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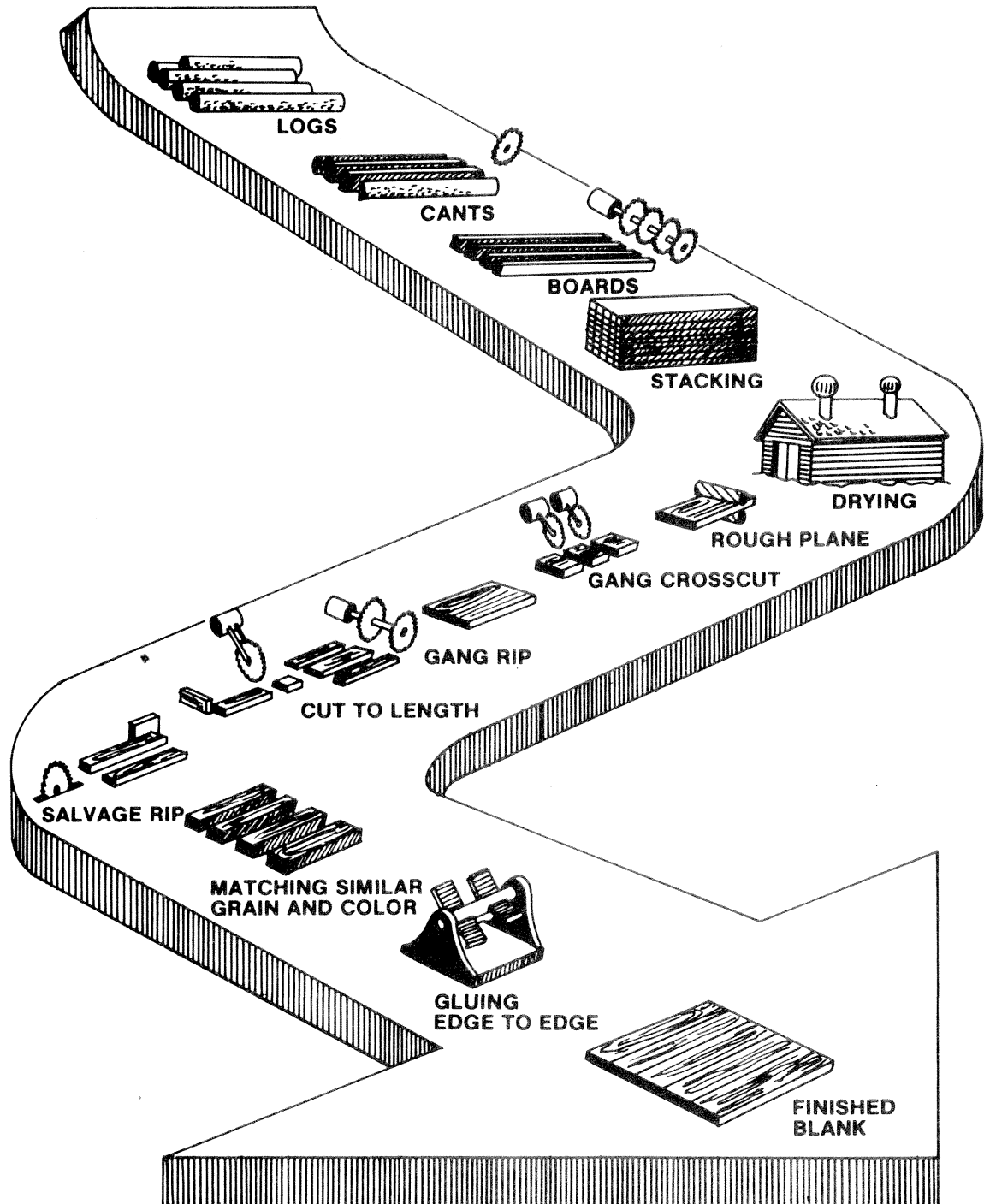
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New Technology for Low-Grade Hardwood Utilization: System 6

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Charles J. Gatchell received his bachelor's degree in forestry from the University of Massachusetts in 1955. After a tour of duty with the U.S. Navy, he returned to the New York State College of Forestry at Syracuse University where, in 1961, he received his master's degree in wood-products engineering. From 1961 to 1965 he was a project scientist in the product and process development project at the Forest Products Laboratory in Madison, Wisconsin. He is now project leader of the Low-Grade Hardwoods Utilization Research Work Unit at the Forestry Sciences Laboratory of the Northeastern Forest Experiment Station at Princeton, West Virginia.

Abstract

System 6 is a technology for converting low-grade hardwood to high-valued end products such as furniture and kitchen cabinets. Among its concepts are: (1) a new, nonlumber product called standard-size blanks; (2) highly automated methods of converting the logs to blanks; (3) total processing of every board that contains a minimum-size cutting; and (4) minimized machine operator decisions and limited choices. While details of procedure and machinery may vary, the seven steps given are considered mandatory for profitable low-grade hardwood conversion.

