Shirley A. Graham,[1] *Ph.D.*

Anatomy of the Lindbergh Kidnapping

REFERENCE: Graham SA. Anatomy of the Lindbergh kidnapping. J Forensic Sci 1997; 42(3):368–377.

ABSTRACT: The kidnapping and death of American aviator hero Charles Lindbergh's young son in 1932 was labeled the "Crime of the Century." A hand-made wooden ladder left at the scene provided some of the most critical evidence connecting Bruno Richard Hauptmann to the crime. The information was supplied by Arthur Koehler, wood technologist for the U.S. Forest Service who, with remarkable tenacity and by meticulously detailed studies, was able to provide three lines of plant anatomical evidence crucial to Hauptmann's conviction and subsequent execution. Koehler traced part of the ladder's wood from its mill source to a lumberyard near the kidnapper's home through faint machine planing marks even before the suspect was known. After Hauptmann's arrest, Koehler demonstrated by wood anatomical comparisons that one of the side rails of the ladder previously had been part of a floorboard in Hauptmann's attic. Finally, he established that Hauptmann's hand plane had been used to dress the edges of several ladder parts. Koehler's testimony in this important trial was a turning point in the acceptance of botanical evidence as expert scientific evidence in the courts. In spite of the direct connection to Hauptmann indicated by the wood anatomical structure and markings from the ladder, Hauptmann maintained his innocence until the end. The case has been reexamined in recent years by several groups and individuals. Although some believe in Hauptmann's innocence, the wood anatomical evidence remains unchallenged in incontrovertibly linking Hauptmann to the crime.

KEYWORDS: forensic science, Charles Lindbergh, kidnapping, wood anatomy, Arthur Koehler, Bruno Hauptmann, forensic plant science

The kidnapping and death of the 20-month-old son of American aviator and hero Charles A. Lindbergh in 1932, was a crime that drew the attention of the country in a way that has scarcely been equaled, at least until the recent criminal trial of athlete O.J. Simpson. In the 1935 trial that proceeded from the kidnapping of the Lindbergh baby, critical scientific information from plant material presented by wood technologist Arthur Koehler of the Forest Products Laboratory, United States Forest Service, Madison, Wisconsin played a prominent role. His testimony included identification of wood samples, results of comparative wood anatomical studies, and demonstrations of physical markings from tools used to make the wooden ladder used in the crime. This type of forensic information was highly unusual at that time and its acceptance by the court in the Lindbergh case was a turning point in the recognition of plant evidence as valid scientific evidence and plant scientists as scientific experts in criminal proceedings.

The archives of the Lindbergh kidnapping case were first opened to the public in 1981. In 1983, The American Academy of Forensic Sciences, in the light of long-standing questions about the conduct and outcome of the trial, reexamined much of the important evidence presented. The conclusion of the Plenary Session contributors was that, for the most part, the evidence was "found not to have been wanting" (1). In the Academy's publication, Koehler's study of the ladder was referred to by several authors, but his investigation was not reviewed in the same detail as the handwriting, autopsy, and psychiatric analyses (1–4). This paper provides a fuller story of the botanical and physical evidence from the kidnap ladder, recounting the facts and demonstrations that jurors considered most highly influential in convincing them of the prime suspect's guilt. It also considers how the plant anatomical evidence fares in retrospect after more than 60 years of scientific progress and how its significant impact on the guilty verdict has been dealt with by recent proponents of the convicted kidnapper's innocence.

Charles Lindbergh, a modest, youthfully handsome, 25-year old part-time air showman and airmail pilot, gained fame and fortune in 1927 as the first person to fly solo nonstop across the Atlantic on a flight from New York to Paris. His marriage two years later to the demure Anne Morrow, second daughter of U.S. Ambassador to Mexico, Dwight Morrow, and the subsequent birth of the couple's first child, Charles Jr., was followed with enormous interest by the news media, the country, and the world-at-large. It was thus an unthinkable tragedy when their young son was kidnapped from his second-story nursery on the evening of March 1, 1932. Because the child was taken from the Lindberghs' new home in Hopewell, New Jersey, the New Jersey State Police were the first to be called. The Superintendent of the New Jersey State Police who took charge of the case was H. Norman Schwarzkopf, father of the more recently renowned "Stormin' Norman" Schwarzkopf, military commander of Operation Desert Shield/Desert Storm in the 1990–1991 Persian Gulf War.

Evidence left at the scene was scanty. It included the ladder by which entry was gained to the child's room, found about 60 ft from the house; a discarded or dropped $^3/_4$ in. wood chisel; marks left by the ladder in the soil and on the house outside the nursery window; a vaguely outlined footprint near the ladder; and a ransom note left on the nursery window sill (Fig. 1).

In Madison, Wisconsin, the newspaper headlines announced the kidnapping on the morning of March 3rd. Arthur Koehler, wood technologist and wood identification expert for the Forest Products Laboratory of the United States Forest Service in Madison, read the account of the crime and was immediately stirred by the possibilities of tracing the ladder's maker (5). Koehler's reputation in wood identification was well established. He had graduated from the University of Michigan with a degree in forestry in 1911 and obtained his master's degree at the University of Wisconsin in 1928 while employed at the Forest Products Laboratory (6). He had previously provided testimony in several legal cases (7). One, in 1918, was a murder case in which Koehler was able to connect

[1]Associate Professor of Biology, Department of Biological Sciences, Kent State University, Kent, OH.

Received 29 May 1996, accepted 10 Sept. 1996.

FIG. 1—*Lindbergh home at Hopewell, New Jersey, with the ladder used in the kidnapping in place next to the second-story nursery window (NJSP).*

a bomb packed in a box made of elm wood to the workshop of a suspect where shavings of the same species were identified (6). However, the use of scientific expert witnesses was an uncommon and limited practice at that time, and the evidence of a wood technologist had little standing in a criminal law court. Respected scientific evidence in 1932 was limited primarily to analyzing fingerprints and handwriting, and to examining stomach contents and bullet markings.

Koehler immediately wrote to Lindbergh offering his services. He was not surprised by the lack of a reply after he learned that thousands of letters had poured in to the family (5). However, about 10 weeks later, the Director of the Forest Products Laboratory, Carlile P. Winslow, asked Koehler to identify slivers of wood taken from the kidnapping ladder. The Laboratory involvement came at the request of Superintendent Schwarzkopf to the Chief of the U.S. Forest Service, Major R. Y. Stuart. Koehler reported back that four kinds of wood composed the ladder; one was identifiable to the important group of commercial timber pine species of the southeastern United States commonly called yellow pine, southern pine, or North Carolina pine (*Pinus* spp.); two others were the western timber trees, ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.) and Douglas fir, (*Pseudotsuga menziesii* (Mirb.) Franco); and the fourth was birch (*Betula* sp., probably *B. alba* L.) (8). Koehler also meticulously noted the presence of colored fiber strands tangled in the wood which he thought might have come from the kidnapper's clothes. These subsequently proved to have come from a blanket police had used to wrap the ladder (5).

