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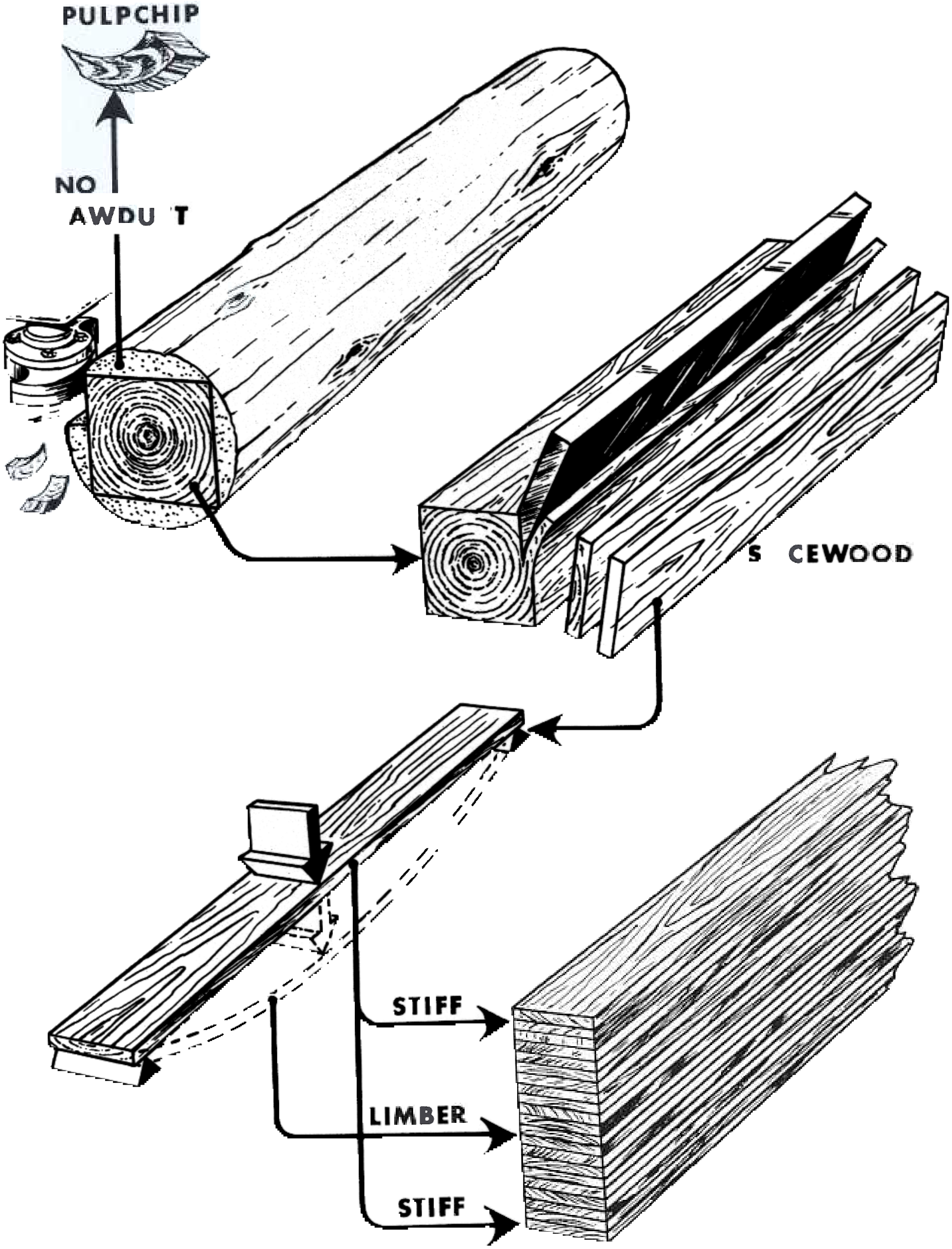

Beams from Boltwood:

Ne Processing System for Southern Pine

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Beams from Boltwood: A Feasibility Study