Introduction

Only the best part of the hardwood resource is presently used to make the solid wood parts in high-valued products such as furniture and kitchen cabinets. Conventional technology starts with the harvesting of large, high-quality trees of selected species. Only the highest quality logs, bucked from these tree stems, are sawed to standard hardwood lumber. And, only the best lumber (1 Common and Better) is generally used for the solid wood parts of furniture and kitchen cabinets. As a result, only a small part of the harvested hardwood resource is used in these finished high-valued products.

What is done with all the rest of the hardwood resource? Trees of low quality or less desirable species and the low-grade lumber from the better logs are used for railroad crossties, pallet parts, mine props, pulp chips, firewood, and many other products. However, these products have lower value than furniture and kitchen cabinets. The value of the end use of the raw material usually determines which trees can be harvested and processed profitably.

A hardwood forest of small, poor quality trees has a very poor profit potential, and much of the hardwood resource in the eastern United States fits this description. Removing only part of the trees and leaving the best to grow to a mature, high-quality forest is often not profitable. The value of the poor timber removed often will not cover the cost of the timber stand improvement (TSI) work.

Furniture and kitchen cabinet manufacturers also have problems. Hardwood forests do not yield an adequate supply of large, high-quality logs, and this causes a shortage of high-quality lumber. Shortages cause price rises. In the half-decade 1975 to 1979, hardwood lumber prices rose 160 percent while hardwood furniture prices rose only 40 percent.

We believe that gradual, profitable conversion of low-quality,

small-diameter forests to mature, high-quality forests is possible. But the low-quality, small-diameter trees that are removed must pay for the TSI work. The small trees must be profitably converted to high-valued products. This will require new technology and a new intermediate product. The new technology we call System 6. The new product is called standard-size blanks. Together, they can bring profitable conversion of the low-grade hardwood resource and reduce hardwood shortages.

Basic Concepts of System 6

An overview of the System 6 processing techniques starts with logs that are 6 feet long (75 inches actual) or 8 feet (99 inches actual), sound, and contain no more than 1-1/2 inches of sweep. Because this system is for low-grade, small-diameter trees, diameter is restricted to 7.5 to 12.5 inches on the small end. Larger logs can be better handled with other techniques. We envision System 6 logs for furniture and kitchen cabinets to be part of a multiproduct bucking scheme where tree-length, low-quality logs are bucked to System 6 logs, pallet bolts, pulp bolts, or firewood. However, System 6 may well carry the entire cost of harvesting and processing where markets for such an

ideal mix of products are not readily available (Reynolds and Gatchell 1979).

Four basic concepts differentiate the new System 6 technology from the conventional techniques used to convert hardwood tree stems to furniture and kitchen cabinet solid wood components. These concepts are: (1) a new, nonlumber product called standard-size blanks that is the output of the System 6 process; (2) highly automated rather than manual techniques for converting logs to blanks; (3) total processing of every board that contains a minimum-size cutting; and (4) minimized operator decisions and limited choices. Contrast these with conventional techniques: logs are sawed to lumber. Lumber is sorted by grade, with the higher grades being used to make furniture and kitchen cabinets. The lower grades are used for pallets and other less valuable products. Much of the conventional processing is done manually and operators must choose the best of several options.

Standard blanks have been developed by Araman et al. from an analysis of the rough part sizes required by 32 major manufacturers of kitchen cabinets and furniture. A standard blank (Fig. 1) is a piece of

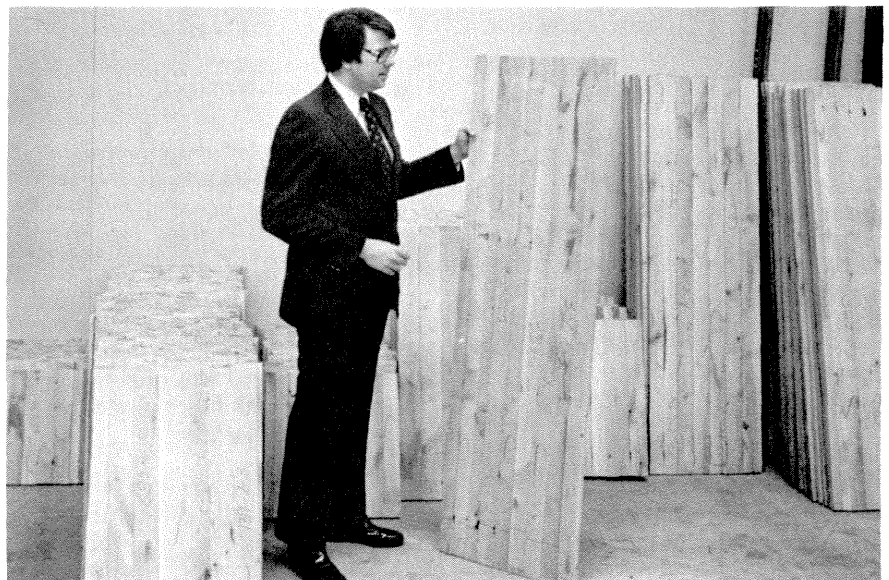


Figure 1.—Standard blanks

solid wood (it may be of edge-glued construction) of a predetermined length, width, thickness, and quality. These blanks may be efficiently processed to the needed rough parts by simple ripping and cross-cutting with a very small loss in kerf and end trim.

