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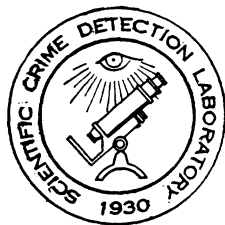
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POLICE SCIENCE



Editor: FRED E. INBAU

TECHNIQUE USED IN TRACING THE LINDBERGH KIDNAPING LADDER

ARTHUR KOEHLER†

That the ladder used in kidnaping the Lindbergh baby would reveal valuable information regarding the kidnaper was obvious as soon as it was thoroughly examined.¹ So many different things could be observed on this ladder that it was almost certain that if one thing did not yield important clues another or several others would. A complete catalog of all the items observed would be too long a list to print, but those which proved to be valuable and some others that appeared to have possible significance are here given.

Observations Made on the Ladder

1. The ladder was home-made, which meant that it contained individual characteristics. It was not one out of a thousand or ten thousand, all superficially alike; it was the only one like it and could be expected to reveal some of the peculiarities and associations of the man who made it.

† Forest Products Laboratory, Forest Service, U. S. Department of Agriculture; maintained at Madison, Wis., in cooperation with the University of Wisconsin.

¹ The examination was made at the request of Colonel H. Norman Schwarzkopf, Superintendent of the New Jersey State Police.

2. The rungs of the ladder, although made of soft ponderosa pine, showed absolutely no signs of wear, which indicated that the ladder had no previous usage and was undoubtedly made for this particular job. This fact made the possibility of tracing it much better than if it had been an older, used ladder.

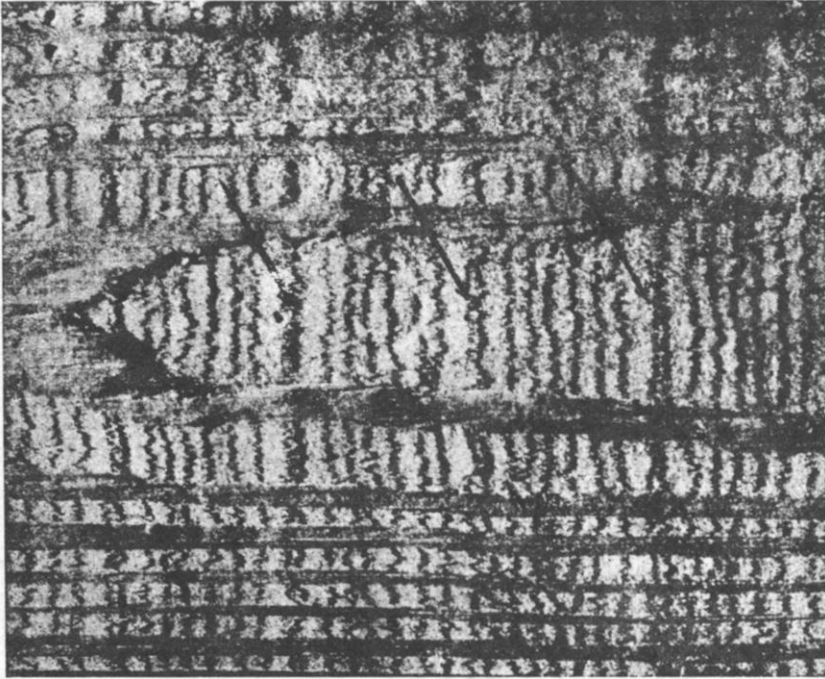
3. It showed poor design and workmanship and indicated that the man who made that ladder was not a high-grade mechanic.

4. It was made in three sections comprising a number of different kinds of lumber. Three of the six uprights, or rails, were North Carolina pine; the other three rails and one rung were Douglas fir; and the other ten rungs were ponderosa pine. The two dowels used to fasten the three sections of the ladder together were birch.

5. Five of the six rails were regular 1x4-inch lumber, which when dressed usually is $\frac{3}{4}$ inch thick and $3\frac{5}{8}$ or $3\frac{3}{4}$ inches wide. One of the North Carolina pine rails, however, had been narrowed down from a wider board as was indicated by hand saw and hand plane marks on the edges. Two of the North Carolina pine rails were cut from one board which was fourteen feet long originally. It could be determined that it had been dressed to $3\frac{3}{4}$ inches in width, which made it unnecessary to pay any attention to similar stock dressed to $3\frac{5}{8}$ inches in width. In fact, that $\frac{1}{8}$ -inch difference in widths narrowed down the tracing of lumber from sixty-three to forty-five carloads.

