

# Poetic Engineering and Invention: Arthur Troutner, Architect, and the Development of Engineered Lumber

JONATHANREICH  
University of Idaho

An article in a recent mainstream architectural journal addresses the current debates about the use of wood in architecture. The debate goes something like this: first nervousness is expressed about the use of wood and the depletion of the resource of older trees which are large enough to saw into boards and beams. A grim statistic is given that suggests that even if the remaining "old growth" were available to be logged, the supply would only see us through a few more years. The idea of forest management for sustainability is discussed in relation primarily to continuing (surprisingly) the supply of sawn lumber. Steel is considered and the debate continues over which is "greener," wood or steel. "Engineered" wood is suggested as an important alternative and some of the technical issues about it are discussed. The magazine reminds us that it first reported on the declining quality of available wood in December 1990. (Holbrook)

Over 40 years ago one person was already thinking about how wood could be combined with other materials to improve its strength and stretch its supply. He began a series of inventions that led to the development of engineered lumber. This person happened to be an architect, and his historic work

places him squarely in the tradition of innovative development of building materials.

## "OUT WEST"

High in the mountains that rise abruptly out of the town of Boise, on a bitterly cold early March day in 1955, two men struggled to attach triangular brackets made of angle iron to a 2' diameter section of steel pipe that rose 3-1/2 stories out of an exposed spine of rocks on a steep ridge. The vertical pipe was to be the central column of a 16 sided house that would be half embedded and half projecting from the promontory point of the ridge. When assembled, the 16 angle iron brackets radiating out from the central column resembled a flat topped dish that would form the bottom floor and support the house. The pipe rose out of the center of the construction ready to receive the second floor and then the roof. However there was some question as to whether there would be funds sufficient to get to the roof. The two worked with little discussion. They were brothers and attended the task with a quiet intense cooperation developed from years of needing to do difficult physical work in adverse conditions. One was a 34 year old architect named Art Troutner, the other was his brother Paul who was a stone mason.

Troutner had bought the land from a Basque sheepherder. The site looked into an empty draw that drained the slopes of a prominent hill called "Table Rock," and then angled down to the south where it dropped away suddenly, revealing the green carpet of the town along the river below. Beyond the town, the desert stretched out 50 miles flat to the Owyhee mountains. He liked the site because it was above and removed from town and all its confusion, and yet the town was visible as were the distant mountains he had worked in before the war. Though just 3 miles from town, the mountains right around his house were abundant with wildlife. There were deer, elk, bear, eagles, hawks, ground squirrels, rabbits, mice, and snakes. A family of red foxes lived in a den in the rocks under the house. The wildlife was familiar to him from years of hunting and fishing and traveling the territory. This is how it was in the West. He

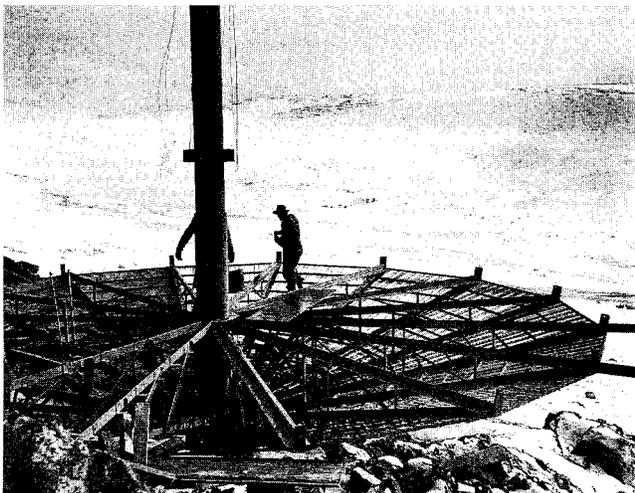


Fig. 1. Construction of the Troutner House, Boise, Idaho 1955.  
*Photo: Art Troutner. Used by permission.*

felt very comfortable. It was a good place to make his home.

Thanks to the Boise River, the town is an oasis of green in the stark landscape of southwestern Idaho. Boise was named for its trees (bois = wooded) by French fur trappers who removed most of the beavers from the rivers and streams in the region between 1808 and 1840. The beavers were made into fashionable hats in demand by well-to-do people "back east" and in Europe. This was the first example of "natural resource extraction" in the mountain west. In 1955 Boise was still a very remote place. There was no freeway. The good roads were two lanes that wound through the steep mountain ravines and stretched straight for miles across vast expanses of the high, dry, sagebrush covered Snake River plain. The nearest other city, Salt Lake City, over 350 miles away, took more than a day to get to by car, weather permitting. The small airport had limited service. There was little television. There was one high school, a small junior college, many churches, many bars, and a state prison.

Most people were employed in the production of food, construction, or in resource extraction industries (mining and forestry), and were concerned primarily with providing themselves with the basic necessities of life. In remote places, where life can be harsh, it is unexpected to find someone devoted to experimental architecture at great personal cost. Troutner was not a rich man, and so his relatively isolated effort to practice architecture in an innovative way took some courage. From his brother Paul's point of view it was not at all unusual. The two of them were used to working outdoors and enjoyed making things. The relatively strange house they were building was just another in a long series of unusual projects his college educated brother had got into.