Automated processing must be used to reduce costs and increase production. Current hardwood production techniques are essentially manual and require high-quality logs and lumber. A machine operator views a log or a piece of lumber to be processed and decides how to process it. Then he controls the machine as the operation is performed. For example, the lumber crosscut operator in a furniture rough mill has the task of cutting out pieces of specified lengths with a minimum of defect and making optimal use of each board. He views the board, moves it manually under the saw, pulls the saw through the board, and decides where the next crosscut should be made. Low-quality lumber has many defects, making decisions difficult and production slow.

In System 6, manual processing is minimized. The crosscut operator examines each board, decides which one of three gang crosscutting options is best, and enters this choice into a gang crosscut saw. While the saw is automatically making the board crosscuts, the operator is examining the next board.

With standard hardwood lumber, the higher grade boards are sold and processed for different end products from the lower grades. In System 6, however, every board produced from the 6-foot logs is processed through each step if it contains at least one minimum-sized cutting. This will be done without regard to any other board-quality factors such as grade or wane.

Details of System 6 Technology

The details of System 6 (Fig. 2) technology have been developed from numerous trials at our Methods Testing Plant at Princeton, West Virginia. Several manufactur-

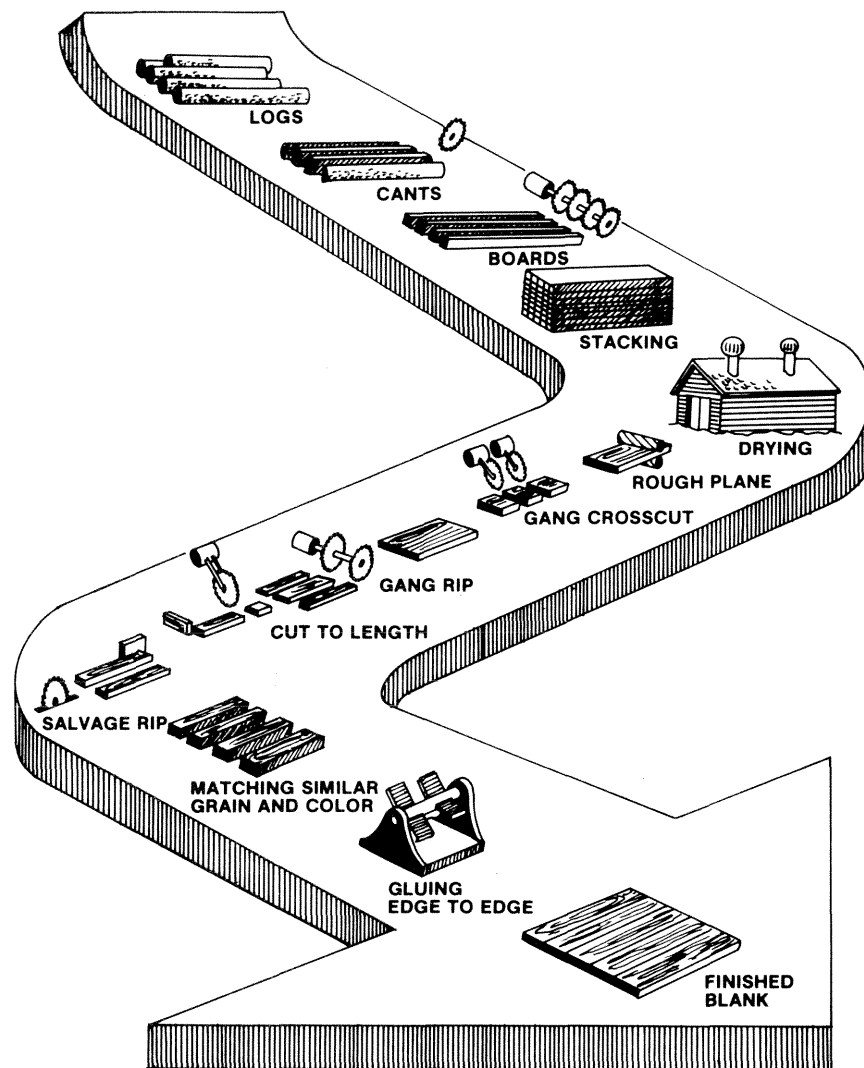


Figure 2.—System 6 begins with logs and ends with blanks

ers of furniture and kitchen cabinets have evaluated the output of System 6 and found it satisfactory for the production of fine solid wood products. For System 6 to give the best results, seven sequential steps must be considered:

1. Divide the low-grade hardwood resource into different round-wood products.
2. Saw System 6 bolts to cants, not lumber.
3. Use automated cant sawing to make boards.
4. Use best drying practices.
5. Remove the majority of defects with automated cut-up.
6. Bring pieces to specified size and quality with manual cut-up.
7. Make standard-size blanks as the final product of the System 6 rough mill.

