presented in the referenced report. After obtaining an X-Ray photograph

of the sample, the sample is again installed on the dolly. Before the joint was removed and after the joint was installed the displacements as shown on the instrumentation were recorded. The third simulated floor board that was used to support the cleat remained affixed to the dolly.

PART III

RESULTS

The baseline curve for determining the intervals for taking the X-Rays and the curve that shows the interruptions for taking X-Rays are shown in Figure 3. Even though precautions were taken in handling the specimen, it was difficult to replace the specimen in the exact location where it had been before it was removed. Note the abrupt changes in the curve each time the specimen was removed from and replaced on the dolly.

The X-Ray photographs of the specimen are shown as Figures 4 through 10. If the X-Rays are to be compared with Figure 2, the specimen in Figure 2 must be oriented so that the longitudinal direction of the simulated floor is vertical and the two nails in the same longitudinal plane of the cleat are above the third nail. The darker portions on the photograph are analogous to the ends of the simulated floor boards. Because the nails are not in the same horizontal plane, the nail that is closer to the film appears to be shorter and smaller than the other two nails. This appearance is due to the shadow effect produced by the X-Rays being emitted in a conical pattern and the nails in horizontal planes between the X-Ray emitter and the film.

By superimposing the seven X-Rays and maintaining the position of the nail head, the results are as shown in Figure 11. Note that during

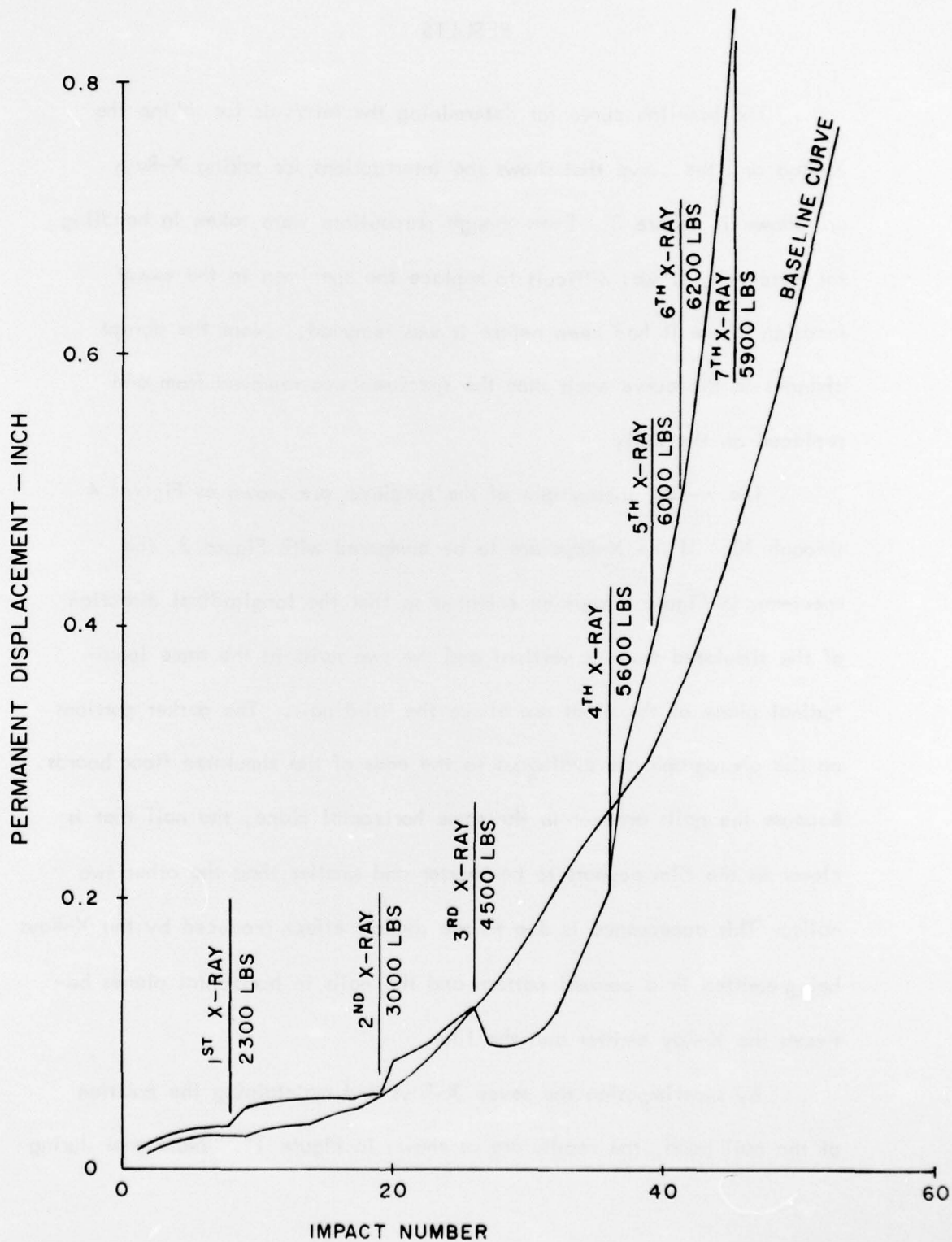


FIGURE 3. DISPLACEMENT AND FORCE SUSTAINED BY SPECIMEN WHEN X-RAY PHOTOGRAPH WAS PRODUCED.