Troutner was born in Pingree, in southeastern Idaho in 1921. Pingree is just across the Snake River from the Fort Hall Indian Reservation, home to the Shoshone-Bannock tribes. He was one of 5 children of a subsistence level

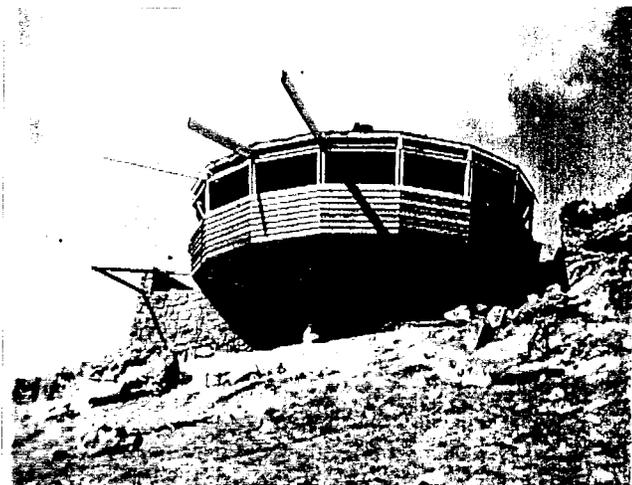


Fig. 2. Construction of the Troutner House, Boise, Idaho 1955  
Photo: Art Troutner. Used by Permission.

farming family that grew sugar beets and potatoes. He spent a lot of time hoeing weeds. Hunting game was another source of food, and this activity often took him into the back country for extended periods. Learning to live in the wilderness can develop in a thoughtful person a love for the land, an appreciation for the efficiency of nature, and a disdain for the messy waste that so often results from human settlement.

### CREATIVITY AND THE NECESSITY OF INVENTION

It has been said that necessity is the mother of invention. Living on a remote farm in Pingree, where scarcity was the norm, required a certain amount of invention everyday just to keep things running. By all accounts Troutner always had an especially inventive mind, but this impulse in him seems to spring from something besides necessity; perhaps from a different definition of need. When he was 9 years old, he fashioned a miniature threshing machine out of junk he found around the farm. The toy actually worked. His mother recognized his mechanical intelligence and sent him to live in Boise where he could attend a good high school. To get around Boise he made a motor scooter out of an old Maytag engine. He describes how there are certain times of day when his thinking seems so clear that he can literally "see" an idea that eventually becomes an invention. He then becomes obsessed with developing it to the exclusion of day-to-day concerns. Often his inventive projects have led to nothing. Maslow's hierarchy of needs would have us believe that people will take care of their basic needs before concerning themselves with tangential inventiveness. Troutner currently holds more than 50 patents for things such as composite wood products and the machinery for making them, all of which have made him very wealthy. But he also holds patents for such things as a toy rubber band gun, a hydro-planing sailboat, a vertical axle wind powered generator, and a solar mirror furnace, and much more. He has spent a great deal of time and money developing things that went nowhere, gaining him nothing but a healthy attitude about risk and failure. In his case, play is equal to necessity as a mother of invention. He is someone who finds simple joy in devising creative solutions to problems of great complexity, and approaches them fearlessly. Some of these attitudes are innate in him and some were developed.

### WARTIME INNOVATION

In 1942, the 21-year-old Troutner enlisted and found his calling in the Army Air Corps. Because he had not gone to college, the option of being a pilot was not readily available. He was trained as a flight mechanic and soon made a mechanic crew Chief and flight engineer. Finally he had the job of modifying the B-17 and B-29 bombers that were rolling off the assembly lines. The assembly lines could not be re-tooled fast enough for changing developments in bomber design. To keep up with the demand for bombers, the same basic chassis

was built and then adapted with the addition of the latest equipment. Sometimes this customizing took place right on the assembly room floor. Troutner's mechanical aptitude, inventiveness and can-do attitude fit right into this situation and was encouraged. Solutions had to be quick and had to work. There was little time for exhaustive research and testing. Because the work involved aircraft, efficient strength-to-weight ratios were always required. Because so much talent and money were employed in the war effort, the latest in materials were made available. Troutner was introduced to many of these new materials and thrived in this setting.

Many of the new materials were developed to make up for shortages of standard materials. One principal method of development was to look for new ways various materials could be combined and processed. The water resistance and durability of softwood plywood which had been invented around the turn of the century was improved in 1933 by the addition of new synthetic urea-formaldehyde resin glues. (Elliot) The vacuum form molding process was developed at this time, enabling veneer plywood to be formed into complex curves. Aircraft wings, fuselages, nose cones, turrets, and boat hulls which might have otherwise been made of scarce metals were made of this new "plastic" plywood. (Freidel)

Larger than usual structures with very long spans were built of wood to conserve precious structural steel. Glue laminated timbers were employed to build the immense Hughes aircraft plant in Culver City, California. Giant hangers for the Navy's fleet of dirigibles were built on the Oregon coast, using glue laminated arches that spanned an incredible 246 feet, 50 feet more than the previous record span with wood. A large navy yard machine shop was constructed to be 3 very tall stories (125' high) with columns made of laminated timbers and floors made of wood trusses. The entire structure was built using wood members no larger than 4 by 16 inches or longer