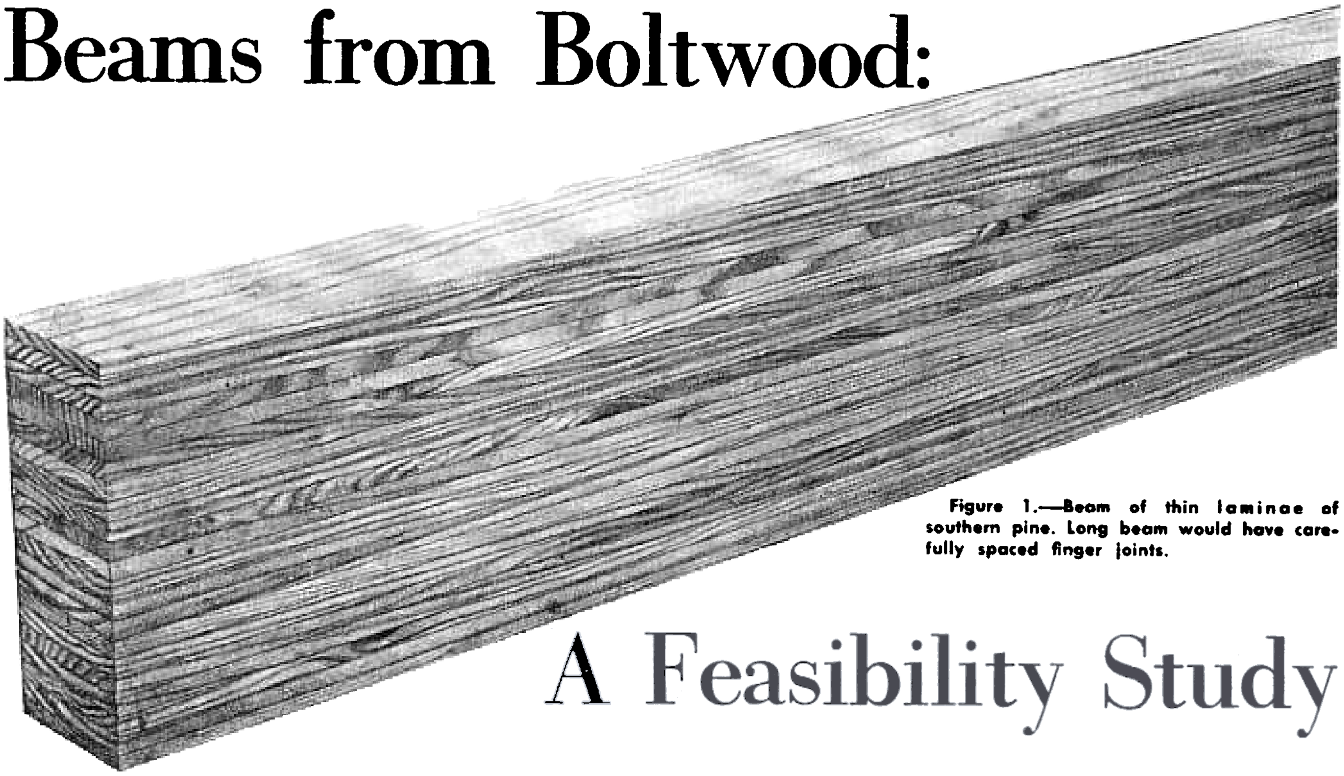

Figure 1.—Beam of thin laminae of southern pine. Long beam would have carefully spaced finger joints.

Abstract

Previous papers in this series of four have explored technical aspects of converting southern pine boltwood into long laminated beams of uniform high strength. This final discussion examines production and economic aspects of the proposed system.

It is estimated that a plant can be built for $1,300,000 to manufacture beams plus pulp chips or flakes for flakeboard. On a two-shift basis, approximately 146 cords of rough bolts would be consumed daily; output would be approximately 2,750 cubic feet of beams per day plus 188 tons of green pulp chips or flakes. The plant would employ 131 people plus truckers and contract boltwood suppliers. Total investment, including working capital, is estimated at $1,700,000. Annual sales would be $2,606,000 and annual profit before income taxes is estimated at $341,000, a 40 percent return on a cash investment of $850,000 (half the capital is assumed to be borrowed). These figures are based on a boltwood price of $18 per standard rough cord f.o.b. plant, a cost per pound of mixed waterproof adhesive of $0.45, a pulp chip selling price of $6.20 per ton f.o.b. plant (green), and a net sale price f.o.b. mill of $3.48 per cubic foot of actual beam volume.

The system is predicated on the anticipated development of a practical slicer that will produce a green veneer measuring 0.6-inch thick.