The ponderosa pine rungs were cut from two 1x6-inch boards that were first ripped along the middle before the cross cuts were made.

6. The two bottom North Carolina pine rails were dressed on a planer with eight knives in the cutter heads that dressed the wide surfaces and six in the cutter heads that dressed the edges, as determined by the number of individual knife cuts between successive cuts made by a defective knife. The lumber went through the planer at the rate of 0.93 inch per revolution of the top and bottom cutter heads and 0.86 inch per revolution of the cutter heads that dressed the edges, as determined by the distance between identical cuts made by a defective knife on each surface. It was by means of the number of knife cuts per revolution of the cutter heads and their widths that these two rails were traced to the M. G. and J. J. Dorn Company of McCormick, South Carolina.



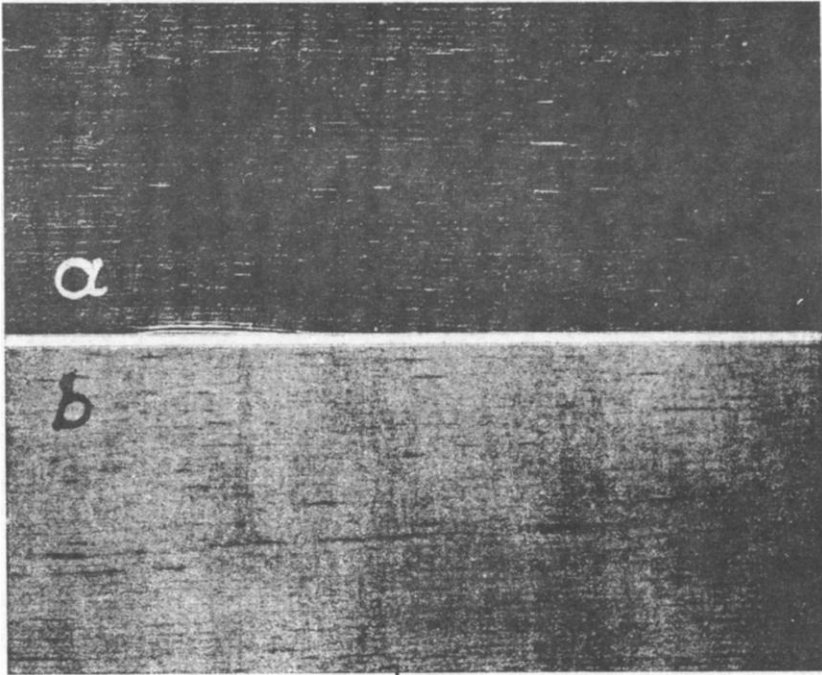
Photograph by New Jersey State Police.

FIGURE 1.

Machine planer knife marks on the sides of the North Carolina pine rails in the bottom section of the ladder by means of which the two bottom rails were traced to the M. G. and J. J. Dorn Company, McCormick, South Carolina.

Note the recurrence of the narrow cut every 0.93 inch (arrows) which indicates the distance the lumber passed through the planer per revolution of the cutter heads and which was the factor that positively linked this lumber with the Dorn mill.

The other pine rail was dressed on a different planer; and, strange as it may seem, the three Douglas fir rails were dressed on three different planers, which tripled the chances of successfully tracing at least some of the fir lumber through the mill at which it was manufactured. The ponderosa pine rungs were dressed on a planer having eight knives in one cutter head and six in each of the other three—a most unusual combination. In fact, only two mills out of a hundred or so that shipped pine lumber to the New York district in 1931 had such a planer. One was located in Bend, Oregon, and the other in Spokane, Washington.



Photograph by U. S. Forest Products Laboratory, Madison, Wis.

FIGURE 2.