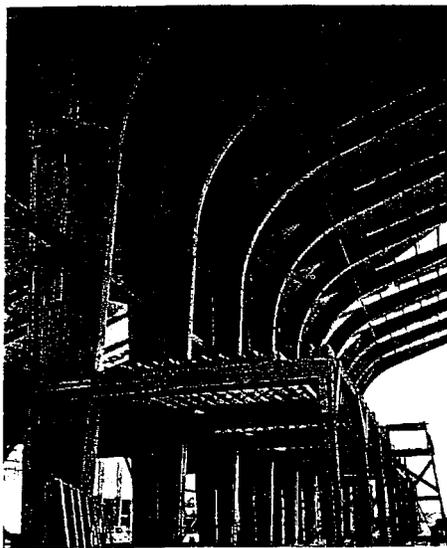


Fig. 3. The Hughes Aircraft Plant in Culver City, California, supported by laminated timber columns and arches. *Photo: Hughes Aircraft Company.*

than 24 feet. It was designed around prefabricated units to enable rapid on-site assembly. (Freidel)

The United States has always viewed itself as a nation with a limitless supply of timber-producing forests. But in 1942, the enormous increase in demand for wood caused by the war outstripped the production capacity of the timber industry. There was a sudden timber shortage that caused a great deal of alarm. The war industry responded quickly with the development of ways to stretch the available supply of wood. The Homasote Company of Trenton, New Jersey came up with a panel material that was made of wood pulp and ground newspaper bound with resin, to be used in place of siding and sheathing for buildings. (Freidel)

### THE ARCHITECT IN THE MOUNTAIN WEST

Troutner had been shipped around the country in his capacity as a hotshot mechanic crew chief and flight engineer. He saw much of the material innovation that was being done and this experience had a significant influence on his thinking. He was impressed with the expertise of the engineers who were devising the solutions. So when he was discharged in 1945, he returned home to Idaho and entered the engineering program at the University of Idaho, making use of the G.I. Bill. However, he soon switched to the study of architecture. He was motivated to switch because he found that engineering was too cautious and rule-bound once the urgencies and necessities of the war effort were removed. Architecture seemed to offer more opportunity for an open ended and creative approach to problem solving. He was neither very interested in the comfort of conformance with strict rules nor very good at strict procedure. He was exposed to ideas about interpretation and representation of culture in school, and he studied history of art, painting and drawing. He was introduced to the work of Frank Lloyd Wright, whose work became a major influence on his ideas about architectural form.

Troutner graduated in 1949 and moved back to Boise. Almost immediately he began to design and build houses and small commercial buildings. His architecture developed along two major themes. The first theme is his love of the land in the American west. In this way his work reflects the influence of Frank Lloyd Wright's idea of an "organic architecture," which is anti-urban, individualistic, and an inventively picturesque abstraction of buildings in the landscape. The second theme relates to Troutner's conviction that architecture is based on structure, and that structural form should be creatively manipulated in architecture to produce what he has called "poetic engineering." He developed his ideas about architecture through a series of houses built for various clients as well as for himself, such as the 16-sided house near Table Rock in 1955. Consistent with his experience in the military, his work tended to be experimental, and he was fascinated with finding solutions to structural problems. He has used several of the houses to showcase his invented products.

## THE INVENTOR ARCHITECT

From early on Troutner was being asked for designs that included longer and longer roof spans beyond the limit possible with sawn lumber joists. Large glu-lam beams seemed to him to be a waste of wood and deep trusses seemed to waste space. He decided to try and invent a new structural system to suit the forms of the houses he was designing and building. He worked out a new kind of lightweight engineered open web system of connected trusses in the form of decking. He modified war surplus aircraft parts to make the machinery necessary to fabricate the system and began producing the system himself. He called his invention "trus dek." The top and bottom chords of "trus dek" consisted of four 1x6 T&G boards connected together with steel rods. The rods also served as the pin connections of four webs made of thin wall steel tubing in a Warren truss configuration. He produced the trus dek in sections that were generally 2' wide, 32' long, and 9" deep. He used the new system in several houses and charged \$1 per square foot for it installed. The most notable use of trus dek is in the Phillips House completed in 1958. The house was constructed as 3 folded plate triangles made of trus dek tilted up in a 3 gabled A-frame configuration. There was little interest in the invention, despite Troutner's efforts to show it to people. Then one of the people to whom he showed it tried to steal the trus dek idea by filing a patent on it. Troutner was able to save his invention, and he knew he was on to something. Unfortunately, there was nothing in the building industry quite like it, and thus it was viewed with some suspicion. (Bunderson)

In 1956, Troutner met Harold Thomas, who was a commission sales representative for several wholesale lumber companies. Thomas understood immediately that Troutner had a potentially very valuable invention on his hands. Thomas had a keen understanding of the market, and he convinced Troutner that what was needed was a long span



Fig. 4. Completed Troutner House, Boise, Idaho 1955. Photo: Art Troutner. Used by permission.