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THE SEQUENCE contemplated for manufacturing laminated beams from 100-inch southern pine bolts includes these steps: 1) scaling incoming bolts; 2) barking; 3) producing S4S, wane-free, heart-center cants plus pulp chips or flakes for flakeboard; 4) heating cants; 5) slicing cants into veneers 0.6-inch thick; 6) drying veneers; 7) sizing veneers to 0.5-inch thickness, crook-free; 8) segregating veneers by stiffness; 9) preparing vertical finger joints on ends of veneers; 10) end-gluing and face-laminating; 11) finishing; and 12) shipping. Virtually all the processes are innovations. Thus it may be expected that commercial application will involve many a development problem.

Production Feasibility

It will be assumed that there are 75 cubic feet of solid wood in a standard cord (128 cubic feet) of 100-inch, rough, southern pine bolts having an average diameter inside bark of 8½ inches. Approximately 2.2 cubic feet of bark-free round wood are required to make 1 cubic foot of S4S, wane-free, green cant. Tests indicate that approximately 55 percent of the volume in each green cant can be recovered as dry volume in the finished laminated beam: a) width shrinkage of veneers in combination with crook elimination permits 76 percent width recovery; b) thickness shrinkage in combination with surfacing allowance permits 83 percent thickness recovery; c) rejection of excessively distorted or weak veneers permits 91 percent piece-count recovery; and d) end joints permit 99 percent length recovery. In sum, approximately 4 cubic feet of bark-free round wood are required to produce 1 cubic foot of laminated beam.

The major demand is for beams in widths of 3¼, 4¼, and 5¼ inches, and it is important that bolts be of a suitable average diameter. Theoretically, a bolt with a minimum diameter of 7.6 inches, inside bark, will contain a wane-free cant measuring 4¼ by 6 inches (yielding 10 veneers 0.6 inch thick by 4¼ inches wide), 5¼ by 5.4 inches (yielding 9 veneers), or 6¼ by 4.2 inches (yielding 7 veneers). In practice, an average bolt diameter of 8½ to 9 inches at midlength would be required

If the headrig cuts five cants per minute for 360 minutes out of a 480-minute shift, the per-shift production

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of green S4S cants will be 2,500 cubic feet. This volume is equivalent to an output of 1,375 cubic feet of laminated beams and requires 73 cords or 1,800 bolts per shift.

If the green bolts (after barking) average 100 percent moisture content and weigh 62.4 pounds per cubic foot, specific gravity of the laminated beams (ovendry weight and volume at 12 percent moisture content) will be slightly over 0.5. Furthermore, approximately 94 tons (green weight basis) of pulp chips or flakes will be produced per 8-hour shift, along with 20 to 25 tons of green bark and about 20 tons of dry sawdust, shavings, and hogged waste.

Bolt Scaling

Specifications for incoming rough pine bolts might call for 100-inch lengths plus or minus 2 inches, and a minimum top diameter of 5 inches. A grapple-type crane with built-in weight scaling device would be convenient for unloading trucks or cars, building the sprinklered cold deck, and feeding the barker.

Barking

Oversize rough bolts suitable for rotary-cut veneer and cull or undersize rough bolts suitable only for pulp could be diverted for resale into two sorting pockets ahead of the barker. A feed speed of 42 feet per minute sustained for 360 out of 480 minutes per shift is well within the range of a rotating-ring mechanical barker. This operating rate would yield 1,800 bolts or 73 cords per 8-hour shift, assuming an average bolt diameter of 8½ inches.

The barker might feed via a 40-foot-long live deck directly to the headrig. To avoid interrupting the barker in the event of headrig breakdown, it would be desirable to have an ejection station to crane-serviced storage. The headrig deck could be supplied by crane from this storage pile if the barker were forced to stop.

Cant Production and Sorting

Of the three headrig designs described in the August issue of the *Journal*, two were analyzed to determine their practicability. These were the peripheral-milling and the shaping-lathe configurations. Both are designed to machine five bolts per minute. Both are entirely automatic from the time the bolt is delivered to the log deck until the S4S cant is removed by forklift from the sorter behind the headrig. The degree of closure of the charging jaws automatically measures bolt diameter and guides the charging, setworks, discharge, and sorting mechanisms. A sawyer stands by to observe the action, overrides the automatic setworks if necessary, recycles to eliminate wane, and corrects mechanical troubles. Bolt diameter determines cant size.