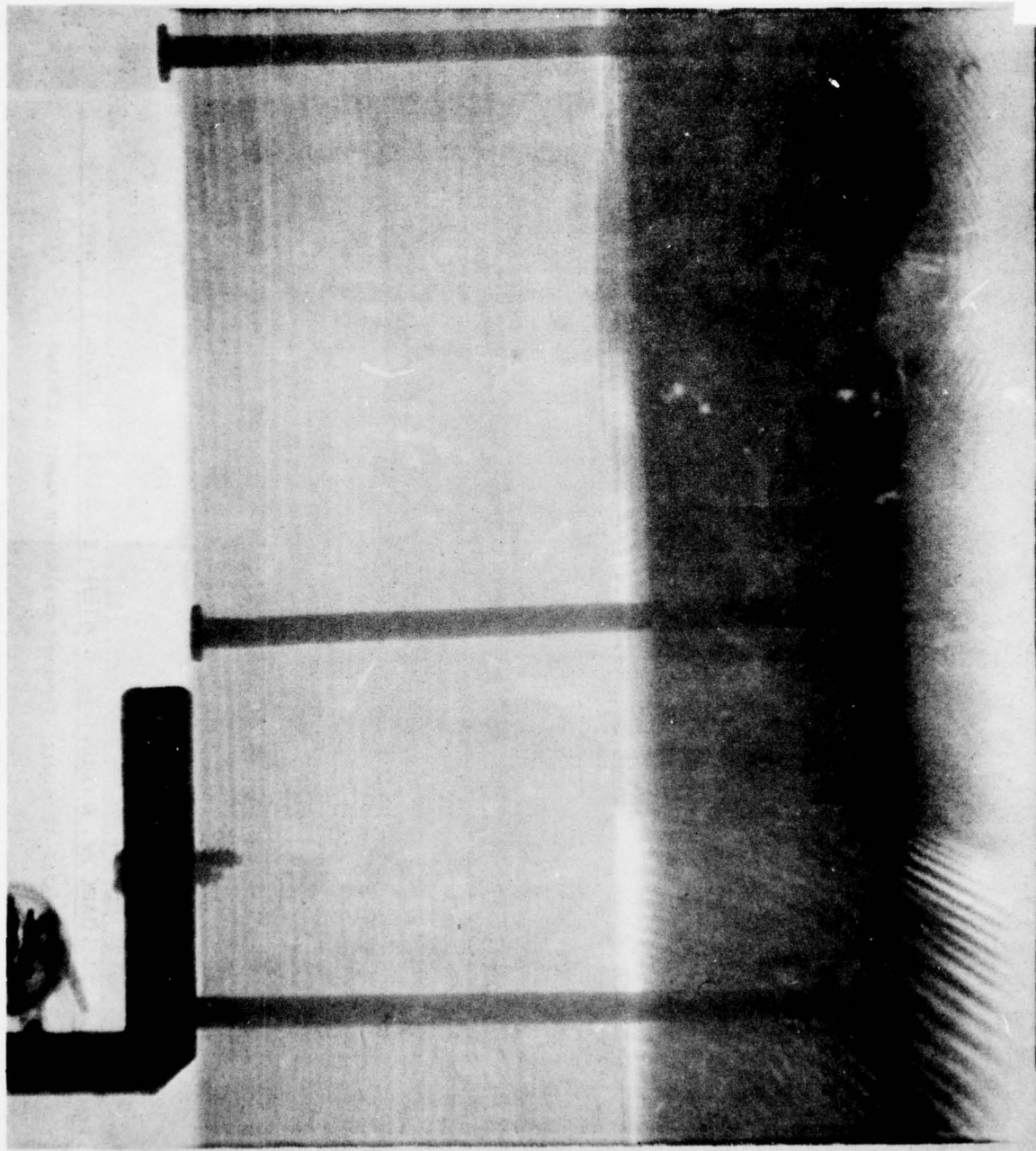


Figure 4 | DARCOM AMMUNITION CENTER - SAVANNA, ILLINOIS | November 1976
Nail distortion after 8 impacts. Permanent displacement equals 0.03 inch.