joist instead of the trus dek. Troutner moved his operation into an old parachute and bombsite testing hanger at Gowen airfield. There he proceeded to develop a freestanding truss that utilized stress-rated single 2x4s as top and bottom chords and the same thin wall steel tubing as web chords in a Warren truss configuration. The first model was 20" deep, weighed three pounds per lineal foot, and was produced in lengths up to 50 feet. Troutner also designed the machinery for making this new invention, which he called the "trus joist". (Bunderson) His efforts left him broke. He had spent all of his money developing his inventions and building his own and other experimental houses. He owed money all over town. By 1959 Harold Thomas convinced Troutner to make him the exclusive marketing agent for the trus joist, and in 1960, with scant financial backing, they incorporated Troutner's trus dek and trus joist products into a company they called Trus Dek Corp. Troutner had the responsibility of manufacturing the product and Thomas marketed it. Sometimes Thomas would return from sales calls and help with the production. (Bunderson)

Even good ideas can take time to catch on, and acceptance of trus joists remained a problem. The idea that a lightweight, wood and steel trus joist could be mass produced to be both a standard off-the-shelf item and also a custom designed relatively high tech structural element was revolutionary. The market for trus joists was in small scale commercial and custom residential buildings. This market was not necessarily ready for sophisticated structural concepts and contractors were reluctant to try anything new. There was a popular mindset that structures had to be heavy and massive to be strong. Troutner and Thomas had an independent lab run load tests. They took the risk of inviting the local building officials to the tests. Fortunately, the tests confirmed their calculations, which led to eventual code acceptance. (Bunderson)

Architects were easier to convince. Thomas would call on architects, "...and when invited to state his business he would lay a small gold fringed red tablecloth on the architect's desk. Then he would produce a short section of the trus joist, set it on the tablecloth and stand back with his arms folded, not saying a word. Most architects would look at the product and study it with amazement. This sales approach proved to be innovative and effective." (Bunderson) Joseph La Marche was a young architect working in Boise at the time. He was impressed with the trus joist and went to visit the shop at Gowen Airfield. He still smiles today when he describes the stamping and rattling noises of Troutner's Rube Goldberg-like production machinery. La Marche was the first to use the product in a commercial building. To assist architects in designing with the product, Troutner had typical construction details drawn up for architects to use, which when combined with loadspan tables, made for a complete pre-engineered proprietary system. Trus joist was selling their expertise along with their innovative technology. The company broke even with \$49,000 in sales its first year and was profitable thereafter.

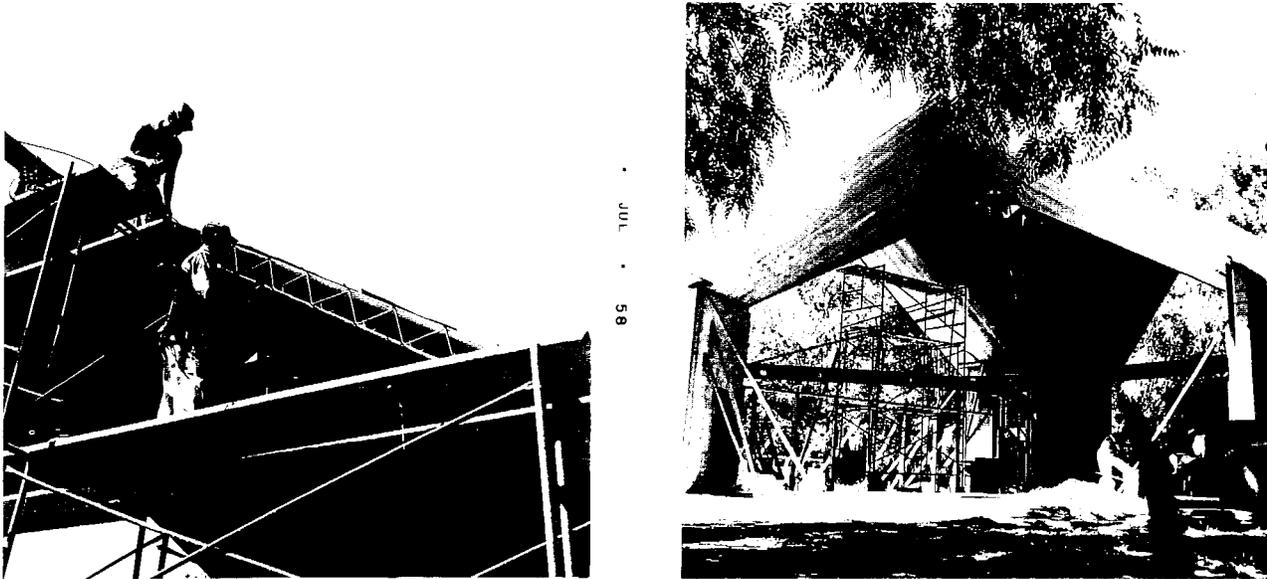


Fig. 5. Construction of the Phillips House using Trus Dek, Boise, Idaho 1958. Photos: Art Troutner. Used by permission.