With the peripheral-milling configuration, a 4½- by 3-inch cant is likely to be the minimum practical. One forklift operator can probably offbear 4-foot-wide tiers of cants from the sorter, place stickers, and build 4- by 4-foot packages of cants for delivery to the steaming chamber. Possibly the forklift driver will need a helper.

The shaping-lathe configuration is principally designed to make cants 4¼ by 3 inches and larger, but it will accept bolts of 3- and 4-inch minimum diameter for conversion into round fence posts. Manpower requirement is identical to that for the peripheral milling rig.

Approximate price of the headrig equipment (not installed) is estimated as follows: peripheral-milling layout complete with automatic controls, log deck, charging equipment, headrig, discharge chains, and sorter—$130,000; shaping-lathe layout with similar equipment—$121,000. Knives and grinding room equipment require additional sums.

Preparation of Cants for Slicing

Optimum slicing temperature for southern pine is 180° to 200° F. Eight hours in a steam chamber should achieve this temperature (4). For two-shift production, it would be desirable to have four small steaming chambers, each with a capacity of 900 cants. Fifteen 4-foot by 4-foot by 100-inch forklift packages would contain 900 average cants. Thus each chamber might measure 16 feet high by 24 feet long by 10 feet wide and hold enough cants for 4 hours of production.

Slicing

An experimental slicer is being developed by the U.S. Forest Products Laboratory in Madison, Wis. It is assumed that the development will be successful.

The system under discussion requires that, at maximum, 48 veneers per minute be sliced for 360 minutes out of a 480-minute shift. It is likely that veneers will not be narrower than 4¼ inches or wider than 10¼ inches. An overhead hopper feed for the slicer will probably be desirable. The hopper could, in turn, be fed by a tilting elevator and transfer chain somewhat in the manner of a high-speed timber sizer or planer.

To minimize waste it is necessary that the slicer create neither a starting nor an ending shim in cutting the 0.6-inch veneers, and hence, that all cants coming to the slicer during any particular run be uniform in size.

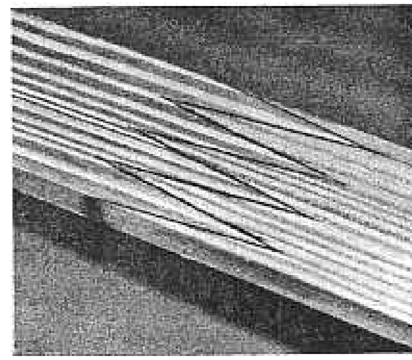

Figure 2.—Finger joint used to convert veneers into continuous laminae.

Drying

Several drying systems are possible. A conventional lumber kiln causes little resin exudation but necessitates stacking and unstacking. In press drying, distortion and surface roughness are minimized, but mechanical problems arise and resin exudation may cause difficulty. In jet drying, resin exudation and some distortion are encountered, but handling and mechanical problems are largely averted.

A production rate of forty-eight veneers per minute, each 4¼ inches wide and 100 inches long, requires drying about 140 square feet of veneer per minute. To permit illustration of the production requirement, it is assumed that a jet dryer will be used and that it will be coupled to the slicer through a 40-foot-long storage chain terminating with a tipple that will feed the three decks of the dryer. The tipple design will be unconventional in that the charge for each deck of the dryer will be accumulated from the side. Following accumulation, the 14-foot-wide by 100-inch-long charge must be fed longitudinally into the dryer. It is anticipated that the charger will be fully automatic, but an operator will be provided to cope with mechanical difficulties.

If the jet dryer operates at 300° to 350° F., a drying time of approximately 60 minutes can be assumed for 0.6-inch-thick veneers, and therefore, a 14-foot-wide, 3-deck, 200-foot-long machine feeding at 3⅓ feet per minute would be adequate. Because stiffness testing should not be carried out at an elevated temperature, it will be necessary to have a cooling section attached to the end of the 200-foot heating section. Such a dryer, including infeed and outfeed equipment, is estimated to have an uninstalled cost of $450,000.