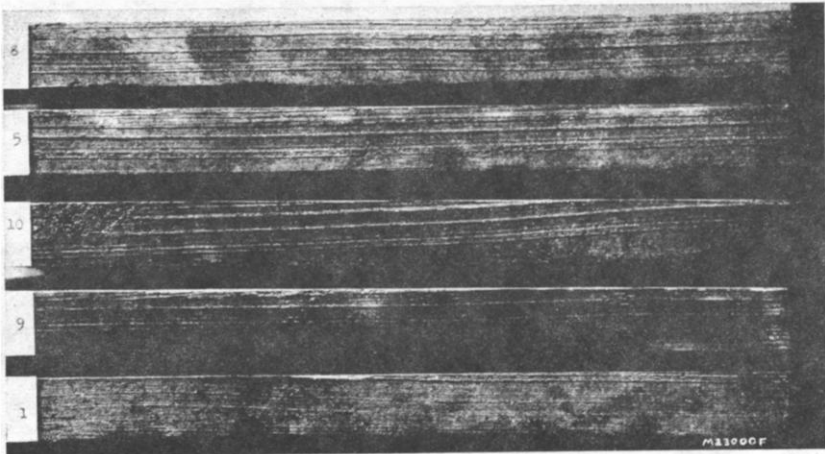
The same piece of Douglas fir lumber photographed by one-sided light (a) to bring out irregularities in the surface and by diffused light (b). The corrugations in (a) represent individual knife cuts of the planer. The short "dashes" represent nicks in individual knives and, because they are repeated in every eighth knife cut, mean that there were 8 knives in the cutter head that planed the surface of the lumber.

7. Peculiar gouges on one edge of each of the two bottom North Carolina pine rails, made by a defective knife in the cutter head (which obviously would be altered as soon as the knives were resharpened) made it possible to identify a shipment of lumber sent from McCormick, South Carolina, to the National Lumber and Millwork Company in the Bronx as the shipment from which the ladder rails came.

8. The famous rail number 16 had four nail holes in it made by 8-penny cut nails. These holes had no connection with the making of the ladder, and therefore indicated previous usage of the

lumber. The rail, although sapwood, showed no signs of having been exposed to the weather for any length of time, since the lumber was bright, unchecked, and had no rust around the nail holes. Therefore, it must have been nailed down indoors and since it was of a low grade of lumber it could not have been used for finish purposes, but rather for rough construction. The suggestion that that rail came from the interior of a barn, garage, or attic was made at the time of the initial critical examination of the ladder.

9. A rather dull hand plane was used in planing the two edges of rail number 16. The plane left numerous characteristic ridges on the wood identical in size and spacing with ridges left by a hand plane on one edge of each of the ponderosa pine rungs. Here were two different kinds and sizes of pine lumber in the ladder planed with the same plane. That meant that very likely the edges of the lumber were planed when the ladder was made rather than on some previous occasion. While the probability of finding that plane in the same condition it was in when the ladder parts were planed became more and more remote as the months and even years elapsed after the kidnaping, the possibility of finding other lumber planed with that plane in the possession of a suspect always remained. (Incidentally, a short piece of lumber planed with that plane was found in Hauptmann's garage.)



Photograph by U. S. Forest Products Laboratory, Madison, Wis.

FIGURE 3.

Ridges made by nicks in bit of hand plane on the edges of five of the ponderosa pine rungs in the kidnap ladder. The ridges were so fine that they were hardly perceptible except in one-sided light.

10. The chisel used in cutting out the recesses for the rungs was a $\frac{3}{4}$ -inch chisel, as could be seen from the width of some of the cuts made with it. This chisel was so sharp that it left no other identifying marks except its size and that it was in excellent condition of sharpness. The chisel found on Colonel Lindbergh's premises on the night of the kidnaping answered the above description, although there undoubtedly also were numerous other sharp $\frac{3}{4}$ -inch chisels in existence. The chisel was identified by the manufacturer in New England as having been made about forty years ago. The age therefore greatly limited the number of such chisels still in use. At the time of Hauptmann's arrest it developed that he had a $\frac{1}{4}$ -inch chisel of the same make and pattern.

11. Some of the saw cuts made in cutting out the recesses for the rungs were made deeper than the depth to which the recesses were chiseled out, which made it possible to determine the width of the saw cuts as 0.035 inch. Hauptmann possessed nine saws, two of which made cuts of that width, both with 10 teeth per inch, one of which was dull and the other sharp.

12. Scratches made on the sides of some of the rungs by accidentally drawing the side of a sharp crosscut saw over the side of the board from which the rungs were cut, or vice versa, revealed through a rather complicated mathematical analysis that they were made with a saw having ten teeth per inch.

13. A thin shaving about the size of a 25-cent piece had been cut with a pocket knife or chisel from the broad sides of two of the rungs near an edge. The cutting edge of that knife or chisel had nicks in it which might have yielded valuable corroborating evidence if the maker of the ladder had been apprehended within a few weeks after the kidnaping. No reason was apparent for the removal of the shavings and the only possible purpose in so doing that presents itself is that an accidental injury in making the ladder might have resulted in a couple of blood spots on the wood which the maker thought best to remove.