A description of each of these seven steps follows:

Step 1. Divide the low-grade hardwood resource into different roundwood products. Maximum use of the small-diameter, low-grade hardwood resource requires markets, such as pallets, pulpwood, or firewood, for species not used for furniture and those portions of desired species that are not adequate for System 6 processing because of crookedness, lack of soundness, or size.

The System 6 bolt criteria are:

Minimum length:	6 feet nominal; 75 inches actual or 8 feet nominal; 99 inches actual
Sweep:	1-1/2 inches maximum, any diameter
Diameter:	8- through 12-inch diameter classes (7.6 inches minimum to 12.5 inches maximum diameter inside bark on small end)
Quality:	Sound and solid. Sound defects without limit.

Small hardwood timber and low-grade hardwood timber are synonymous most of the time. We have made recovery tests with bolts having three or four clear faces and compared them with tests where straightness and soundness were the only criteria.

Surprisingly, the poor-looking bolts had practically the same yield as the good-looking bolts. "Beauty was only skin deep" on the good-looking bolts; the clear wood was only an inch or so deep. This thin covering of good wood is cut off during the making of cants and boards.

The maximum sweep of 1-1/2 inches over the bolt length controls the bucking decisions when tree-length logs are cut to shorter lengths. Experience has shown (Reynolds and Schroeder 1978) that 6 feet is the shortest length that will minimize crook and sweep while al-

lowing an acceptable yield of long, clear cuttings.

The lower diameter limit for System 6 material is the 8-inch diameter class (7.6 inches actual) on the small end of the bolt. System 6 bolts are processed to two cants whose thickness determines the width of System 6 boards. Minimum cant thickness has been set at 3-1/4 inches and a 7.6-inch diameter bolt is the smallest that will give two 3-1/4-inch thick cants.

The upper diameter limits for System 6 bolts are set at the 12-inch diameter class (12.5 inches actual) on the small end of the bolt. Material larger than 12.5 inches is better processed with more conventional technology. Bolts at or near the upper limit will very nicely produce two cants that are 4 inches thick.

Step 2. Saw System 6 bolts to two-sided cants, not lumber. Saw-

mills lose money sawing small factory grade 3 and poorer logs to lumber. Twenty percent or less of the lumber from these logs will be 1 Common and Better—the profitable grades. Yet small factory grade 3 sawlogs are, for the most part, the best available in the low-grade resource. The sawmills must make a different product—one that can be quickly and easily produced and one that can be sold at a profit.

In System 6, sawmills make two-sided cants instead of lumber (Fig. 3). A marketing analysis (Reynolds and Gatchell 1979) shows that circular headrig sawmills should be able to make cants profitably if they use the following procedure:

1. Load the bolt onto the small carriage and saw a 3-inch minimum wide face.

2. Rotate the bolt 180°.



Figure 3.—Sawmills make 2-sided cants

3. Make the second saw cut so that the bolt has the thickness of two cants plus a saw kerf.

4. With the third and last saw cut make two cants, either 3-1/4 or 4 inches thick.

When large numbers of System 6 bolts are to be sawed, automated sawmills that can make the two cants in one pass are practical.

The requirement for 3-1/4- or 4-inch-thick cants reflects the needs of automated ripping. Boards wider than 4 inches may contain more than one cutting and this system is not designed to return a board for a second cut. We recommend only two thicknesses (3-1/4 and 4 inches) because these cants require a minimum of sawing to produce a valuable sawmill product.

Step 3. Use automated cant sawing to make boards. One of the reasons that conventional hardwood sawmilling is costly is that logs are sawed to get the highest grade of lumber. This requires numerous turns of the log and the judgment of a highly skilled sawyer. Low-grade hardwoods do not contain enough high-quality material to permit such sawing for grade. Instead, they need a rapid, automated sawing technique to saw cants quickly into boards. Automated sawing means that the saw is set and runs without additional operator attention once the material is committed for processing.

Circular gang resaws (Fig. 4) meet the automated sawing requirement quite well. They are relatively inexpensive, well proven through years of use in the hardwood pallet industry, and provide excellent accuracy. These machines require two flat parallel faces on the wood being sawed. Two-sided cants are ideally suited for these machines as the two rounded sides do not affect the sawing.