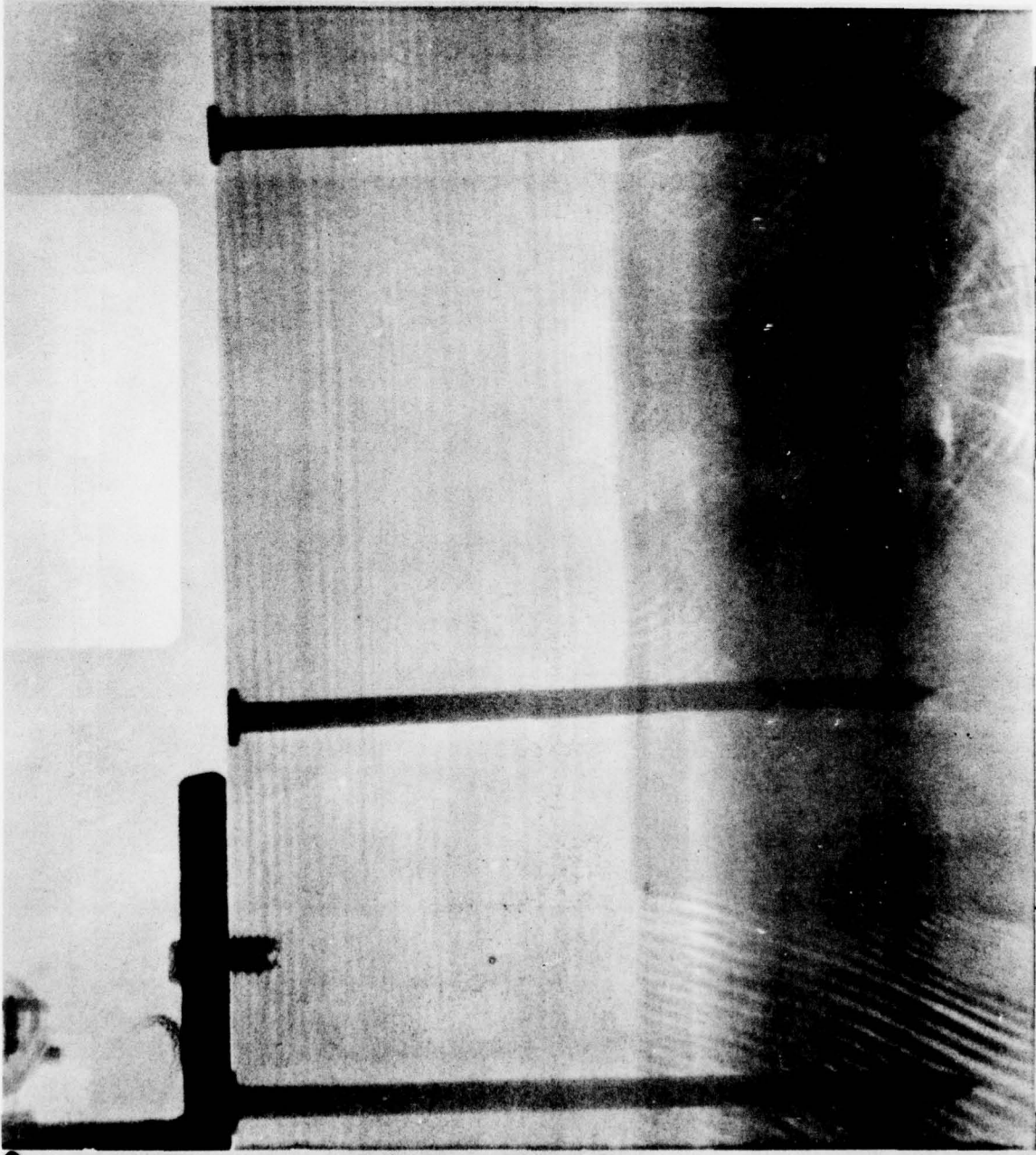
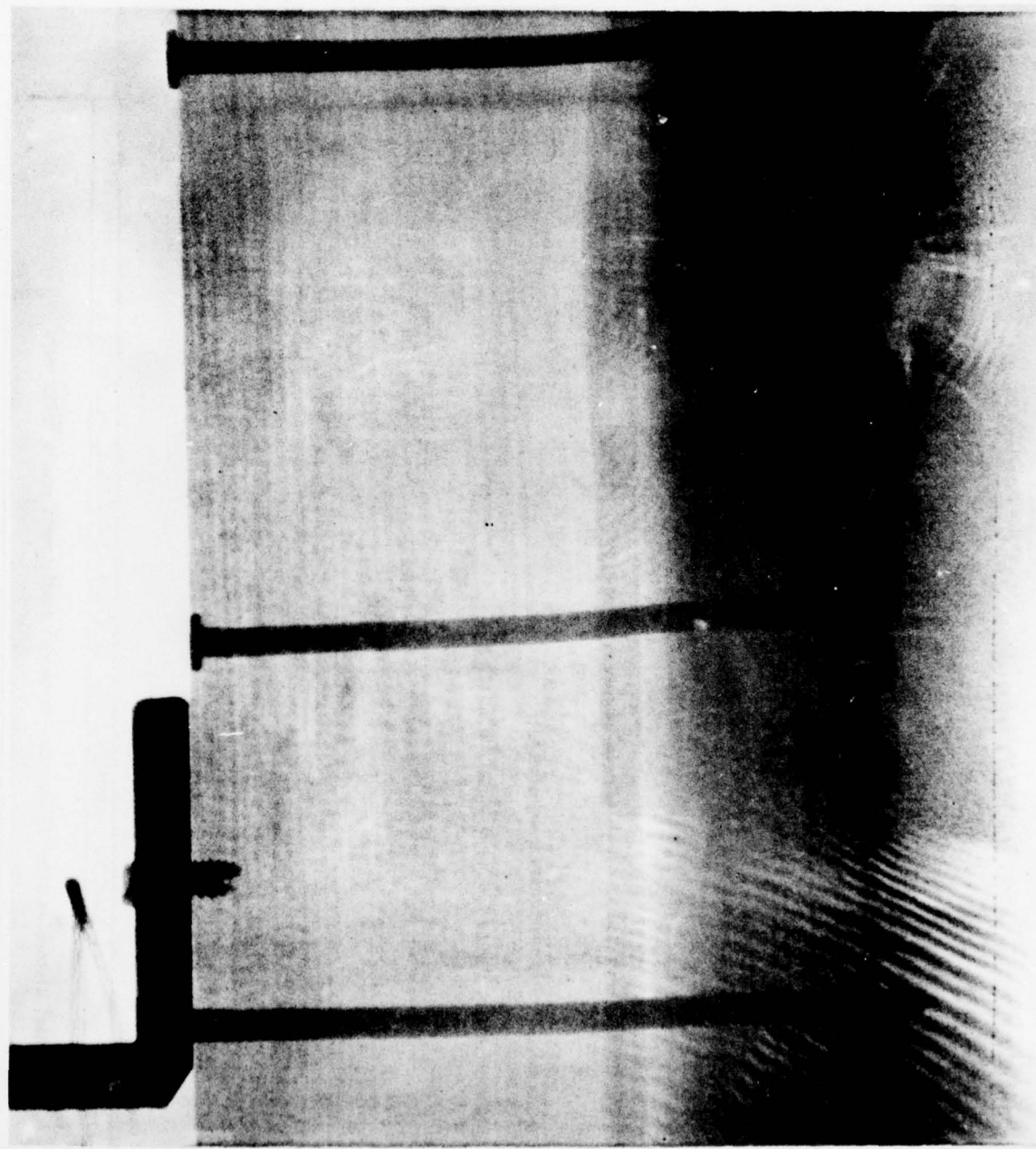