14. One of the fir rails had across one face and edge a stripe of red paint several inches wide. It was found to be similar to paint marks made on lumber cargos to mark off lots from individual shippers, although the color of the paint used for that purpose is not always red. The red paint mark narrowed down the tracing of the particular shipment of fir lumber from which that rail came to those for which red paint was used as an identifying mark.

15. The nails used in making the ladder were 8-penny wire nails made by a Pittsburgh wire nail manufacturing concern, as was indicated by their mark, a "P", in the shank of the nail immediately under the head.

16. Only a few hammer dents were visible around the nail heads in the rungs. They, however, showed no peculiar characteristics by means of which the hammer that made them could be identified.

17. There was some barely legible handwriting on one of the Douglas fir rails.

Clues

With such a variety of clues and their possible combinations to work on, the problem was to pick out and follow those that appeared most likely to lead to the kidnaper. Some of the clues obviously would not be valuable until a suspect had been found, such as the hand plane marks on the edges of the lumber in the ladder, unless by sheer accident an investigator ran across lumber with similar characteristics. But if it had not been observed when the ladder was examined that the edges of some of the parts were planed with a dull hand-plane and that two different kinds and sizes of lumber in the ladder had been planed with the same plane, thereby indicating that the plane was used when the ladder was made, Sergeant Wallace of the New Jersey State Police would have had no reason to attach any significance to the plane that he saw on a shelf in Hauptmann's garage. Or if it had not been observed that *both* edges of rail number 16 had been sawed and planed by hand, thereby indicating that it very likely was cut down from a wider *tongued-and-grooved* or *shiplapped board*, Detective Bornmann of the New Jersey State Police probably would not have given any thought to the missing piece of 1x6-inch *tongued-and-grooved* flooring board in Hauptmann's attic when he searched it for ransom money.

Other clues, as the kinds, dimensions and combinations of woods in the ladder, the machine planer marks, the dowels, the red paint, and the nails, offered opportunities for immediate further investigations, some of the results of which are already well known to the public.

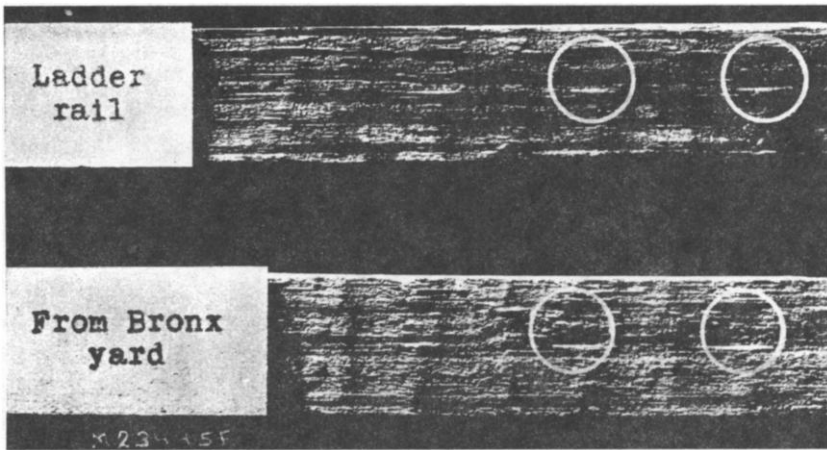
Methods Used in Examination of Ladder

Each piece of wood in the ladder was microscopically examined for identification by means of its cellular structure according to methods well known to wood technologists. In that way it was possible to determine the identity of the lumber much more accurately than by superficial inspection, since the "grain" of any kind of wood may vary but the structure of the individual cells or fibers of a species remains constant.