In 1964, its fourth year of business, the company sold over \$1 million worth of product. (Bunderson)

Meanwhile, in 1962-3, Troutner and his design team developed a series of kit cabin designs able to be prefabricated out of trus joists and delivered as an affordable package that could be erected quickly. This experience interested him in the mobile home industry. Mobile homes have always been a source of quick, inexpensive affordable housing in the west. One requirement of mobile homes is that they be lightweight. In 1968, Troutner invented a lightweight wood "I" joist, originally in a bowed profile for mobile home roofs. The curved version proved too costly to produce but the straight version was very inexpensive. The wood "I" joist was another breakthrough. With it, the company had a product that could fill a market that trus joists were too expensive for. Built in the shape of an I-beam, it consisted of 2x3 or 2x4 flanges with a plywood web dadoed into them and glued. It was less expensive than the

trus joist and used less wood than sawn lumber. Introduced in 1970, it was an immediate success, used widely in multi-story wood construction.

1970 was also the year Dennis Hayes organized the first "Earth Day," signaling the beginning of the mainstream environmental movement. But even before the I-joist was introduced, Troutner had become very concerned with the waste of wood resulting from trus joist production. Though the trus joist and "I" joist used less wood to begin with, there was still significant waste resulting from their production because so much wood had to be culled to get long enough pieces of stress-rated 2x4 for top and bottom cords. The supply of quality wood was quickly becoming less reliable. The lengths of trus joists at this time, for instance, were limited more by material availability than by strength. The company found itself with a growing inventory of odd length pieces. Troutner and Thomas realized that the supply of trees would not last forever and also that the waste was costing a

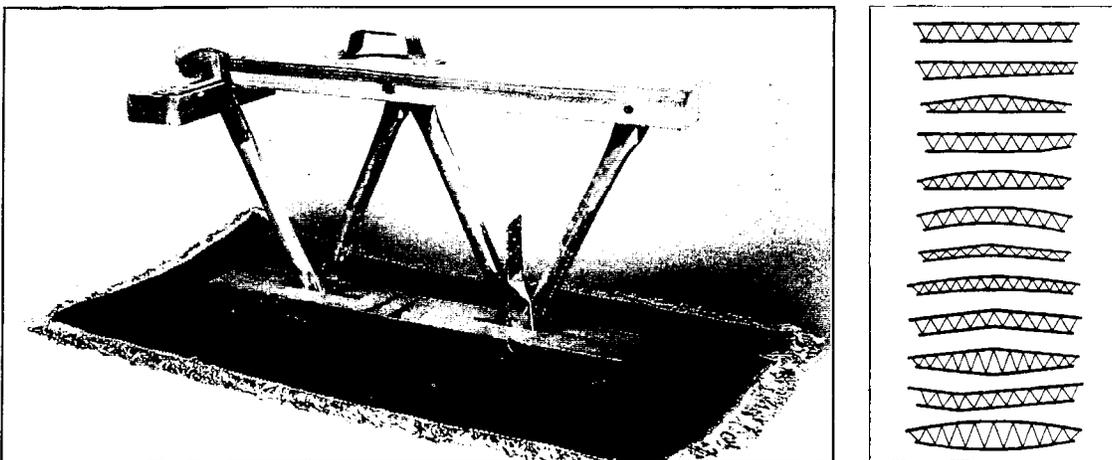


Fig. 6. (Left) Thomas' Trus Joist Sales Presentation. Photo: Courtesy Trus Joist MacMillan. (Right) Trus Joist profiles.

lot. They wanted to find a way to use all of the wood, to not have to throw any of it away.

Troutner revisited the concept of reconstituting wood through glue lamination of thin veneers. Plywood was the best known modern example of this; and the concept had been around for over a century. Furniture makers had long used glue laminated wood veneers. Steinway and Sons had used them for the curved sides of pianos since the middle of the 19th century. (Elliot) The problem however was scale. No one had been able to devise a manufacturing process of glue laminating veneers in a way that could make pieces large enough for structural uses. The big forest products companies such as Weyerhaeuser had tried and given up, saying it was too costly. Troutner visited Weyerhaeuser's operation and is said to have commented that "expensive research leads to expensive results," and he went to work with a small team to try and solve this manufacturing problem. They invented machinery that continuously glued and hot pressed veneers together, producing laminated veneer lumber billets 4 feet wide, 3-1/2 inches thick, and 80 feet long. The product was introduced in 1971 and was called "Micro=Lam LVL." Its characteristics are impressive. The process diminishes the importance of the natural defects found in wood by randomizing them throughout the product. The glues are up to 2.5 times stronger than lignin (wood's natural binder) so the resulting engineered wood can be 2.5 times stronger than sawn lumber. "Micro=Lam" is also uniformly predictable in its structural performance and more dimensionally stable because the moisture content is controlled throughout production. (Wheelwright) Micro=Lam allowed trus-joists and I-joists to be more reliable and able to be produced in longer

lengths. The product also found a market for use as headers and beams. Troutner demonstrated the structural capability of the material by designing and building a house in Hagerman, Idaho using box beams made of Micro=Lam. The house features enormous cantilevers which might normally be expected to be built in steel. Troutner also designed and demonstrated high voltage electrical utility poles built out of the same Micro=Lam box beams in an effort to show how this kind of utilitarian item could be produced using less wood.