Figure 5

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Nail distortion after 19 impacts. Permanent displacement equals 0.053 inch.

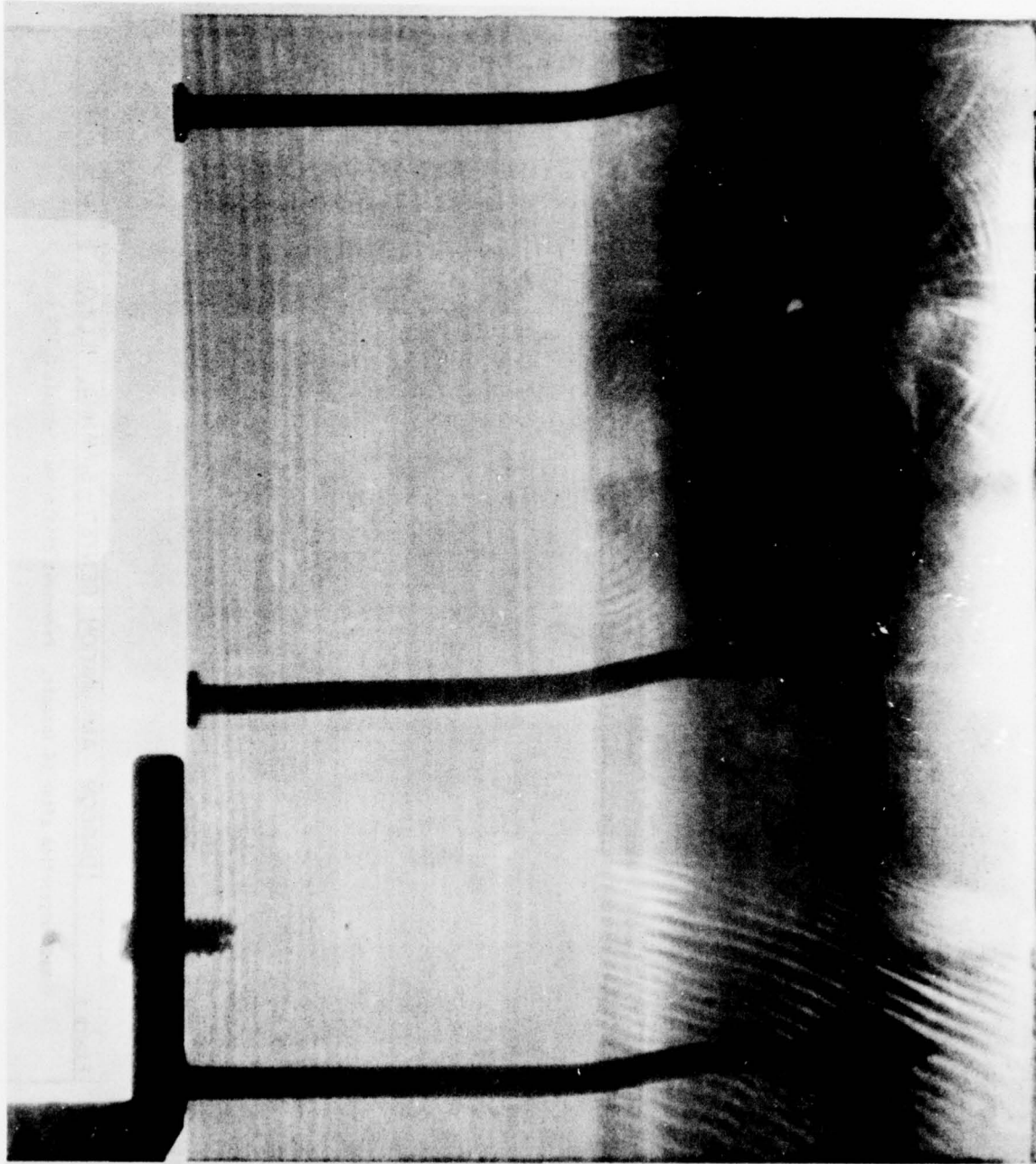


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Figure 6

Nail distortion after 26 impacts. Permanent displacement equals 0.109 inch.