Eleven days after the kidnapping, contact was made with the kidnapper or his representative in the Woodlawn Cemetery, Bronx, New York, and on April 2, a ransom of $50,000 was paid at yet another Bronx cemetery, St. Raymond's, in return for instructions on finding the child. The contact was described as a man of medium size with a distinctly German accent. The instructions proved false and the remains of the child were found several weeks later, on May 12, only a few miles from the Lindbergh estate. The investigation continued for two years without any major breakthroughs.

Koehler's involvement in the case intensified when, in March 1933, a year after the crime, he was called to the New Jersey State Police headquarters in Trenton, New Jersey (9). In a quest for new leads, Schwarzkopf had turned again to the ladder, hoping that an inspection of the ladder itself, not just samples of the wood, might be more productive. With this visit Koehler began a remarkably detailed investigation that produced the most unshakeable evidence of the trial to connect one man directly, Bruno Richard Hauptmann, to the crime. The information Koehler assembled from his study of the ladder was of three types: identification of woods used in the ladder's construction; comparative wood anatomy, which involved comparison of annual growth rings and other growth patterns such as knots; and physical evidence in the form of marks left on the wood by tools.

Construction of the Ladder

Having been initially limited to identification of a few wood fragments, Koehler now found so many unique features of the ladder, he was certain it would yield specific information about the kidnapper (10). The ladder was a slender, homemade affair weighing only 38 pounds (11). It was built in three nested sections, each about 6 ft, 8 in. long, and was held together by birch dowels to form a kind of extension ladder (8) (Fig. 2). Disassembled, it could be carried in an automobile. The 11 cross pieces, or cleats, fit inexpertly into roughly chiseled notches and were uncomfortably spaced for climbing at 21 in. apart. They showed no wear, suggesting the ladder had been made especially for use in the kidnapping. To Koehler, the ladder was the crude construction of a "slovenly carpenter," but the lack of finish might also have been because the ladder was intended for use only once (5).

Koehler numbered each ladder part beginning with the bottom cleat. Both cleats and side rails were a mix of used and new wood of three kinds. The first 8 cleats were of ponderosa pine cut from a single 1 by 6 in. board first cut lengthwise and then crosswise. Cleats nine and ten had been cut from a second piece of 1 by 6 in. ponderosa pine, whereas the eleventh was of Douglas fir (10). The bottom side rails (rails 12 and 13) were new pieces of yellow pine sapwood cut from young, second-growth trees. They exhibited a singular repetitive machine planing pattern when viewed under low oblique light (8). Rails 14, 15, and 17 were Douglas fir that had seen prior use, as evidenced by the presence of one to three round nail holes not related to the ladder construction. Rail 16, uniquely, was fashioned from a used piece of yellow pine of a poorer grade than the new pieces of rails 12 and 13. It was the only rail not cut from standard 1 by 4 in. strips. Rail 16 had been

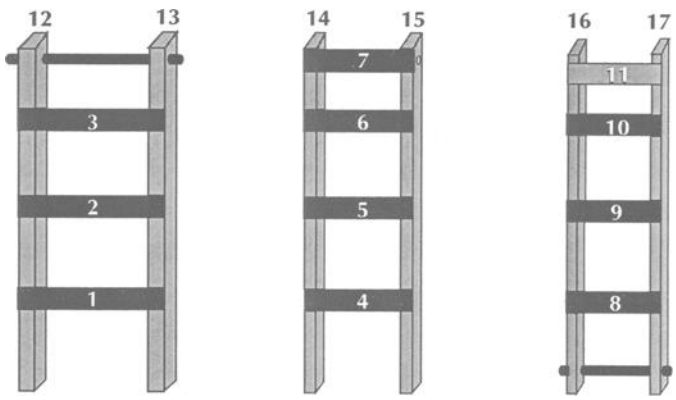

FIG. 2—*Diagrammatic construction of the ladder numbered according to the scheme of Arthur Koehler. Lumber used for side rails 12 and 13 was traced to its mill source and then to a lumberyard near Bruno Hauptmann's home. Rail 16 was constructed from part of an attic floorboard located above the Hauptmann's apartment.*

cut from a wider board and the long edges hand-planed by a dull, nicked plane which left a "signature" pattern of ridges. Significantly, rail 16 held four nail holes made by old-fashioned, square-cut, eight-penny nails spaced at distances of 16 and 32 in., a spacing that suggested the board had seen prior permanent use. Koehler, in his thorough fashion, calculated that the probability of four holes appearing in exactly the same spatial relationship in another board of the same size was only 1 in 10^{15} (5). The lack of rust around the holes suggested the wood had been sheltered, and the presence of three knots indicated it was of a low grade typically used in the interior construction of barns, storage sheds, and attics. One edge of the cleats also bore the same embossed signature of the nicked hand plane blade used to dress rail 16. The police were alerted to look for missing boards in any future suspect's quarters and to take into custody any hand planes that might be found. Koehler found the birch dowels were a type manufactured as handles for mops or toys but because they were so common, tracing them soon proved a dead end and they were not considered further (5).

After four days of examining all natural characters and man-made marks on the ladder, Koehler was able to reconstruct the number and size of the original pieces of wood the maker had used and even determine the initial relationship of the pieces in the boards before they were cut (8). He had measured all parts of the ladder to $^1/_{100}$ in. (Fig. 3). The two bottom rails (rails 12 and 13) matched end to end, having been cut from a single 14-ft or greater strip. It was possible to tell that the top end of rail 12 had grown near the bottom of a leaning tree because it was formed of more dense compression wood, wood that shrinks little in drying. That rail end was $3^{11}/_{16}$ in. wide, $^1/_{16}$ in. wider than the other end. This was a clue that the original board must have been machine-dressed to $3^3/_4$ in. rather than the typical $3^5/_8$ in. The compression wood had shrunk $^1/_{16}$ in. from the manufactured size. The knowledge that the original board was $3^3/_4$ in. wide later allowed Koehler to narrow his tracing of the original shipment of yellow pine from 63 to 45 carloads (10). In part, the success in locating the final retail source of the wood ultimately depended on recognition of the $^1/_{16}$ in. difference in the width of one ladder rail.

Tracking the Wood of Rails 12 and 13

Koehler returned to Madison where most of the ladder was shipped to him for further study. There he found a distinctive machine planing pattern on rails 12 and 13 when viewed in oblique light in a darkened room. The pattern had formed as the board was fed into a planing mill. In its travel through the planing machine, a board is trimmed simultaneously by two sets of paired cutters, one set shaving the top and bottom faces of the board, the other set trimming the edges. The cutters are a set of blades fixed at equal distances around a drum. As the board is fed through the planer by a feed roll, the drums revolve, cutting away the wood (Fig. 4). Koehler discovered that the distinctive patterns on the faces and edges of the board occurred because, serendipitously, there was one defective, nicked knife in each set of face and edge cutters. With these defects as markers, he determined that the face cutters had eight knives (eight individual knife cuts from one nick mark to the next) and the edge cutters had six knives. Based on the distance between nick marks he was also able to calculate that the board was being fed through the planer 0.93 in. each time the cutter drum revolved once, i.e., 0.93 in. was the distance covered by eight knife cuts or one revolution of the face cutters. Knowing that the cutters usually made 50 revolutions per second, he was able to calculate the speed of the feed rolls as 0.93 in. in $^1/_{50}$ of a second or about 230 ft/min. This was a fast feed for a mill planer;