The big forest products corporations considered Micro=Lam to be a niche product and continued to focus on providing conventionally sawn lumber. Few realized what Troutner knew in 1969; that the paradigm for building with wood had changed. No longer could trees be considered as sources of sawn lumber. Instead, trees and other plants needed to be considered as sources of fiber which could be engineered into lumber. It wasn't until the 1980s that restrictions imposed on logging because of environmental concerns convinced the big forest products companies to move into engineered lumber in a major way. Oriented Strand Board (OSB), and Parallel Strand Lumber (PSL) were developed by other forest products companies, but not until the mid 80s. Parallel strand lumber was developed by MacMillan Bloedel Corp. of Canada, however the product was not profitable until MacMillan Bloedel formed a partnership with Trus Joist, and Troutner and his research and development staff were brought in to re-design the production processes.

## CONCLUSIONS

Arthur Troutner, an architect, pioneered the invention of technologies that revolutionized the use of wood as a composite structural building material. These inventions ("Trus Dek", the "Trus Joist", the wooden "T" joist, and laminated veneer lumber) are now valued by architects for several reasons: their structural capability makes possible a variety of building forms; they can contribute to elegantly simple aesthetic design as structural pieces; and they are more efficient in the use of the resource of wood. Not only did Troutner conceive of the products, but in each case he also invented, or led the team that invented, the crucial technologies and machinery that made industrial production of these products possible. T J International Corporation, now a Fortune 500 company and the leader in this field, is the result of his work.

These developments in wood construction are as important as the addition of steel reinforcing was to concrete construction. In both examples materials are combined to greatly extend their design capability. But Troutner's work led to fundamental changes in understanding as well.

Before Troutner's inventions, trees were always seen as sources of logs to be sawn into lumber. After Troutner's inventions, the understanding of wood as a resource changed. It is now understood that trees and other plants are sources

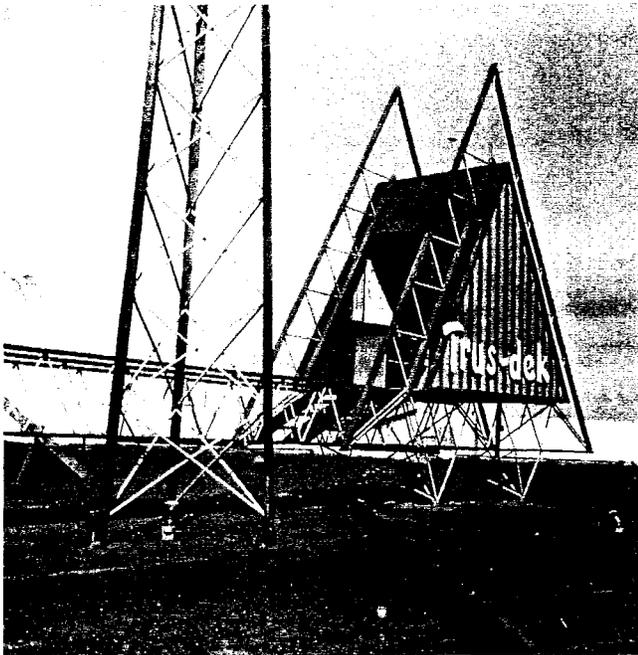


Fig. 7. Trus Dek Corp.'s pavilion made of trus joists for the 1962 Idaho State Fair. Photo: Nels Reese. Used by permission.

of fiber which can be combined with a variety of materials to produce structural elements of great strength and efficiency.

Therefore, Troutner's work has not been merely innovative, though it would certainly be enough if that were all that it was. The implications of the work Troutner began in 1954 are of extraordinary importance now because the supply of large trees traditionally used for sawn lumber has diminished to the point where it is clear that the future of the use of wood for buildings will actually depend on the concepts he pioneered. For this reason, he can be counted among the visionaries of our time because he understood that the future demand for wood as a natural resource would require new technologies. His work greatly enhances the potential for wood to be a truly renewable resource for building.

Many people who become wealthy do so out of a drive to succeed in achieving wealth. Although Troutner welcomes the financial rewards of his work, he seems to have been motivated more by a love for invention and making things. The wealth that has come his way is a byproduct of

that. In this way he is more like a "successful" artist whose creative work continues long after his success. He is currently working on what he says will be another major step in the development of composite wood structural materials. His relationship to the corporate culture resulting from his company's success has not always been comfortable. His methods of working and his results have not always been predictable. But Troutner's history with Harold Thomas and the company they founded illustrates the symbiotic interdependence between creative inventors and skilled business people necessary for the success of innovation.