Veneer Sizing

The three outfeed decks of the dryer must be designed to deliver, in a fully automatic and orderly manner, the dry, relatively cool veneer onto a 50-foot-long transfer chain leading to the feed table of a two-saw straight-line edger. As all veneers entering the dryer on a given run will be uniform in width, the edger can be set up for a single width. For example, veneers having a green width of 4¼ inches will be edged back to 3⅜-inch dry width in order to eliminate crook and differential width shrinkage. If the stock is butted as it travels through the edger, a feed speed of 400 lineal feet per minute will suffice. This rate can be attained with a planer-type feed table, modified somewhat in the manner of the "Temple–Jones Crook Reducer" (2). The two saws on the edger must be of such design that they hog the excess veneer as they remove it.

Immediately in line behind the rip saw, a two-way-thicknessing double surfacer (5) will dress the veneers on two sides to 0.5 inch net.

The veneers emerging from the sizing equipment will be 100 ± 2 inches long, uniform in width, straight, and S2S 0.5-inch thick. A single operator will feed the edger and surfacer. It is visualized that no offbearer will be necessary for the dryer.

Stiffness Segregation and Sorting

The double surfacer will feed onto a 40-foot transfer chain directly coupled to the infeed table of a mechanical stress-rating machine (7) operating at the same maximum speed as the edger and surfacer, 400 lineal feet per minute. A single operator will be stationed at the infeed end of the stress rater.

The stress rating machine will exhaust onto a grading chain with room for eight manual sorts: 1) stiff, clear veneers suitable for tension and compression skins; 2) stiffest veneers, not clear but suitable for the laminations immediately adjacent to the tension and compression skins; 3) veneers of intermediate stiffness; 4) limber veneers; 5) veneers that need re-edging; 6), 7), and 8) spare sorts. Four pullers are required on this sorting chain. The chain might terminate at a repair station where a fifth crew member would patch veneers with open edge defects and return them via conveyor to the head end of the chain. It should be noted that lineal feed speeds from dryer through the stress rater will be inversely proportional to width of stock. The maximum of 400 lineal feet per minute will be required only on the narrowest stock—that resulting from green veneer 4¼ inches wide.

Preparation of End Joints

It is contemplated that all laminae will contain vertical finger joints (Figure 2) rather than scarf joints. To cut these joints, bundles of veneer in a particular stiffness classification can be firmly clamped and processed through a double-end finger cutter at a rate of approximately 4 bundles per minute sustained for 360 minutes out of a 480-minute shift. If each bundle contains sufficient veneers for 1 cubic foot of beam (11 veneers, each 3⅜ inches wide, for instance), the requirement per shift can be satisfied. A four-man team should be able to feed and offbear such a machine. A somewhat similar vertical-finger cutting operation has recently been described (1).

End Gluing and Lamination

Curing of the beam with R/F is contemplated. A press cycle on the order of 8 minutes for beams 3⅜ inches wide is probable. At 100-percent efficiency, this amounts to 45 cycles in 360 minutes. To satisfy the per-shift requirement of 1,375 cubic feet of beams, each press load must contain 30.6 cubic feet of finished beams. The press might accommodate a single beam or a combination of beams up to 30 inches deep and 9¼ inches wide. If the average charge is 3⅜ inches wide and 28 inches deep, the press must be 48 feet long to satisfy the per-shift requirement.

It is proposed that the veeners be fed into the press on edge. Cycle time will be roughly proportional to beam width. The process will be continuous. Laminae will be fed from hoppers through constraining channels and glue spreaders into the RF press. As the laminated beam emerges, it can be cut to any desired length up to 60 feet. It will then pass directly through a 30-inch double-surface before it is offloaded to the shipping department. Figure 3 diagrams the press system.

If the beam indexes 48 feet with each press cycle, six pieces of 8-foot-long veneer must be added per cycle to each of the 60 laminae making up the 30-inch press capacity. It is also evident that 8 minutes are available for the complete end-jointing cycle. It is contemplated that each of the 60 end-jointing stations (one for each lamination) will be equipped with a piston-actuated hopper feed. In each hopper, the previously finger-jointed, 8-foot-long veneers will be preheated on both ends. Adhesive will then be applied to the fingers of the final six veneers in each hopper, which will be promptly ejected one by one into a closely constrained channel leading