Circular saws are put on the gang-saw arbor with spacers between them that determine the board thickness. With System 6, all boards from a cant are sawed to the

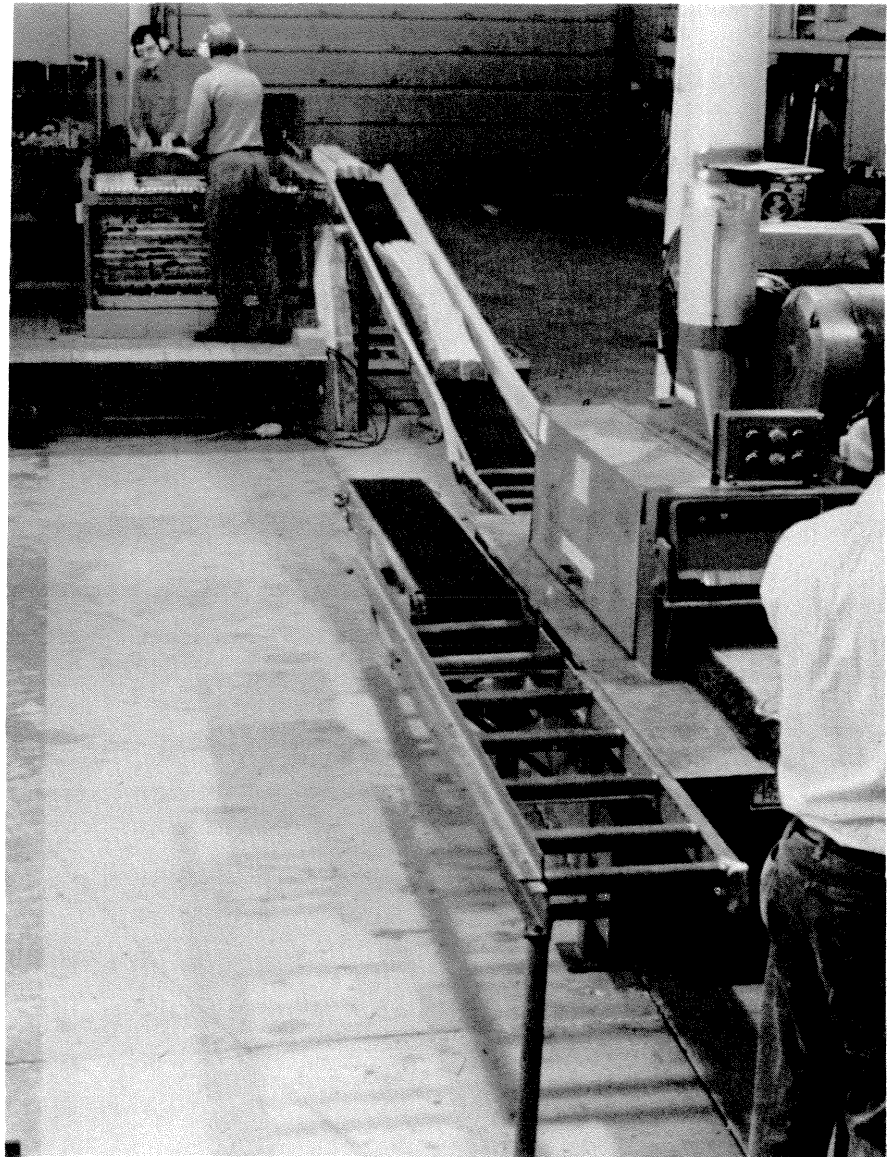


Figure 4.—Circular gang resawing

same thickness. As will be seen later, proper drying is very important—so important that we recommend stacking straight from the gang saw. Boards must be of the same thickness for optimum drying. Boards that do not have one minimum-size (1-1/2 inches wide x 15 inches long) clear area are rejected before stacking. All other boards are used.

Sawing a few boards from the cant and returning the remainder of the cant for further sawing does not always work. Often there are enough growth stresses in small-diameter hardwoods to cause a crook in the cant when a few boards are sawed at one time from one side. When the remainder of the crooked cant is sawed, the board nearest the fence is always thin on

one end and of no value. We recommend a single-arbor circular gang saw with a large enough motor to saw all boards automatically in one pass.

Step 4. Use best drying practices. The output of the gang-sawing step is boards that are 3-1/4 or 4 inches wide, about 6 or 8 feet long, and full of stresses that must be relieved during drying. The drying step is crucial to the success of System 6.

In our System 6 pilot plant at the Princeton Forestry Sciences Laboratory, a conveyor runs from the cant saw to the stacking jig (Fig. 4). The boards are sticker-stacked in 4x4x6-foot packages banded with polypropylene strapping and are brought to the air drying yard or to the forced-air predryer on the day the boards are sawed.

System 6 drying experiments have shown that three practices will permit good drying and stress relief: First, boards should be stacked for drying immediately after they are sawed. Second, smooth 1/2-inch-thick stickers on 2-foot centers should be used in stacking. These thin stickers keep the boards' surfaces from drying too fast initially. Third, 2,000-pound concrete slab top weights (Fig. 5) should be used to prevent twist and cup in the top layers of the drying stacks.