Accurate measurements to 1/100 inch were made of all parts of the ladder. These measurements revealed not only significant differences or similarities in dimensions, but showed whether variations were due to manufacture of the lumber or to subsequent shrinkage, as the ladder had been stored in a warm room for several months previous to critical examination. For example, the end of one of the bottom rails of the ladder, which was the top end in the tree of the fourteen-foot board from which the two rails were cut, was $3\frac{5}{8}$ inches wide when examined, whereas the end of the other rail, which represented the bottom end in the tree, was 1/16 inch wider. The question arose as to whether or not that board was supposed to be a $3\frac{5}{8}$ -inch board which had accidentally been manufactured so as to be slightly wider at one end—or had the whole board shrunk from the next wider standard size, $3\frac{3}{4}$ inches? Careful examination of the wood in the two rails showed that the wider end was of an abnormal type of wood formed most frequently in the lower end of leaning trees. This abnormal wood does not shrink across the grain as much in drying as does normal wood. This observation, together with the fact that dressed lumber usually has parallel edges when first manufactured, indicated that the board had shrunk subsequent to manufacture and was originally $3\frac{3}{4}$ inches wide. It might be pointed out here that making accurate measurements and comparisons of dimensions is one of the best ways of discovering peculiarities which might escape notice on superficial examination.

Irregularities in the surfaces of the lumber in the ladder were observed by examining the wood in one-sided light, at first from a partially shaded window and later at the Forest Products Laboratory with a spotlight in a darkened room shining at a very acute angle from one side. Distinctions had to be made between irregularities due to the grain of the wood and those made by extraneous agencies, such as tools and machines.

In diagnosing the cause of the shallow intermittent depressions on the edge of the two bottom North Carolina pine rails, which proved so important in locating the National Lumber and Millwork Company in the Bronx as a source of the rails, it became necessary to determine whether the depressions were dents or gouges. This was done by moistening the wood in the depressions. If they were dents due to compression of the wood, the moisture would swell the compressed wood back to its original position. No such swelling occurred, which meant that the wood was cut out by a projection on the edge of the planer knife.

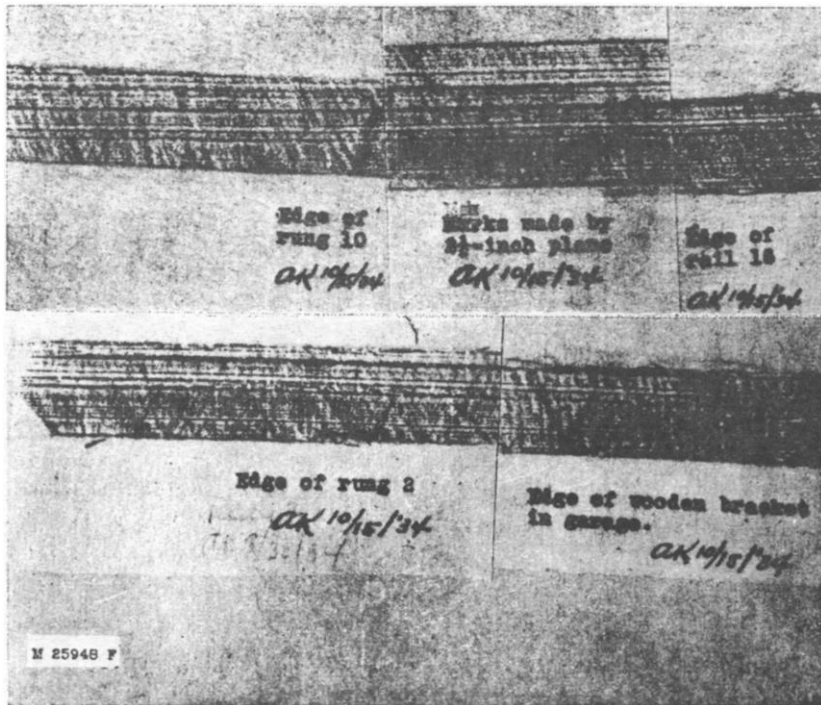


Photograph by U. S. Forest Products Laboratory, Madison, Wis.

FIGURE 4.

The identical intermittent shallow grooves (within circles) on edges of the bottom rails of the ladder and on lumber found at the National Lumber and Millwork Co. in the Bronx fixed the latter as source of part of the ladder. It later developed that Hauptmann had been employed at that lumber yard prior to the kidnapping.

In comparing the hand-plane marks on the edges of the rungs with those on rail number 16 on initial examination, and later with those made by the plane taken from Hauptmann's garage, a simple but unusual method was used. Thin pieces of paper were held tightly over the planed surfaces and a soft pencil was rubbed back and forth over the paper in close succession for about two inches at right angles or nearly so to the ridges made by the nicks of the plane. In that way an impression of the marks was obtained in the form of conspicuous to fine lines on the paper which could be easily compared end to end.