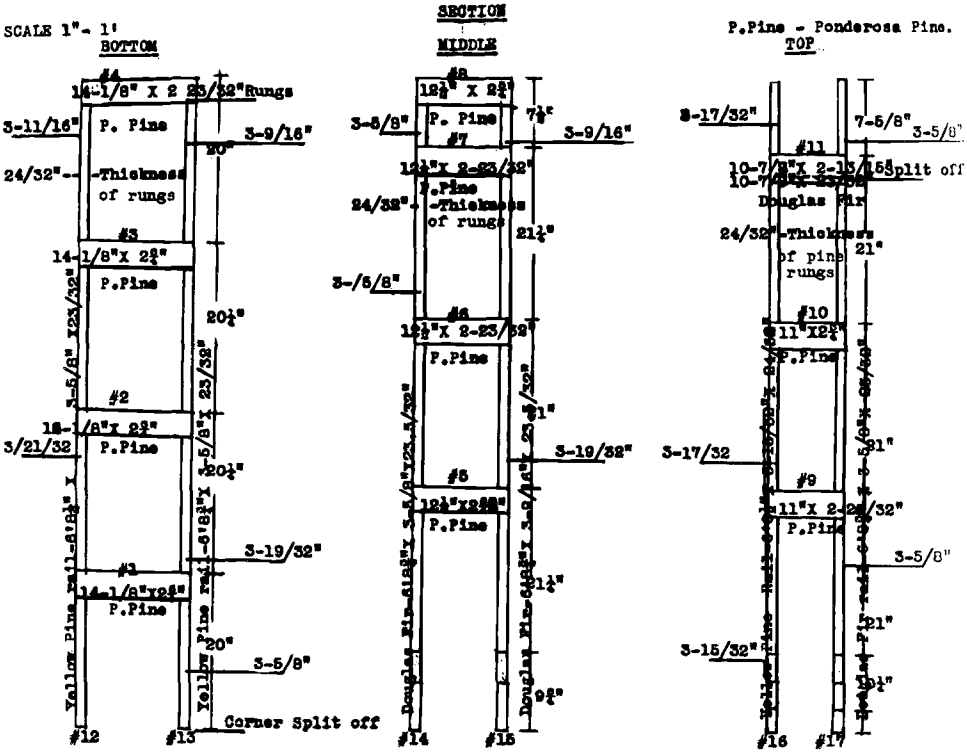

FIG. 3—*A diagram by Arthur Koehler providing the detailed measurements of the kidnapping ladder (NJSP).*

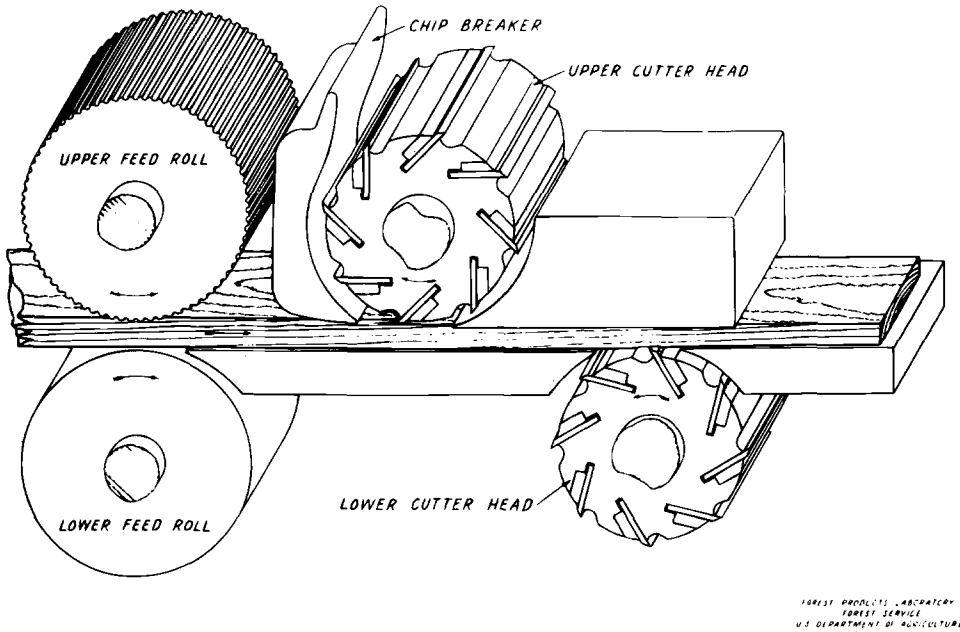

FIG. 4—*Simplified plan of a commercial planing mill. The set of face cutters with eight knives that plane the board surfaces and the feed rolls are shown; the set of edge cutters that plane the edges are not included (USFS).*

typically they move at less than half that speed. Koehler was now looking for a mill with a planer that had eight knives in the face cutters, six in the edge cutters, and a feed roll speed of 230 ft/min that might have shipped a load of yellow pine dressed to $3^3/_4$ in. to the general New York area shortly before March, 1932 (10).

As luck would have it, the type of planer he was seeking was rare in the East, and of the nearly 1600 mills from New York to Alabama to which he sent letters of inquiry, only 23 met the planer and dressed-size specifications (20). Viewing samples sent from the 23 mills, only one was found with the requisite 0.93-in./sec feed roll speed. The mill of M. G. and J. J. Dorn, in McCormick, South Carolina had altered its planer speed by changing a pulley in September, 1929 (5). Records showed that they had shipped 46 carloads of $3^3/_4$ in. dressed yellow pine north of the Potomac River after that time. However, at some point after 1929, the nicks on the cutter knives had appeared and subsequently had been sharpened away. Koehler determined to find some tell-tale boards still remaining in lumberyards from those 46 carloads that would pinpoint localities where the kidnapper could have purchased the wood for rails 12 and 13. Again, he was lucky to learn that 18 of the 46 carloads had been purchased by two factories for making small crates for their products (6). This material had been securely stored and subsequently cut into lengths too short for use in the ladder construction.

Koehler, now accompanied by New Jersey State Police Detective Lt. Lewis Bornmann, whom he came to call his "Siamese Twin," searched yard after yard and innumerable construction sites near the Lindbergh estate (5,12). Their persistence paid off when they found a bin in a Long Island lumber yard constructed from Dorn Mill wood *almost* identical to the ladder piece. A slight difference in the setting of the edge cutters suggested that the shipment they were seeking might have been made either just before or just after the Long Island one. Checking prior deliveries led them to the National Lumber and Millwork Company in the Bronx, New York where a shipment had been made nine days before the Long Island one. There, on Nov. 29, 1933, they discovered a storage bin constructed from Dorn Mill wood with cutter markings identical to those of the ladder wood (Fig. 5). Both were certainly part of the same shipment of 2263 feet of 1 by 4 in. lumber received by the Bronx lumber company on Dec. 1, 1931, just three months before the kidnapping (5).