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Figure 7

Nail distortion after 36 impacts. Permanent displacement equals 0.196 inch.

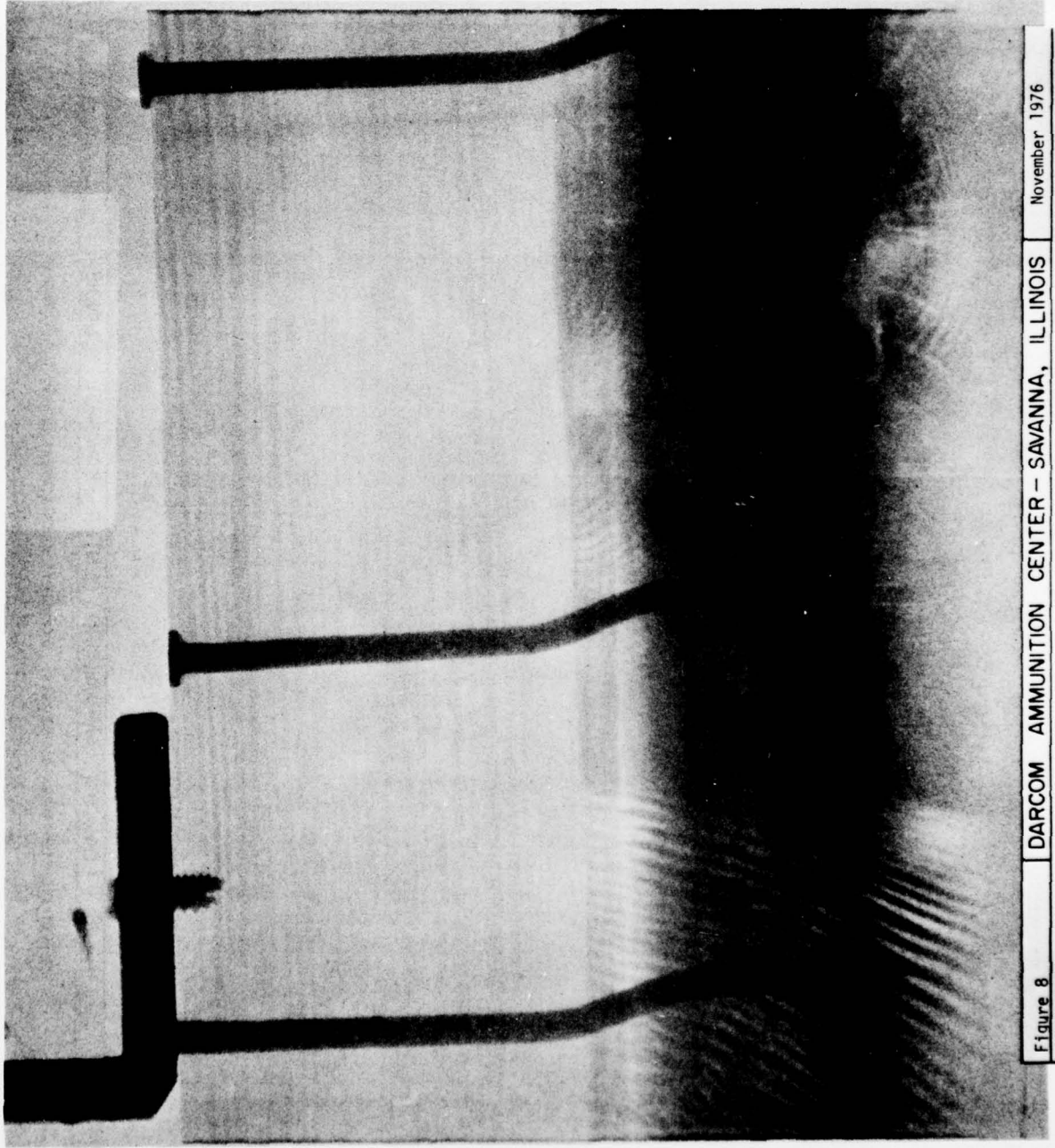


Figure 8

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Nail distortion after 39 impacts. Permanent displacement equals 0.366 inch.