Troutner the architect / inventor is of historical importance as another key figure who exemplifies the relationship between technical evolution and design culture. His story also illustrates key ideas about the complicated relationship between Westerners' love of nature and the land, and their use of its natural resources. But over and above all else is the story of Troutner's fearlessly inventive creativity pursuing his idea of "poetic engineering," and this makes

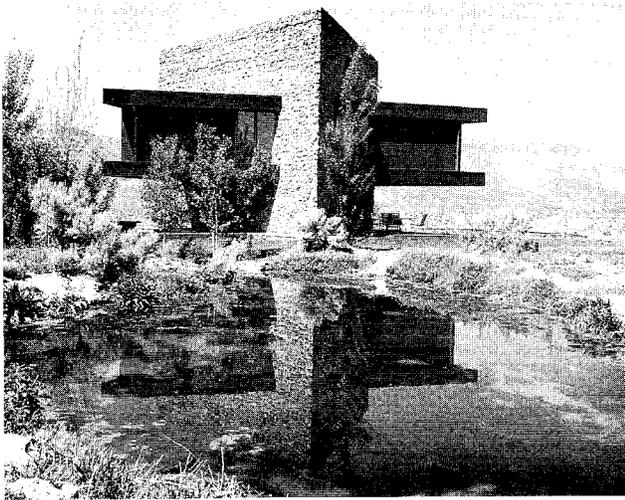


Fig. 8. Troutner House, Hagerman, Idaho, 1985. Photo Art Troutner Used by permission

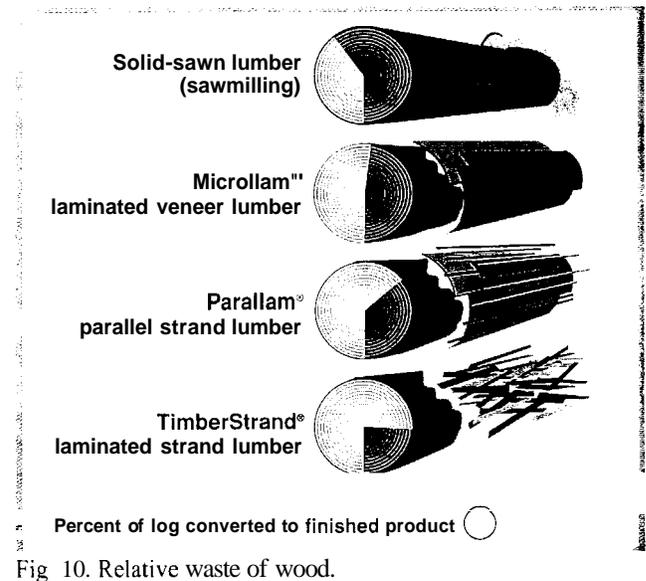


Fig. 10. Relative waste of wood.

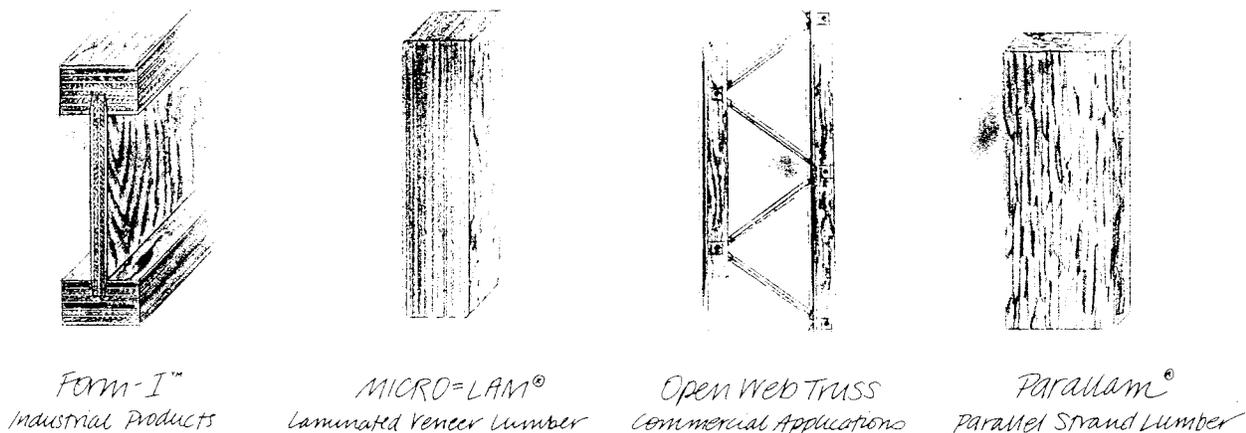


Fig. 9. Troutner Inventions, Trus Joist products.