Unfortunately, after successfully tracing the wood, the critical sales records that would have narrowed the search to a few customers were not available. The company had switched to a cash-only policy prior to the Dorn Mill purchase. However, on the faintest of evidence and in just nine months time, Koehler and Bornmann had determined that the kidnapper most likely was a carpenter living in the vicinity of the Bronx National Lumber and Millwork Company. Although they could get no closer to his identity, they had narrowed the search geographically and, independently, it corresponded to the area in which the ransom had been payed. They began once again, this time to trace the shipments of Douglas fir and ponderosa pine, hoping to locate a company that did keep sales records. Before they had gone very far, a break in the case came from another direction.

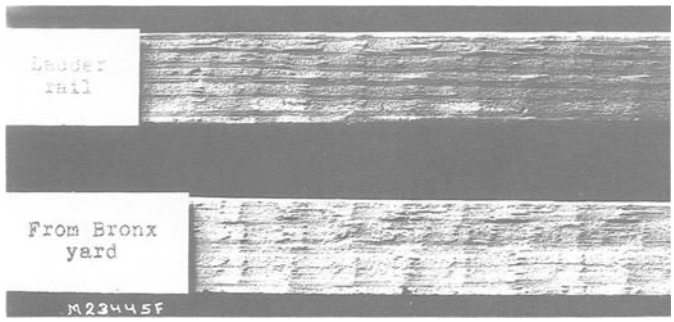

FIG. 5—*Coarse planer waves on the edge of a side rail of the ladder and comparable waves on the edge of a board from the National Lumber and Millwork Company, Bronx, NY. The series of pronounced crests indicates the distance the lumber passed through the planer during each revolution of the cutter heads. The crests are sharply gouged to form two lines of short "dashes" toward the bottom of each edge (not clearly visible in the photograph), as a result of a defective knife in the cutter head (USFS).*

The Arrest of Bruno Richard Hauptmann

During the course of Koehler's investigation, bills from the ransom began to appear in the New York area, especially in upper Manhattan and in the Bronx (13). They were five, ten, twenty, and fifty dollar gold certificates which in April, 1933, by executive order of President Roosevelt, had become illegal tender. Holders were requested to exchange them for non-certificate notes under threat of a $10,000 fine and a prison sentence. Gold certificate bills thus became increasingly rare after the exchange deadline. A list of serial numbers of the ransom money was circulated and a five dollar reward was offered to any person who turned in a ransom bill. Gas stations were requested to record the license number of any car whose owner passed a gold note. The break came finally in September, 1934, when a gas station attendant wrote the car license number on the margin of a $10 gold ransom note cashed for gasoline. The license was traced to Bruno Richard Hauptmann (Fig. 6), a German carpenter who lived with his wife and small son in the upstairs apartment at 1279 East 222nd Street in the Bronx, just 10 blocks from the National Lumber and Millwork Company and less than four miles from St. Raymond Cemetery where the ransom had been passed (11).

Hauptmann was arrested Sept. 19, 1934. A police search turned up $14,600 of the Lindbergh ransom hidden in Hauptmann's garage. A week later Lt. Bornmann, two New York City detectives, and two police carpenters, entered the Hauptmann attic to search for more of the ransom (13). The only access was through an opening in a small closet in the Hauptmanns' apartment. For the first time (there had been nine previous visits to the attic by officials), Bornmann noticed that one of the floor boards under the eaves in the southwest corner of the attic was about 8 ft shorter than the others. The end had been sawed away, exposing four floor joists, and leaving a small saw cut in the adjacent flooring strip. Bornmann returned to the attic with Koehler and rail 16 on Oct. 9 and together they determined that the four square nail holes in the rail lined up perfectly with the square holes in the joists.

FIG. 6—*Bruno Richard Hauptmann (UPI/Bett).*

The Evidence from Rail 16

The square, eight-penny nail holes in rail 16 were found not only to correspond to those of the attic joists in position and size, but also in angle and depth. With the nails in place the rail was oriented exactly parallel to the floorboards (Fig. 7). In addition to the nail holes, other novel features of rail 16 that Arthur Koehler had carefully detailed at the beginning of his investigation now allowed him to make wood anatomical comparisons that conclusively demonstrated that rail 16 and the sawn attic floorboard had once been a single piece of yellow pine. Although $1^3/_8$ in. were missing between the two pieces, photographs at the same scale from their ends illustrated perfect agreement in number, variation in size, and curvature of the annual rings (Figs. 8 and 9). Later, in trial testimony, Koehler drew particular attention to the pattern of three narrow annual rings flanked on either side by two wider rings that was shared by rail 16 and the floorboard (14) (See arrows, Fig. 9). A demonstration of the individuality of patterns in randomly selected yellow pine boards further supported the contention that rail 16 had been part of the attic board (Fig. 10).

By comparing the slope of the partial knot in each piece, Koehler determined the board and the rail had the same relative position as they had in the tree. The wider side of a knot is typically toward the bottom of the tree. Had the two boards not once been a single piece, there was a 50% chance the rings of the two partial knots would have had conflicting orientation. Further, rail 16 when in place had been planed in the same direction as the floorboard, which again had a 50% chance of occurring (10). The likelihood of two unrelated boards being identical in so many ways is probably impossible to calculate statistically, but it must certainly meet or exceed the exceedingly low probabilities now calculated in the courts for random matches in DNA sequences.

Evidence from the Hand Plane

With the arrest of the carpenter Hauptmann, his tools were taken in evidence (15). Koehler was immediately interested in a hand plane with a dull, nicked blade from Hauptmann's garage. In his initial study of the ladder, Koehler had observed unique patterns of ridges on the edges of the cleats and rail 16 made by such a nicked plane blade. He found the edges of rail 16 and the cleats bore identical markings and had been planed by the same instrument. Now, testing Hauptmann's plane on a wood sample, Koehler found the markings he made were a perfect match for those on the ladder. A small wooden bracket installed in the garage was also found to bear the same signature markings (10,15).

The Testimony of Wood Expert Arthur Koehler

In the courtroom, Koehler testified briefly on the fifth day of the trial, then was recalled for extensive questioning as the final witness for the prosecution, but not before the defense attempted vigorously to bar his testimony. They argued that, "there is no such animal known among men as an expert on wood; that it is not a science that has been recognized by the courts; that it is not in a class with handwriting experts, with fingerprint experts or with ballistic experts. That [sic] has been reduced to a science and is known and recognized by the courts. The witness probably may testify as an experienced carpenter or something like that, but when he attempts to qualify and express opinions as a wood expert,