Some boards will crook while being dried. We have found it best to let this movement occur. Smooth stickers aid in this. When the boards are restrained to prevent crook, the stresses get locked in. Then when these boards are processed to remove defects, the cuttings that result will crook. Obviously, it is best to let this crook occur during drying to relieve stresses and get stress-free cuttings. Predrying and kiln drying schedules that include liberal equalizing and conditioning times will produce boards that are flat and stress-free.



Figure 5.—Stacked board packages with top weight

Step 5. Remove the majority of defects with automated cut-up. System 6 processing results in narrow (3-1/4- or 4-inch) boards of only two lengths (6 or 8 feet). Most of these boards are of poor quality. In our trials to date, one-half to two-thirds of all boards were below the quality standards for 3A Common. Very little was as good as 1 Common. This is certainly much poorer quality lumber than that normally used in furniture and kitchen cabinet rough mills.

We have developed techniques to get all that is good from these boards rapidly and efficiently. Gang crosscutting is followed by gang ripping. What separates our approach from the conventional one is that at each of these steps the operator inspects the workpiece and chooses the best of a very limited number of sawing options. Once these decisions are made, the board is processed automatically. These techniques have been developed so that all boards, regardless of quality, may be processed.

Gang crosscutting

A multiple-saw gang crosscut is used to make one to four pieces from each board (Fig. 6). The spacing between saws will depend upon the lengths of blanks that are to be made. The number of pieces generated will depend upon the quality and length of the board.

The outer saws are used to trim the ends of those best boards (approximately 10 percent) that contain one full-length cutting. Medium-quality boards (approximately 20 percent) contain a cutting that is long, but less than full length. The

outer saws and one inner saw are used to cut these boards to one long piece and one short piece. Low-quality boards (approximately 70 percent) are crosscut to three short pieces (6-foot boards) or four short pieces (8-foot boards). A degree of flexibility is gained by allowing the operator to turn the board end for end. However, once the combination of saws to be used is chosen, the crosscutting is done automatically without further guidance from the operator. This gang crosscutting procedure may be done rapidly by an operator with very little training.

Gang ripping of acceptable pieces

Pieces coming from the gang crosscut saw are accepted if they contain at least a minimum-size cutting (1-1/2 inches wide by shortest blank length to be made). Only one cutting will be made from each piece. To speed processing and ease the operator's decisions, we recommend cutting-width increments no smaller than 1/2 inch. In our work, we have standardized on cutting widths of 1-1/2, 2, 2-1/2, 3, and 3-1/2 inches.