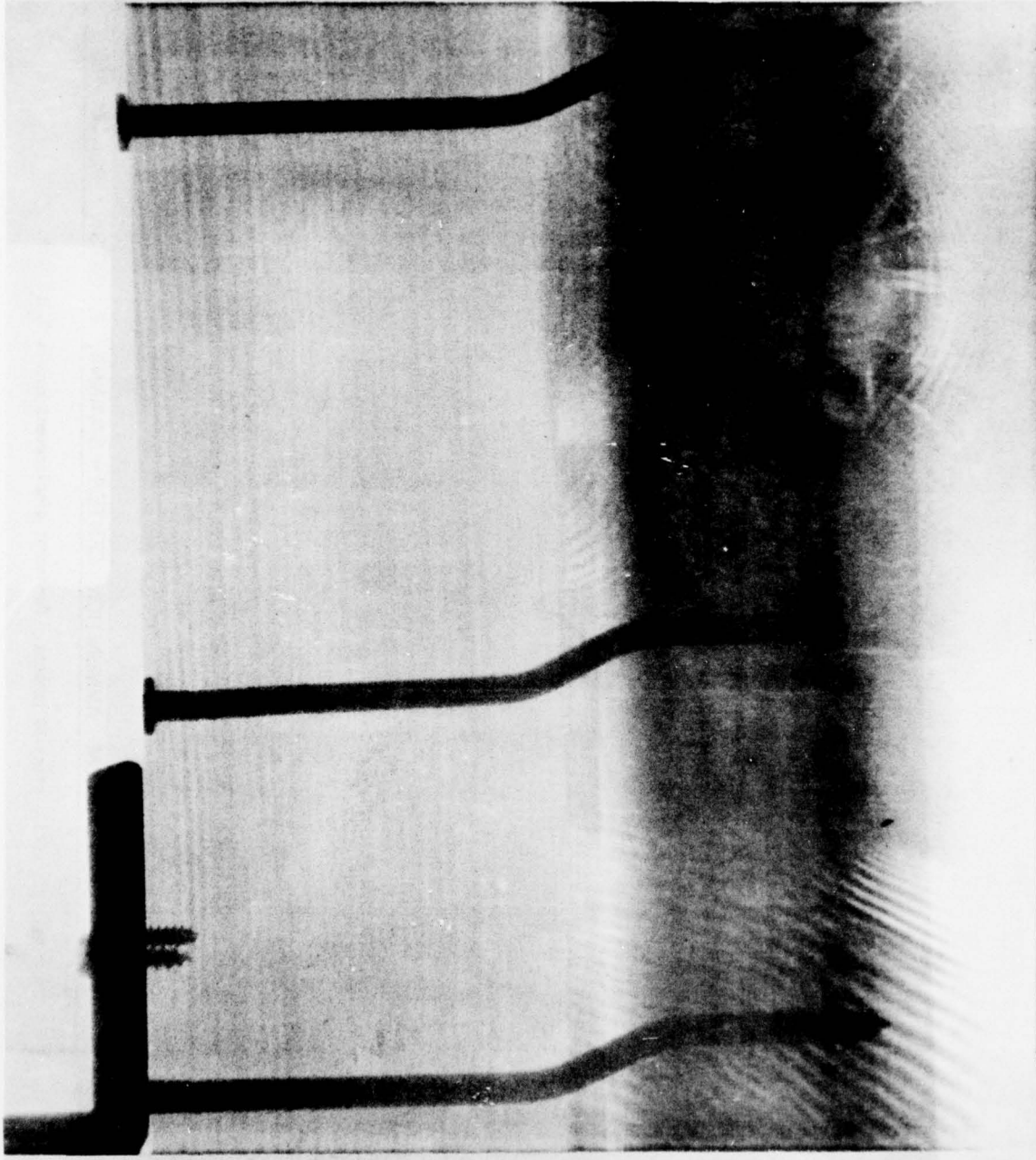


Figure 2	DARCOM AMMUNITION CENTER - SAVANNAH, ILLINOIS	November 1976
Nail distortion after 41 impacts. Permanent displacement equals 0.467 inch.		