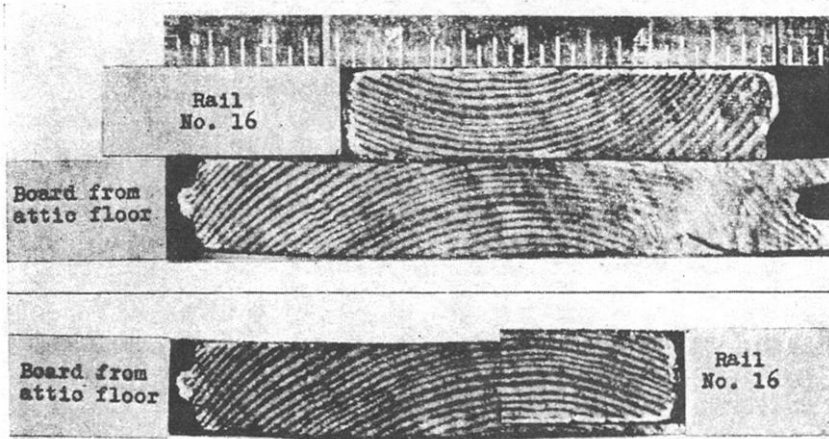


Photograph by U. S. Forest Products Laboratory, Madison, Wis.

FIGURE 5.

Impressions of hand-plane marks made by rubbing a soft pencil back and forth on thin paper placed over the marks served as a speedy and accurate means of matching the marks on the ladder with those on wider pieces of wood planed with Hauptmann's $2\frac{1}{2}$ -inch plane as well as with those on the edges of a wooden bracket found in his garage.

Comparison of the grain of rail number 16 and of a certain board in Hauptmann's attic floor was effected by smoothing adjoining ends of both boards with a sharp pocket knife, photographing the two ends simultaneously so that the scale would be the same, and then superimposing one-half of the picture of the end of the ladder rail on the picture of the end of the floor board. The annual rings of the two were found to match perfectly as to width, prominence, and curvature. This method was more significant than matching the grain on the broad surface only, since more rings as well as their curvatures showed on the ends. A photograph was taken of the ends before smoothing them so that the jury could be shown, if necessary, what the ends looked like originally.

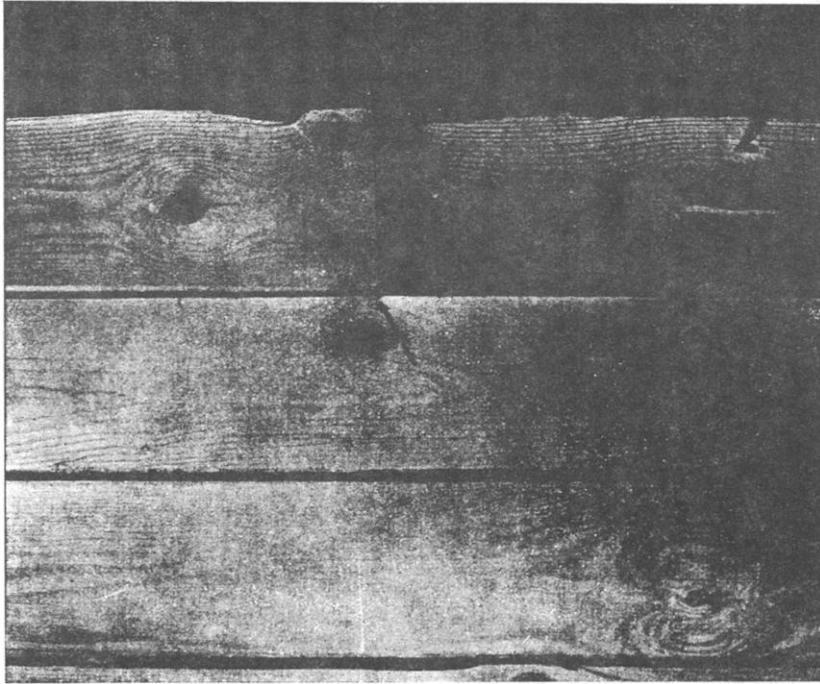


Photograph by U. S. Forest Products Laboratory, Madison, Wis.

FIGURE 6.

End views of one of the ladder rails and of board from Hauptmann's attic showing similarity in curvature, number, and width of annual growth rings. Top: Ladder rail turned upside down on floor board. Bottom: Part of photograph of ladder rail superimposed on photograph of floor board.