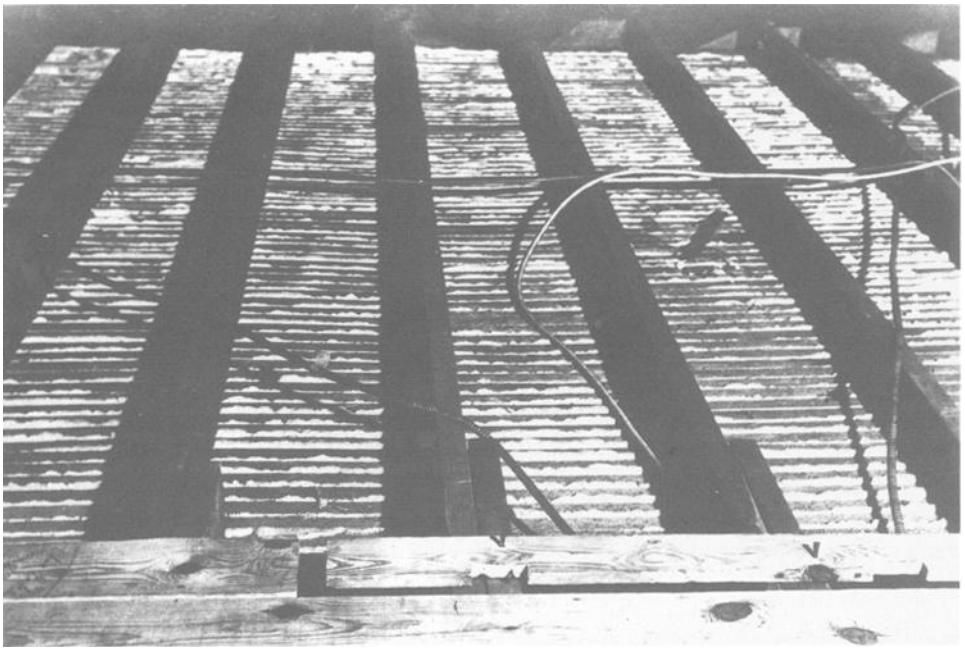

FIG. 7—*Portion of the Hauptmann attic floor under the eaves with rail 16 in place, as a continuation of the floor board from which it was fashioned. Two of the four nails corresponding to the nail holes found in the side rail and joists are shown (USFS).*

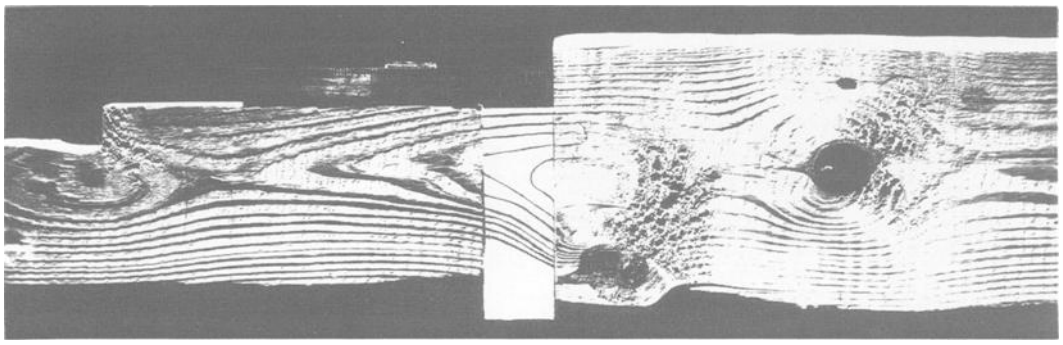

FIG. 8—*Face view of portions of rail 16 (left) and the attic floorboard (right) showing the* $1^3/_8$ *in. gap formed when rail 16 was cut down to the size of the other rails on the ladder. The artificial insertion demonstrates the correspondence of the annual rings on the two pieces (USFS).*

that is quite different . . . This is merely a man who has had a lot of experience in examining trees, who knows the barks on trees and a few things like that. He may come into court and he may tell what he did and what he saw but when it comes to expressing an opinion as an expert or as a scientist, why that is quite different indeed. We say that the opinion of the jurors is just as good as his opinion, that they are just as qualified to judge . . ." (16). However, when asked to pass on the witness's qualifications, the judge replied in what may be considered an historical moment for forensic plant science, "I deam [sic] this witness to be qualified as an expert" (17). Outside the court, Hauptmann's lawyer and friends attempted to belittle Koehler by laughing at his strange, and to them amusing, title—"xylotomist." Privately, the Chief Defense Attorney, Edward J. Reilly, complained, "What a witness to ring in on us—somebody they plucked out of a forest" (6).

The importance of Koehler's testimony was not missed by the jurors or the public. The ladder rapidly became the symbol of the Lindbergh trial. In Flemington, N.J., where the trial took place, 13-year-old George Parker and his brother and friends made and sold souvenir replicas of the ladder for 25 cents each (18,19). Spectators wore these into the courtroom pinned to their lapels or hung around their neck (Fig. 11).

In testimony that lasted most of one day and the next morning, Koehler first explained the plant anatomical and nail hole evidence that confirmed the unity of rail 16 and the attic floor board (20) (Fig. 12). In particular, he drew attention to the corresponding annual rings in the two pieces. He explained the distortion caused by the knot and how the silver nitrate used to process rail 16 for fingerprints had slightly altered its color. He then compared the marks of Hauptmann's hand plane to those found on the ladder rails and cleats. Obtaining permission from the judge, he clamped a vise directly on the judge's bench, fitted in a new piece of ponderosa pine and by the simple method of rubbing a soft black pencil over onion skin paper pressed to the wood, he prepared an impression of the unplanned wood. Next, he planed the piece with Hauptmann's plane and again made a rubbing. Additional rubbings were made from the edge of rail 16, cleats eight and ten, and the edge of the wooden bracket removed from Hauptmann's garage. The jury saw clearly on the new wood how the ridges left by Hauptmann's plane matched precisely those on the ladder parts

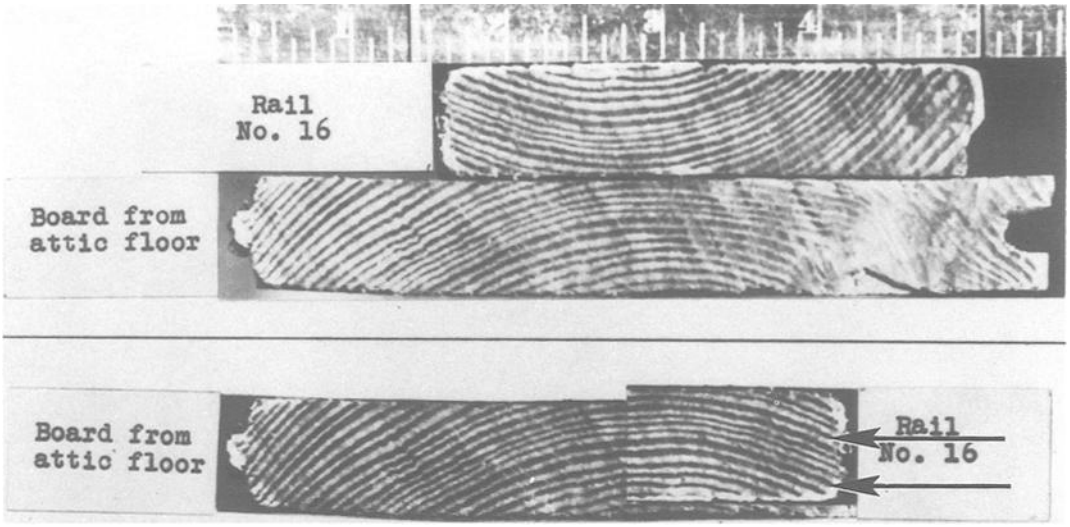

FIG. 9—*End views of rail 16 and the attic floorboard display identical curvature, width, and number of annual rings; top photograph shows rail 16 turned upside down on the floorboard; bottom photograph is a composition photo of the floorboard and rail 16, aligned to show the correspondence in annual rings. Arrows indicate the two sets of wider annual rings that sandwich three narrower annual rings (USFS).*