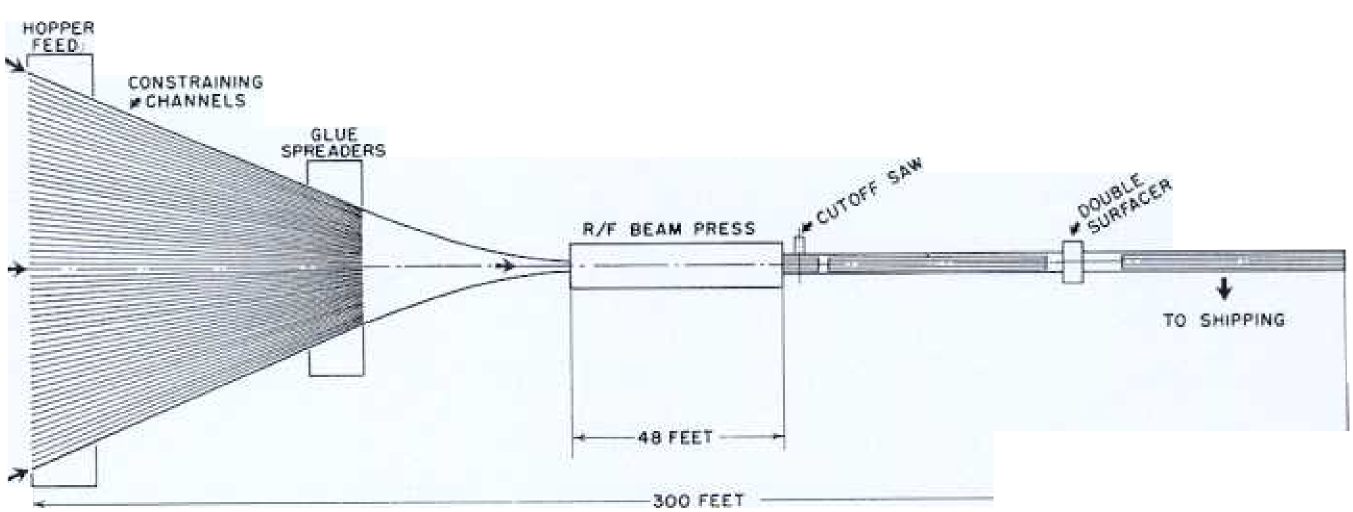

Figure 3.—Flow plan through beam press: laminae travel on edge from 60 hopper-fed layup stations, each holding veneers of a particular stiffness; position of stations can be adjusted for suitable joint spacing in completed beam; during closed portion of press cycle, preheated end joints are partially cured in constraining channels (while stationary and under pressure); glue spreaders apply adhesive to both sides of each lamina, with provision for dry lines where desired; beam is cut to length, passed through a double surfacer and offloaded to shipping.

Table 1. — OPERATING RESULTS IN TERMS OF COST AND PROFIT PER CUBIC FOOT OF LAMINATED BEAM PRODUCED [1]

Item	Amount
Raw material, i.e., boltwood ($18 per cord/75 cu. ft. per cord) (2.2/0.55)	$0.96
Adhesive ($0.45 per lb.) (70 lb./1,000 sq. ft.) (23 sq. ft./cu. ft.)	.73
Direct labor (50 people per shift) ($1.80/hr.) (8 hrs.)/1,375 cu. ft.	.52
Depreciation ($1,300,000)/(10 years) (668,250 cu. ft. per year)	.20
All manufacturing overhead (except depreciation) plus all general and selling overhead (except interest) at 180 percent of direct labor = ($0.52) (1.80)	.94
Interest, 6 percent on unpaid balance if one-half of capital is borrowed. Average interest over repayment period: (0.06) (½) ($1,700,000/2)/668,250 cu. ft. per year	.04
Revenue from chips ($6.20/ton) (93.6 tons chips/shift)/1,375 cu. ft. per shift	.42 income
Revenue from bark ($0 per ton) (0.015 ton green bark per cu. ft. of beam)	.00
Revenue from dry sawdust, shavings, and hogged waste ($0 per ton) (0.015 ton dry waste per cu. ft. of beam)	.00
Profit at 40 percent annually on one-half of capital requirement (0.40) ($1,700,000/2)/668,250 cu. ft.	.51
Total net selling price per cu. ft. FOB mill after all discounts and commissions	$3.48

[1]Projected annual production on two-shift basis, 243 days per year, 1,375 cubic feet per shift.
668,250 cubic feet of beams plus 45,490 green tons of pulp chips (or flakes).
Net annual sales after discounts and commissions $2,606,000
Net annual profit (before income taxes) $ 341,000

into the press. End pressure will be maintained on each lamina during the closed portion of the press cycle to accomplish partial cure of the finger joints. To permit maintenance of a suitable joint distribution in any particular run of beams, the hopper-fed stations must be staggered (and adjustable) relative to the beam press.