Each piece to be gang sawed is inspected to determine the better

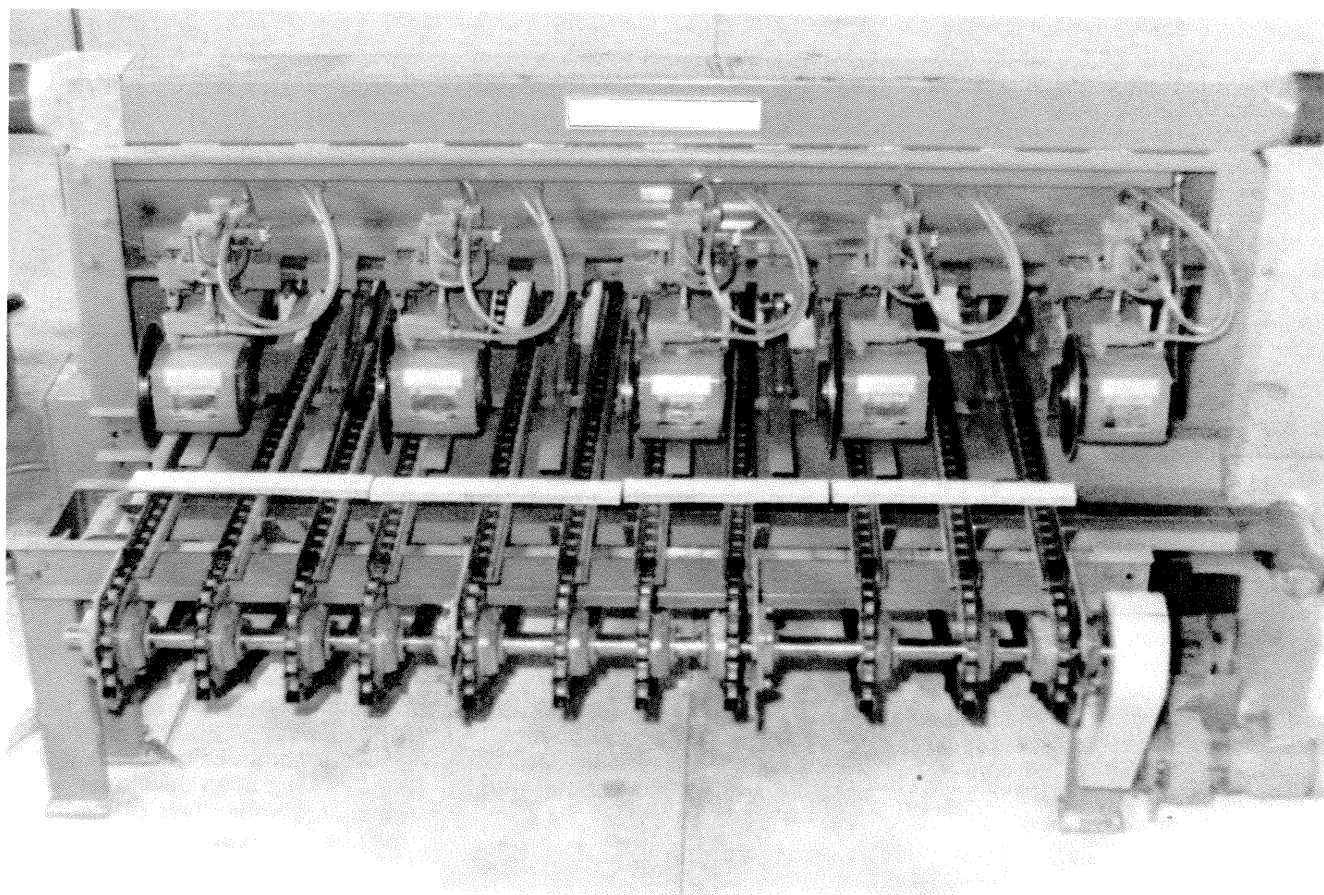


Figure 6.—Gang crosscutting saw, outfeed end (guard removed to show saw blades)

edge; this edge will be given a 1/4-inch dressing cut. The piece is placed in one of five pockets on the gang rip table (Fig. 7) so that the 1/4-inch edge cut and the width cut to remove defects are made at the same time. The gang rip saw operator can easily recognize into which pocket each piece should go because we use only five widths and each is separated by a 1/2 inch increment from the other. Pieces coming from the gang rip saw must have edges of glue-joint quality.

Any piece with large defects on both edges is unlikely to have a minimum-size cutting in it. It will

therefore be rejected before the gang ripping step. Other pieces will have a better edge that may be discovered by flipping the piece from face to face.

Gang ripping does not work well for boards wider than 4 inches because they may contain more than one cutting. Boards that contain more than one cutting require the operator to recognize both and make the necessary decisions to secure both, which is too complicated for rapid operation. In System 6, once the operator places the piece in a rip saw pocket, he is through with it. Bolts up to 12.5 inches in di-

ameter, when sawed to two cants, will yield the 4-inch maximum width System 6 requires.

Step 6. Bring pieces to specified size and quality with manual cut-up. After gang crosscutting and gang ripping, the cuttings are in no more than five lengths. Eighty percent or more of the defective wood will have been removed after step 5. However, there may still be some defects that need removal. A manually operated crosscut saw is used to remove end defects. Pieces are cut to blank lengths. A manually operated glue-joint rip saw is used for salvage ripcuts when required.