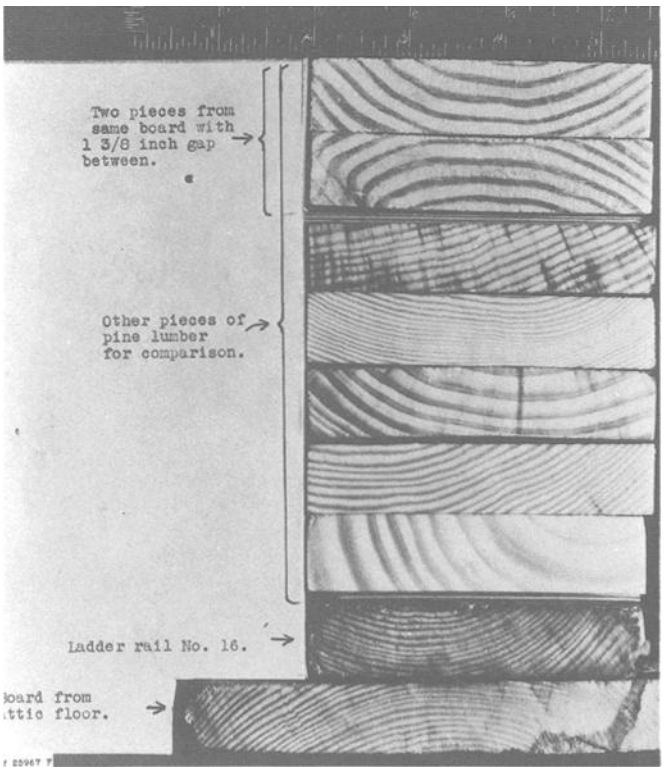

FIG. 10—*End views of an assortment of pine planks compared to those of rail 16 and the attic floorboard demonstrate the uniqueness of individual annual growth ring patterns. The top two pieces are a board separated by a $1\frac{3}{8}$ in. gap and illustrate that the annual growth ring pattern is continuous in spite of the missing section (USFS).*

FIG. 11—*George Parker (middle) and younger brother (foreground) selling souvenir ladders in Flemington, New Jersey, during the course of the kidnapping trial (UPI/Bett).*

and bracket (Fig. 13). Finally, Koehler detailed the means by which he had traced the bottom rails 12 and 13 of the ladder to the Bronx lumber yard.

No aspect of Koehler's testimony could be shaken by the defense's cross examination and they offered no rebuttal. The wood evidence irrefutably tied Hauptmann to the kidnap ladder. In interviews following the trial, jurors stated that the wood evidence was one of the most influential and convincing parts of the State's case (18). Forensic scientists have since called Koehler's investigations "elegant and convincing" (1) and "outstanding for their thoroughness and simplicity" (4).

The $\frac{3}{4}$ in. Buck Brothers brand chisel found at the crime scene could not be sufficiently narrowed in its distribution after manufacture, nor unquestionably tied to the construction of the ladder or to Hauptmann. It was not emphasized by the prosecution in trial, although testimony was given that Hauptmann's tool box contained a $\frac{1}{4}$ in. Buck Brothers chisel but lacked the $\frac{3}{4}$ in. chisel which normally would have been part of the set (15,21).

A further piece of relevant evidence brought forward at the trial was the information that Hauptmann had been employed for a short time at the National Lumber and Millwork Company and a sales record, kept because he had been an employee, showed he

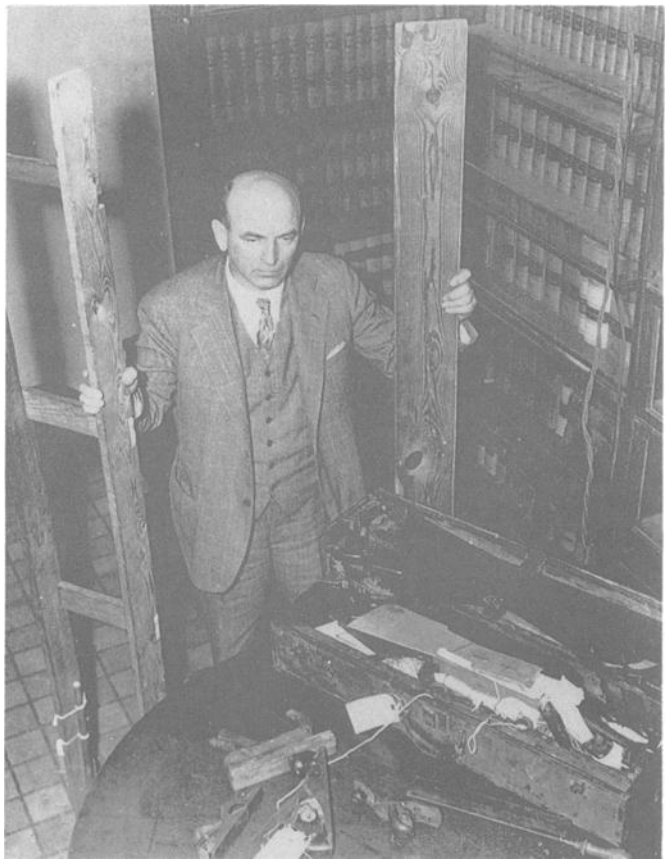

FIG. 12—*Arthur Koehler holding a section of the ladder and the floorboard from Hauptmann's attic. Hauptmann's tool chest and hand planes are shown in the foreground (NJSP).*

had purchased $9.31 of lumber of an unspecified type in Dec., 1931, three months before the kidnapping (9,11,22).

Responses of Hauptmann and Others to the Wood Evidence

Hauptmann withstood examination throughout the trial with his composure scarcely ever ruffled. His demeanor was interpreted by some as deferential but assured, by others as detached and arrogant. Three strongly incriminating sources of evidence had been introduced against him. He had a logical explanation for possession of part of the ransom money which had been found secreted in his garage. A friend and sometime business partner, Isidor Fisch, who owed him money, had asked him to keep a shoebox while he returned to Germany. Fisch died while abroad, and Hauptmann only later discovered the box contained money. He claimed he planned to spend what was owed him and send the rest to Fisch's family. Handwriting evidence from the first and several later ransom notes was debated by experts on both sides. The defense argued that significant features were merely indicative of a person schooled in Europe. The 1983 review of the handwriting concludes that Hauptmann wrote all the notes (23). Two other reviews have reached the opposite conclusion (13). Response to the wood evidence was critical because only it unequivocally tied Hauptmann to the crime.

Hauptmann's responses to Koehler's testimony were either to answer in an indirect manner or to deny flatly (24). To the question from his attorney, "Did you build that ladder?," he responded, "I am a carpenter." Again, "Did you build the ladder?" "Certainly not. Looks like a musical instrument." "In your opinion does it look like a well-made ladder?" "To me it [hardly] looks like a ladder at all. I don't know how a man can step up." "Did you take any board from the attic of your house?" "I did not." "Did you carve or cut a side of this ladder from that board?" "I did not." In the face of overwhelming evidence to the contrary, Hauptmann swore he had neither built nor owned the ladder.