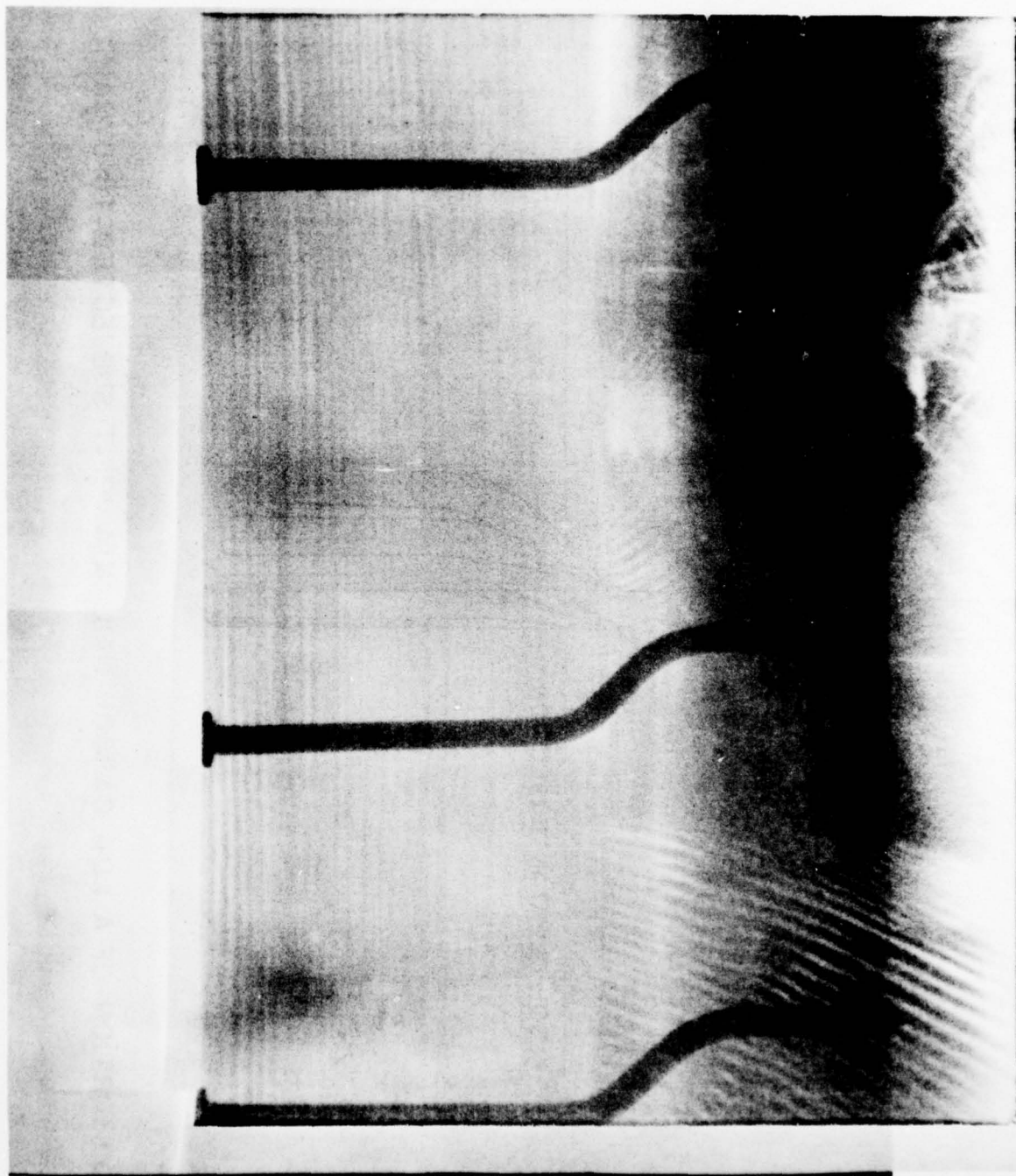


Figure 10 DARCUM AMMUNITION CENTER - SAVANNA, ILLINOIS November 1976

Nail distortion after 45 impacts. Permanent displacement equals 0.841 inch.