As a further check that rail number 16 was cut from the board in Hauptmann's attic it was desirable to determine whether the two boards, when the ladder rail was placed in its original position in the attic as determined by the nail holes, corresponded with each other as to position in the tree. This was done partly by the slope of the knots in the lumber, which usually slope upward from the center out, but more accurately by the fact that a pine knot is eccentric with the wider side toward the bottom of the tree. By comparing the knots it was possible to determine that the two boards had the same relative position to each other in the attic as they had in the tree itself. This observation was of considerable significance since if the two boards had had no connection with each other there would have been a 50-50 chance that the upper (or lower) ends of the two boards would not lie in the same direction in the attic. This, of course, would have been inconsistent with the theory that the two boards were once a single board that had been cut in two after it was nailed down as part of the attic floor. It was even determined by the planer knife cuts that the two boards when in their original position in the attic were run through the planer in the same direction—another 50-50 chance of an inconsistency if the boards had had no connection with each other.



Photograph by New Jersey State Police.

FIGURE 7.

End of discontinuous attic floor board (left) as found in Hauptmann's attic and of ladder rail No. 16 (right) replaced in its original position. That the rail was made from a piece of a board removed from the attic floor is indicated by the following facts:

- (1) A saw cut in line with the end of the floor board extended into the adjacent board a short distance (arrow) which showed that the board was cut off after it had been nailed in place;
- (2) There was sawdust on the lath and plaster below the end of the board;
- (3) A carpenter in laying the floor would not have allowed one end of a board to overhang beyond a joist;
- (4) Four cut nail holes in the ladder rail coincided with four nail holes in the joists, and when so placed the ladder rail was parallel with the rest of the floor boards in the attic and it corresponded with the discontinuous floor board as to original position in the tree;
- (5) The cut nail holes in the ladder rail were of the same size as others in the attic floor, for which 8-penny cut nails were used;
- (6) The grain in the end of the ladder rail matched that in the end of the floor board;
- (7) Both edges of the ladder rail had been planed by hand;
- (8) The machine planer marks on the sides of rail No. 16 were precisely like those on the discontinuous attic board.

Shortly after the discovery of the missing board in Hauptmann's attic, measurements were made of the depth of the vacant nail holes in the joists on which the board (from which rail number 16 was cut) apparently had been nailed. This was done to determine if the nail holes were consistent in depth with those made by the type of nail used in the rest of the attic floor. The holes were found to be of the right depth for the 8-penny cut nails used. This observation,

which had been recorded in a notebook, proved to be valuable shortly before Hauptmann's scheduled execution when the Governor of New Jersey called attention to the fact that the nail holes apparently were not deep enough to accommodate the full length of that kind of nail after allowing for the $\frac{3}{4}$ -inch thickness of the floor.

To prove that the vacant nail holes in the attic joists originally were deep enough, short pieces of wood including the nail holes were cut out of several joists in the attic and split open through the nail holes. The holes were found to have been deep enough originally, although at the time of this examination they were partly plugged with masses of wood fiber which were microscopically identified as hemlock—the same kind of wood as that of which the joists were made. The plugs apparently were due to the fact that the rail had been replaced in the attic several times and each time the nails pushed in by hand as far as they would go easily, and were not driven all the way in. That caused particles of wood to be scuffed off the sides of the holes and wadded into plugs about half or three-fourths of the way down.

By means of the variations in the width of the growth rings in the ponderosa pine rungs an effort was made to determine the locality from which the lumber came, but the case broke before the investigation was carried far enough to be decisive. Growth rings, especially in a dry-climate tree like ponderosa pine, vary considerably in width with the variations in rainfall that frequently occur in different but not necessarily widely separated localities.

Contrary to many reports in newspapers and magazines nearly all the tracing of the lumber through mills was done by correspondence and only a small amount by actual visitation. In fact, the mill at McCormick, South Carolina, was the only one visited. As a rule, no mention was made of the Lindbergh kidnaping in correspondence and the statement that the investigation was in connection with a crime sufficed to secure a large percentage of returns to circular letters.

A large part of the investigation required intimate knowledge of wood and wood working, such as identification of species, distinguishing between artificial and natural features, and determining that the pine rails came from young second-growth trees commercially cut in the Atlantic Coast States. Such intimate knowledge of wood is a type of specialized training that police officials cannot be expected to have, but it serves to show how technical experts along various lines can often assist law enforcement agencies in tracking down and convicting criminals.