The trial of this first "Crime of the Century" lasted 32 days, brief by today's standards. The jury found Hauptmann guilty on Feb. 13, 1935, after deliberating 11 hours and 24 minutes (25). His execution was ordered for March 18th. Appeals and reprieves followed, during which time the Governor of New Jersey, Harold Hoffman, initiated his own investigation and intervened personally to hear Hauptmann out and view the evidence of the attic floorboard. Nine days before the final execution date of April 3, 1936, Koehler was once again called from Wisconsin to demonstrate to Governor Hoffman and accompanying members of his party how nails placed in the holes of rail 16 fit holes in the joist. To Koehler's consternation, the nails failed to sink completely. Heated accusations by the Governor implied that Bornmann and Koehler had manufactured the evidence in order to gain a conviction or out of a desire for glory and advancement, a charge made earlier before the jury by Hauptmann's attorney (26). To settle the matter, four pieces of joists were cut out and carried to Columbia University where the nail holes in the joists were sliced longitudinally and examined microscopically in the presence of an independent observer in the Physics Department (10,11,27). The holes were found to be partially plugged by minute wood shavings. Hoffman then jumped to the conclusion that one of his own investigators had tampered with the evidence, but Koehler later determined the shavings were hemlock that had been scuffed from the sides of the hemlock joists by nails inserted during several prior demonstrations (10).

Most recently, additional minor points have been seized on by investigative writers as evidence that the testimony about the wood was faulty, even though these points were clearly explained and accepted by the Governor and rest of the group gathered in the attic (27). Writers Ahlgren and Monier (28,29), ignoring this information, write that rail 16 was $^1/_{16}$ in. thicker in the center than the floorboard and therefore not part of the original floor. They fail to present the fact that Koehler had satisfactorily explained that the slight unevenness of the unfinished attic flooring was expected because the low grade wood was not dry when dressed and consequently had shrunken unevenly, although the difference still was actually less than $^1/_{16}$ of an inch.

The day after the trial, two reporters interviewed Hauptmann in jail. When asked about rail 16, he responded, "I got so many boards in my garage, I don't know why I should go to the attic" (30). To questions posed by Governor Hoffman about the ladder, Hauptmann said, "If I was a smart criminal . . . , why would I got in my own house and take up half one board to use for one piece of the ladder—something that would always be evidence against me?" (19). The answer might have been because he could never have imagined the fantastic trail of evidence those pieces of wood would produce, nor that they would lead, finally, directly to him. The U.S. Supreme Court refused to review his conviction, a final appeal failed, and four years after the crime, on April 3, 1936, Hauptmann was executed.

Update

Hauptmann maintained his innocence to the end, as did his widow Anna. After archival records of the case became public in

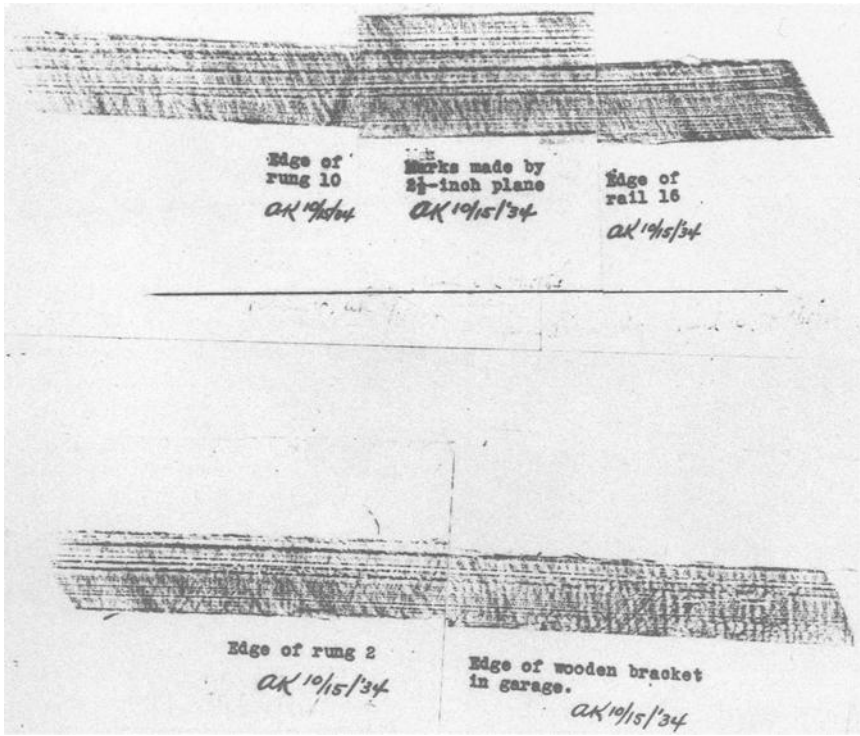

FIG. 13—*Composite photographs showing pencil-rubbed impressions of the hand plane markings. Top photograph: left—marks on edge of cleat 10; middle—marks from Hauptmann's 2 1/2 in. hand plane; right—marks on edge of rail 16. Bottom photograph: left—edge of cleat 2; right—edge of wooden bracket in Hauptmann's garage (USFS).*

1981, Anna Hauptmann sued the State of New Jersey for wrongful execution of her husband. The case was dismissed and the dismissal was upheld in an appeal. In 1986, at age 87, she filed a 10 million dollar civil action suit against the New Jersey prosecuting attorney of the case, David Wilentz, aged 91, and four former members of the New Jersey State Police, including Arthur Koehler's partner, Detective Lewis Bornmann, for wrongful execution and corrupt practices. The court decided "the quest to clear her husband's name should be left to historians" (19). Anna Hauptmann died at 95 on Oct. 10, 1994, still believing in her husband's innocence. Charles and Anne Lindbergh had five more children after Charles Jr. Charles Lindbergh died in 1974 at age 72; Anne Morrow Lindbergh, poet and author of a number of best-selling books, survives still.

In 1985, the papers from New Jersey Governor Harold Hoffman's private investigation were added to the Lindbergh Archives. All of these records are now accessible in the New Jersey State Police Museum and Learning Center, West Trenton, New Jersey. Most scholarly reviews of the material conclude that Hauptmann alone was guilty of the crime. However, access to the archives has stimulated a rash of new, mostly journalistic, reviews and films of the case. Several alternative scenarios are presented ranging from intriguing to ridiculous. They deny the baby was kidnapped (31); they implicate others in addition to or instead of Hauptmann (13,32); they place responsibility on Lindbergh's troubled sister-in-law (19); or they accuse Lindbergh himself of accidentally dropping and killing the child during the course of a practical joke (28,29). One author supports the verdict of the jury and believes that Hauptmann kidnapped the child for the money (11). All recent accounts revisiting the evidence of the case either fail to emphasize or fail even to recognize the importance of the wood evidence as the primary scientifically objective information undeniably connecting Hauptmann to the crime. More insidious are unsupported suggestions that the wood evidence was fabricated by Koehler in cooperation with the New Jersey State Police and the New Jersey prosecutor's office in order to make a strong case against Hauptmann (13,32).