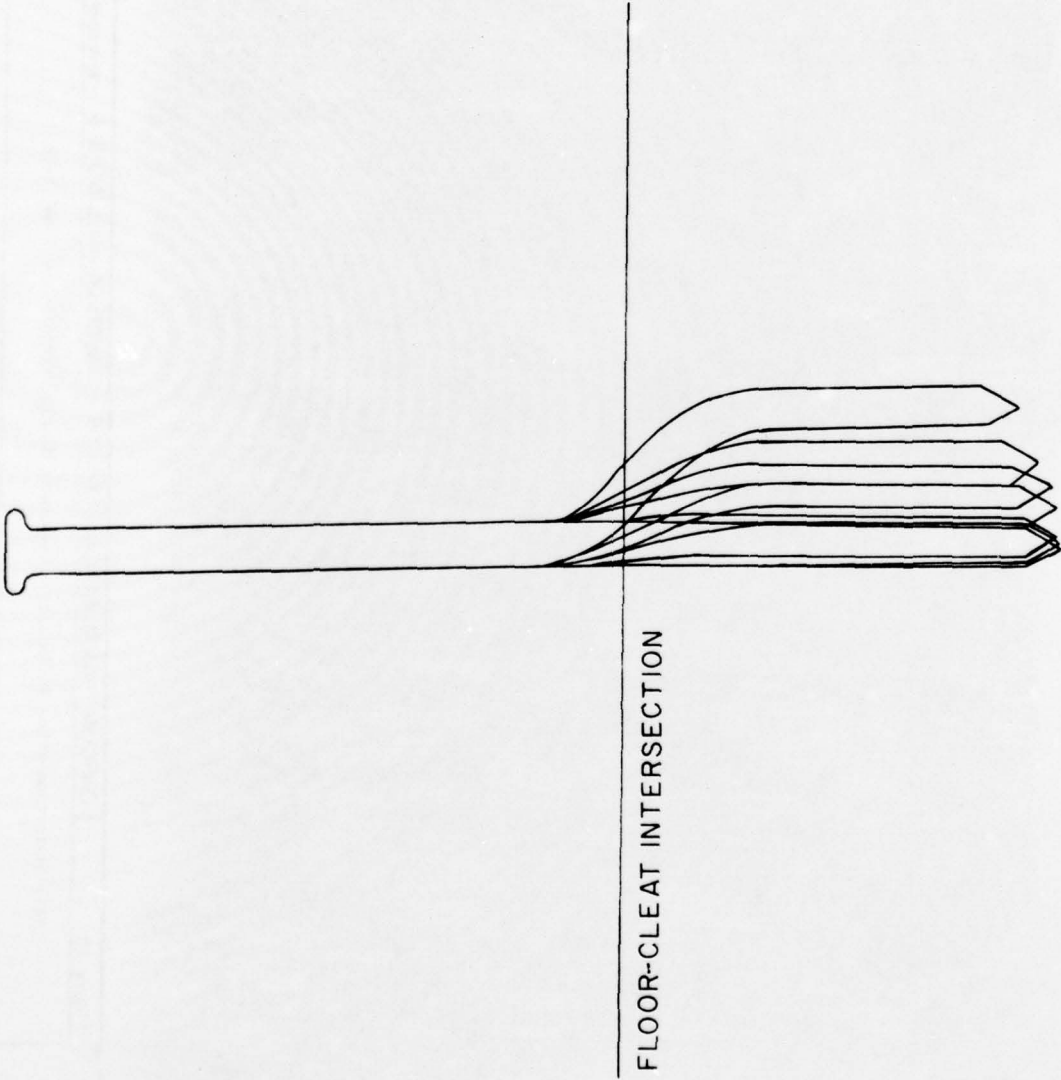


FIGURE II. DISTORTION OF A LOW CARBON NAIL IN A JOINT SUBJECTED TO DYNAMIC FORCES

the test the top board or cleat moved and not the floor as indicated in this Figure. However this arrangement has the advantage of showing the nail distortion and change in depth of penetration with the increase in permanent displacement.

PART IV DISCUSSION

Observe the distortion of the nails shown in Figures 4, 5, and 6. There is no observable distortion in the nails in Figures 4 and 5 but there is some distortion in the nails in Figure 6. As stated in Part II, the yield point corresponds to 0.05 inch displacement. Figure 5 represents the nail distortion at the yield point. Based on this information it appears that the yield point corresponds with the force required to bend the low carbon nail. (At this point the observation must be considered an hypothesis).

That observation is enough to prompt the formation of a relationship which states that the force required to bend a nail equals the holding strength of the joint. But additional analyses all too soon add mud to the water. The force required to bend a nail may vary due to the density of the wood being tested. Look at Figures 9 and 10. The nail distortion in these figures will provide guidelines as to what occurred prior to Figure 5. First observation that you notice is probably the fact that each nail is bent in two locations. Looking closer at the bends and observing the difference in the radius of each bend, the bend in the cleat or top board appears to be smaller than the bend in the simulated floor or bottom board. Furthermore, most of the displacement of the cleat and floor appears to have occurred in the floor - Note the location of the floor edge or intersection of the cleat and floor. Additional X-Ray photographs of failed joints will be performed and may aid in explaining why the nails deformed the way they did. In order for the nails to bend as shown in the figures, the wood at the edge of the holes in each board must be compressed.

The X-Ray photographs indicates that the compressibility of the wood in the floor is higher than that in the cleat. Since the cleat and floor are made from oak lumber, the difference in compressibility must be caused by another characteristic of the joint, such as growth ring spacing or grain orientation, or reaction to the impact. (For example, the moving member transfers forces to the nail in a different manner than the nail transfer forces to the stationary member).

PART V CONCLUSIONS

1. The X-Ray analysis of one wood-nail joint showed that this type of analysis is beneficial in the evaluation of cleat-floor assemblies. It also substantiates the need to perform additional X-Ray analyses on wood-nail joints consisting of various combinations of wood and nails. All of the analyses are not required to be as detailed as the one described in this report; however, X-Ray photographs of failed joints would determine if the difference in nail distortion between several cleat-floor assemblies is great enough to justify conducting another detailed X-Ray analysis.

2. The following observations were made and should be considered when an X-Ray photograph is made of a wood-nail joint.

- a. Record test number.
- b. Use supports, instrumentation, and equipment to align the top of the simulated floor of the joint assembly with the centerline of the X-Ray emitter pattern.
- c. Record the distance of nail from the X-Ray emitter and the distance of the nail from the X-Ray film.

d. Make a sketch of sample showing locations of nails and dimensions of boards if different from sketch in test plan. Also show growth rings (not necessarily to scale). Some samples require modification before X-Ray photographs can be produced. Identify the nail used in observation 3 above.

e. Record orientation of the sample with respect to the film holder. For example which side of the sample was toward the film.

f. Record X-Ray penetration setting and exposure time.

g. Protect X-Ray photograph from overexposure.

The above information would be required if X-Ray photographs of various joints are compared to obtain technical data on the difference between the samples.

PART VI RECOMMENDATIONS

The following recommendations are presented for the subject test:

1. Conduct progressive step-wise X-Ray analysis of a softwood on softwood joint to compare with the aforementioned oak on oak joint. Similarly, conduct progressive X-Ray analysis of oak cleat on soft floor specimen and soft cleat on oak floor specimen.

2. Compare X-Rays of nail distortion and the amount of force sustained by the joint of all failed cleat-floor assemblies with the results produced by the oak on oak subject of this report. This comparison will yield an ultimate-strength-nail deformation relationship for every wood-nail joint configuration that has been tested in the Incline-Impact Laboratory Test Program.