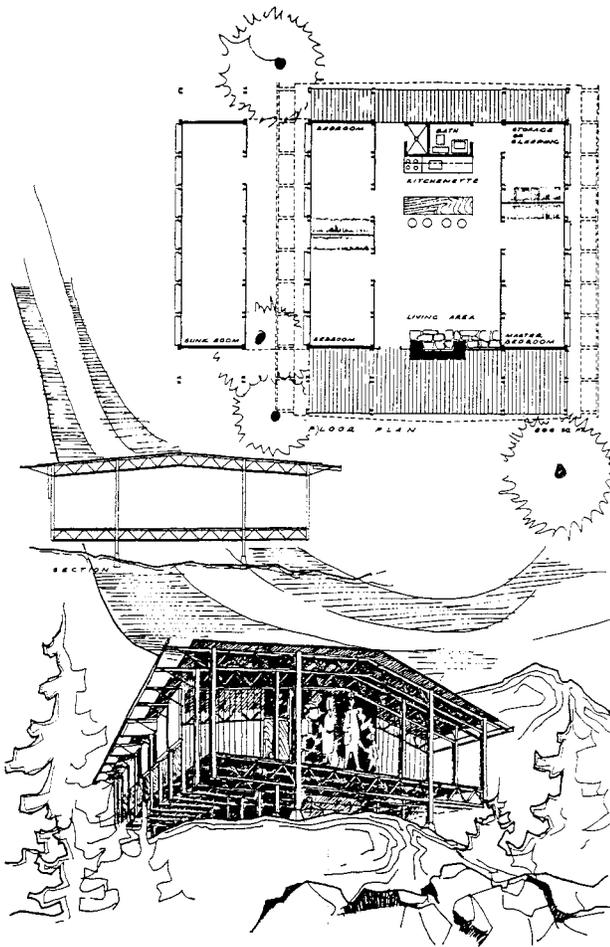


Fig. 12. One of the Troutner designs for a kit cabin, 1962. Drawing: Nels Reese. Used by permission.

his story universally important.

The house that Art Troutner built on the hill next to Table Rock is now surrounded by a sprawl of very large custom suburban style homes of the type that were popular in the 1980s. It seems sometimes that excessive consumption and overpopulation may ultimately outstrip any possible technical fix for resource scarcity.

## BIBLIOGRAPHY

- Bunderson, Harold. *Idaho Entrepreneurs*. Boise State University. Boise, Idaho. 1992
- Elliott, Cecil D. *Technics and Architecture: The development of Materials and Systems for Buildings*. The MIT Press. Cambridge, Mass. 1992
- Freidel, Robert. *Scarcity and Promise: Materials and American Domestic Culture During World War II*. Excerpted in *Blueprints: The Journal of the National Building Museum*, Vol. XII, No.4, Fall 1994
- Holbrook, Dana. "Framing Techniques Change to Match Resource Quality," in September 1995 *Architectural Record*, a publication of the McGraw-Hill Companies
- Interviews with: Arthur Troutner, William Bowler, Nels Reese, Sherm Nelson, George Roberts
- Maslow, A. H.. *Motivation & Personality*. New York. Harper & Bros. 1954
- Sturges, William Gould. "An Exploration of the Relationship Between Houses & Forests in American History". In Vol 46, No.2 of *Journal of Architectural Education*, Wash, DC, Association of Collegiate Schools of Architecture / Butterworth Heineman. Nov. 1992. Whiting, Henry. *Teater's Knoll; Frank Lloyd Wright's Idaho Legacy*. Midland, Mich. Northwood Institute Press 1987
- Wheelwright, Steven. *Trus Joist Corporation*. Harvard Business School Case Study #9-675-207 Harvard College, Cambridge Mass. 1975

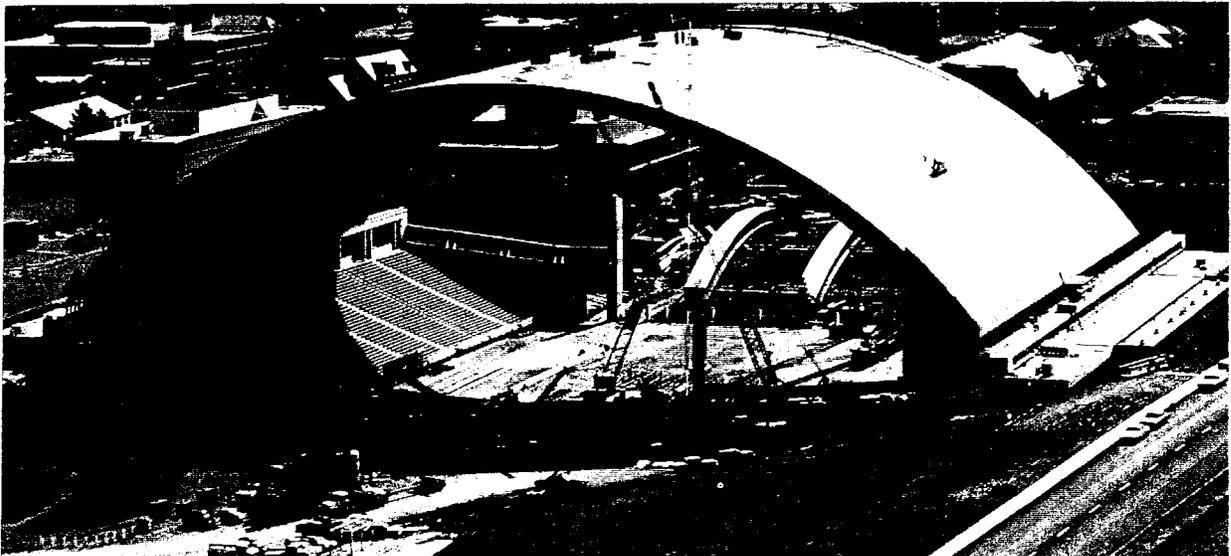


Fig. 11. A modified version of Trus Dek using Micro=Lam was used for the 400' roof span of the Kibbe Dome at the University of Idaho, the longest wood roof span in the world when it was built in 1975. The American Society of Civil Engineers recognized this project as its "outstanding civil engineering project of the year." Photo: Joe Numbers. Used by permission.