As the newly end-glued laminae enter the beam press during the charging portion of the cycle, adhesive can be applied to both sides of each lamina. The applicator mechanism can be similar to that briefly described by Malarkey (6).

The press system might require four men to keep the hoppers full, one man to service and police the glue applicators, one press operator, one trouble spotter, and one man to offbear, to manipulate the cutoff saw, and to operate the double surfacer. This totals eight men, not including supervision and maintenance.

Shipping

It is proposed that beams be made to order, except for certain stock sizes. En route from the press to the railroad car or truck, they would be patched, finished, and wrapped as required. Size of the shipping crew would depend on the degree of finish required; 10 men might be adequate. Probably the bulk of production would be unwrapped, unfinished, industrial-grade beams.

Economic Feasibility

Assessing the economic feasibility of the manufacturing system requires some assumptions about potential markets and economic parameters, including raw material cost. At the outset it is assumed that straight, laminated beams in lengths up to 60 feet, net width up to 9¼ inches, and depths up to 30 inches can be sold in the quantity required at a net price (f.o.b. mill after all discounts and commissions) of $0.095 per pound or $3.48 per cubic foot. Screened, green, pulpable chips should bring slightly more than $6.20 per ton, net f.o.b. chipping plant (3).

It is further assumed that rough southern pine boltwood, averaging 8½ inches in diameter inside bark, can be purchased in 100-inch lengths for $18 per standard cord delivered. The operation is predicated on two 8-hour shifts per day, 243 days per year. As the anticipated consumption is 73 cords per shift, the annual consumption will be 35,478 cords.

Glue cost is estimated at $0.45 per pound of mixed adhesive. The direct cost of labor is assumed to be $1.80 per hour. It is estimated that a per-shift manufacturing force of 50 people, exclusive of foremen and supervisors, is required to produce 1,375 cubic feet of finished beams per shift.

Total capital requirement is estimated at $1.7 million, of which $400,000 is working capital and $1.3 million is invested in plant and equipment. For purposes of investment analysis, it is assumed that one-half of the capital requirement is borrowed at 6 percent interest.

In Table 1 the various technological and economic assumptions are organized to indicate the cost per cubic foot of beam produced.

The table indicates annual sales of $2,606,000 and annual profit before income taxes of $341,000, a 40 percent return on a cash investment of $850,000. A reduction of $0.20 per pound in glue cost would amount to an annual saving of $217,000.

The estimated plant cost of $1.3 million may very well be $500,000 too low. If so, and if the additional sum were borrowed at 6 percent interest, the extra interest and depreciation cost per net cubic foot of beam produced would come to $0.10, and the indicated profit before income taxes would be cut to 32 percent of invested capital.

The investment would still be moderately attractive at a plant cost as high as $2 million, provided that the direct labor force could be held to a maximum of 50 men per shift, exclusive of foremen and supervisors.

Literature Cited

1. Anon. 1964. Joints cut waste. Forest Industries 91: 226.
2. Barrow, John K., Jr. 1964. FPRS annual review of lumber manufacturing. For. Prod. Jour. XIV (3): 137–138.
3. Christopher, J. F. 1963. Pulpwood price trends in the Mid-south, 1946–1962. Southern Pulp and Paper Manufacturer 26 (8): 38.
4. Fleischer, H. O. 1959. Heating rates for logs, bolts, and flitches to be cut into veneer. U.S. For. Prod. Lab. Rept. 2149.
5. Koch, Peter. 1964. Wood machining processes. Fig. 7-9C. The Ronald Press Co., New York.
6. Malarkey, Neil, Jr. 1963. Continuous lamination of lumber. For. Prod. Jour. XIII (2): 68–69.
7. Wood, Lyman W. 1964. Machine-graded lumber . . . out of the laboratory, into commercial trials. For. Prod. Jour. XIV (1): 41–43.