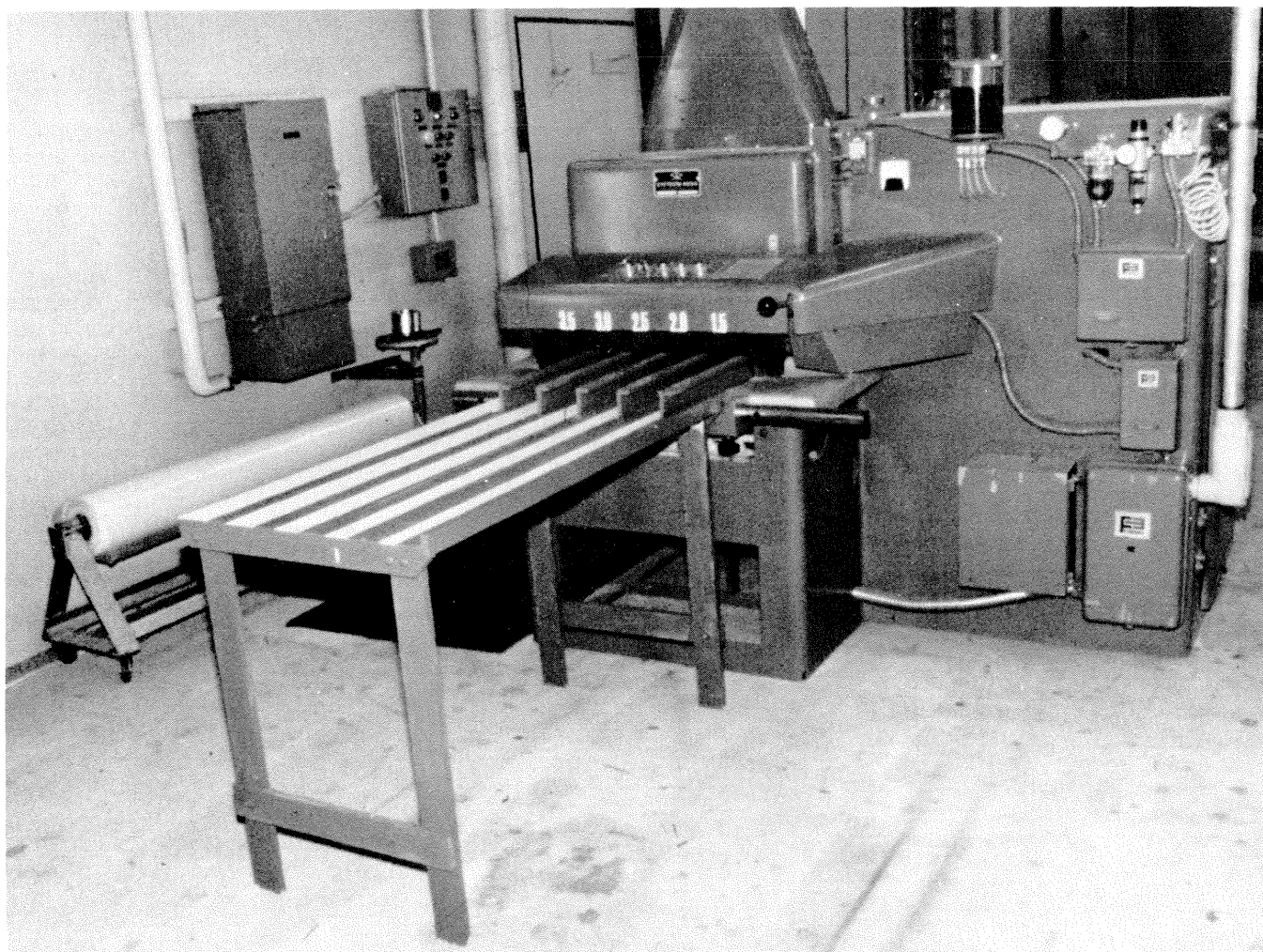


Figure 7.—Gang rip saw

Step 7. Make standard-size blanks as the final products of the System 6 rough mill. The furniture and kitchen cabinet industries use parts in thousands of different sizes. It would be almost impossible to convert low-grade hardwoods directly into these many different parts efficiently. Production runs would be too short and scheduling would be a vexing problem. Fortunately, standard-size blanks (Araman et al. 1982) solve these problems.

Blanks are made to specified thicknesses, widths, lengths, and qualities. They are designed to be the rough size of the most commonly needed parts or to be multiples of the lengths and widths of these rough sizes. Blank widths from 1-1/2 to 3-1/2 inches in 1/2 inch increments work very well for narrow parts, or edge-glued wider blanks can be ripped back to the needed sizes. Clamp-carrier edge gluing with PVA glue at 200 psi (pounds per square inch) pressure has been used at our Methods Testing Plant at Princeton, West Virginia.

Summary

System 6 will require modified procedures all the way from the tree to the furniture rough mill. For greatest efficiency, tree-length logs should be bucked to multiple products including System 6 bolts, pallet bolts, pulp bolts, and firewood. System 6 bolts will be sawed to two-sided cants to aid in the release of growth stresses and to control the width of boards that will be gang-sawed from the cants. A maximum board width of 4 inches is recommended. Boards from cants must be dried immediately. Once properly dried, they will be converted into blanks of specified length, width, thickness, and quality.

The economics of System 6 has been covered elsewhere (Reynolds and Gatchell 1979; Gatchell and Reynolds 1980). There appears to be a sufficient economic potential at each step from trees to standard blanks. In addition, there are opportunities for secondary products: slabwood from the sawmill, rejected boards and slabwood from the cant gang saw, edgings, and trimmings from the kiln-dried boards, and green and dry sawdust—all available for use as fuel or as inexpensive raw material for further processing.

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Errata Sheet (RP-NE-504)

Page 5--para. 3, line 11, "2,000-pound concrete slab top weights"
should be "1,250-pound concrete slab top weights"

Reynolds, Hugh W., and Gatchell, Charles J. New technology for low-grade hardwood utilization: System 6. Broomall, PA: Northeast. For. Exp. Stn.; 1982; USDA For. Serv. Res. Pap. NE-504. 8p.

Small diameter (7.6 to 12.5 inches) low-grade hardwoods can be converted to high-valued end products using System 6. Among its concepts are: (1) a new, nonlumber product called standard-size blanks; (2) highly automated methods of converting the logs to blanks; (3) total processing of every board that contains a minimum-size cutting; and (4) minimized machine operator decisions and limited choices. Details of System 6 technology are presented.

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Keywords: Furniture manufacturing; lumber drying; hardwood dimension

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