Koehler went on after the Lindbergh case to employ his expertise in other criminal and civil cases, one of which led to the conviction of a triple mail-bomb murderer (6). At Koehler's retirement in 1948, after 34 years with the U.S. Forest Products Laboratory, he moved to Los Angeles where he taught an extension course in wood technology at UCLA. In 1952–53, he taught wood anatomy and identification at the Yale School of Forestry as a visiting faculty member (Stern, W. L., pers. comm.). He continued to act as an expert witness until his death at age 82 in Los Angeles on July 18, 1967 (6,33).

The wood evidence in the Lindbergh case was pivotal in opening the door to botanical testimony as serious scientific expert evidence. Koehler perceptively commented in his unpublished report of June, 1948 to the U.S. Forest Service, "Reflecting on this case raised the question whether scientific methods could not be used much more extensively than is now done in crime detection." His analyses established the highest of standards for the emerging role of plant sciences in criminalistics.

Evidence from wood has proven an important resource in criminal and civil courts since that time (34). It might now be possible to apply some more technologically advanced methods of investigation to the materials he studied, such as the use of computerized wood identification programs (34, see literature citations), scanning electron micrographs of wood sections, or possibly DNA fingerprinting from parenchyma or cambial cells if they are present and

the DNA undegraded in the material (35). However, it is difficult to imagine any more convincing results than those Koehler generated through basic, meticulously detailed, accurate observations, and wood anatomical comparisons. After more than 60 years, his work remains sound science and unquestionably supports the verdict of the Lindbergh jury.

Acknowledgment

I am grateful to Mark W. Falzini, Archivist, New Jersey State Police Museum and Learning Center, West Trenton, New Jersey, for exceptional assistance in locating and providing copies of photos and text materials on my visit to the Museum. Dr. Regis Miller, Project Leader, Center for Wood Anatomy Research, Forest Products Laboratory, Madison, Wisconsin, generously searched out Koehler's original negatives in the files and provided all the photographs in this paper credited to the Laboratory. I thank Dr. Gracielza Dos Santos, Rancho Santa Ana Botanic Garden, for helpful advice. The reader is referred to the numerous recent books on the Lindbergh case for general background information not specifically documented in this account (11,13,19,36,37). Sources of photographs are acknowledged by the following abbreviations: NJSP = New Jersey State Police; USFS = USDA, Forest Service, Forest Products Laboratory; UPI/Bett. = United Press International collection in the Bettmann Archives.

References

1. Baden MM. Plenary session: The Lindbergh kidnapping revisited: Forensic sciences then and now. J Forensic Sci 1983;8:1035–7.
2. Haag LC. The Lindbergh case revisited: A review of the criminalistics evidence. J Forensic Sci 1983;8:1044–8.
3. Horan JJ. The investigation of the Lindbergh kidnapping case. J Forensic Sci 1983;8:1040–3.
4. Tanay E. The Lindbergh kidnapping—A psychiatric view. J Forensic Sci 1983;8:1076–82.
5. Koehler A. Who made that ladder? Saturday Evening Post 1935 April 20.
6. Radin ED. Sawdust Trail. In: 12 Against Crime. New York: G. P. Putnam's Sons, 1950;169–87.
7. Koehler A. State of New Jersey vs. Bruno Richard Hauptmann, Trial transcript, 1935;3790.
8. Koehler A. Report of examination of ladder for the New Jersey State Police. Summary of observations and conclusions, Mar. 4, 1933. Lindbergh Archives, New Jersey State Police Museum, West Trenton, NJ.
9. Christensen DJ. The ladder link. Forests & People 1977;7:8–11.
10. Koehler A. Technique used in tracing the Lindbergh kidnapping ladder. J Criminal Law and Criminology 1937;7:712–24.
11. Fisher J. The Lindbergh Case. New Brunswick: Rutgers University Press, 1987.
12. Bornmann LJ. Report to the New Jersey State Police, March 23, 1933. Lindbergh Archives, New Jersey State Police Museum, West Trenton, NJ.
13. Kennedy L. The Airman and the Carpenter. New York: Viking Press, 1985.
14. Koehler A. State of New Jersey vs. Bruno Richard Hauptmann, Trial transcript, 1935;3836.
15. Koehler A. Report of examination of tools and lumber from Hauptmann's garage and home, October 31, 1934. Lindbergh Archives, New Jersey State Police Museum, West Trenton, NJ.
16. Pope F. State of New Jersey vs. Bruno Richard Hauptmann, Trial transcript, 1935;3796.
17. Trenchard TW. State of New Jersey vs. Bruno Richard Hauptmann, Trial transcript, 1935;3805.
18. Interviews with G. Parker, L. Bornmann, jurist, Anna Hauptmann, others from the trial period [videotape]. Reliving the Lindbergh case. Television documentary, New Jersey Network, 1989.
19. Behn N. Lindbergh: The Crime. New York: Atlantic Monthly Press, 1994.
20. Koehler A. State of New Jersey vs. Bruno Richard Hauptmann, Trial transcript, 1935;3836–977.
21. Koehler A. State of New Jersey vs. Bruno Richard Hauptmann, Trial transcript, 1935;3881.
22. Tippo O, Stern WL. Sleuthing with wood. In: Humanistic botany. New York: W. W. Norton & Co., 1977;131–5.
23. Osborn PA. Excerpts and comments on testimony by document examiners in regard to *State of New Jersey v. Bruno Richard Hauptmann.* J Forensic Sci 1983;8:1049–70.
24. Hauptmann BR. State of New Jersey vs. Bruno Richard Hauptmann, Trial transcript, 1935;4113–55.
25. Anonymous. The official premillennial Trial-of-the-Century scorecard. Time 16 Oct. 1995;34.
26. New York Times, 12 February 1935;16.
27. Koehler A. Report of investigation carried on in cooperation with the New Jersey State Police, March 28, 1936. Lindbergh Archives, New Jersey State Police Museum, West Trenton, NJ.
28. Ahlgren G, Monier, SR. Crime of the century: The Lindbergh kidnapping hoax. Boston: Branden Books, 1993.
29. Ahlgren G, Monier SR. Who killed the Lindbergh baby? Remember 1995;1(4):33–9.
30. New York Times, 15 February 1935;6.
31. Scaduto A. Scapegoat: The Lonesome death of Bruno Richard Hauptmann. New York: G. P. Putnam Sons, 1976.
32. Zito T. Did the evidence fit the crime? Life March 1982; 41–54.
33. New York Times, 18 July 1967;37.
34. Miller, RB. Identification of wood fragments in trace evidence. Proceedings, International Symposium on the Forensic Aspects of Trace Evidence, U.S. Department of Justice Federal Bureau of Investigation, Quantico, VA, 24–28 June 1994;91–111.
35. Bourquin JD, Tournier P, Otten L, Walter B. Identification of sixteen grapevine rootstocks by RFLP and RFLP analysis of nuclear DNA extracted from wood, 1994;Vitis 31:157–62.
36. Waller G. Kidnap. New York: Dial Press, 1961.
37. Whipple SB. The Lindbergh crime. New York: Blue Ribbon Books, 1935.

Additional information and reprint requests:
Professor Shirley A. Graham
Kent State University
Department of Biological Science
Kent, OH 44242