United States
Department of
Agriculture

Forest Service

**Northeastern Forest
Experiment Station**

Research
Paper NE-542

1984

System 6:
Rough-Mill Operating Manual

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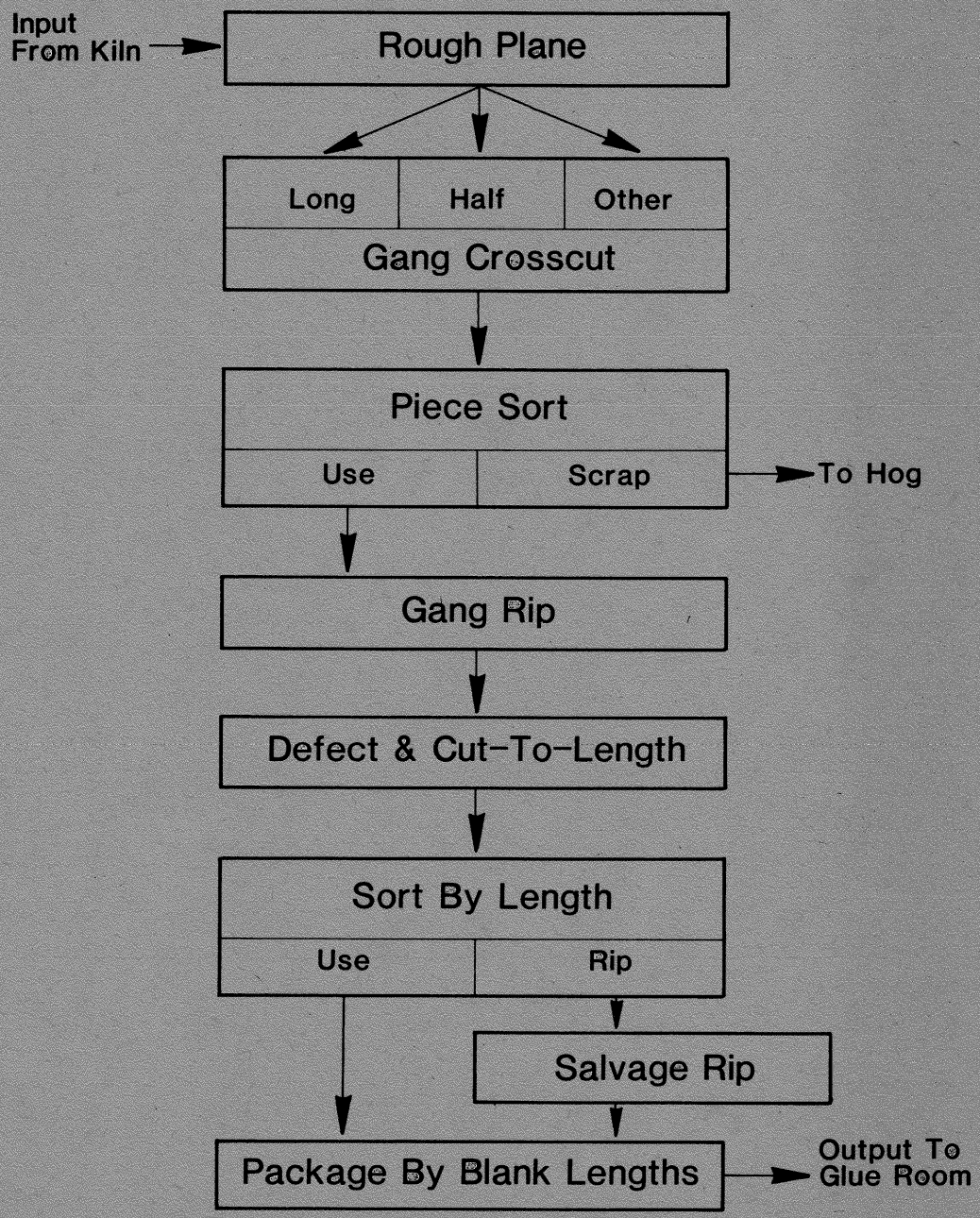

The Author

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Manuscript received for
publication 14 September 1983

Abstract

Includes operating instructions for the System 6 rough mill. Techniques are shown for making standard-size blanks, in all lengths, for each of 13 blank quality/width/thickness combinations.

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402—Stock Number 001-001-00594-1.

Introduction

System 6 is a new technology used to convert low-grade, small-diameter hardwood timber to edge-glued panels for use by the furniture and kitchen cabinet industries. In System 6 (Fig. 1), trees are made to bolts, bolts are sawed to cants, cants are resawed to boards, boards are air dried and then kiln dried, the kiln-dried boards are cut up to defect-free pieces, and the pieces are edge-glued to make standard-size panels (blanks).

The marketing aspects of System 6 were outlined by Reynolds and Gatchell (1979). The technology was explained by Reynolds and Gatchell (1982). The use of System 6 to make upholstered frame parts for the furniture industry (Reynolds and Araman 1983) and to make parts for the kitchen cabinet industry also has been studied (Reynolds et al. 1983).

The output of a System 6 plant is edge-glued panels. These panels are called standard-size blanks (Araman et al. 1982). Blanks are made or purchased by furniture and cabinet makers and are ripped and trimmed to the required part sizes. Parts made from blanks cost no more than parts made in the conventional manner from lumber. However, buying green lumber and making parts requires facilities for air and kiln drying, rough milling, and edge gluing; using blanks to make parts requires just a ripsaw and a trimsaw.

In this paper I explain how the System 6 rough mill—where the kiln-dried boards are made to standard-size pieces free of objectionable defects—is operated. Blanks of only one quality, width, and thickness are made in each run. To set up the rough mill for a run, the quality, width, and thickness must be specified. The heart of the System 6 rough mill is the gang crosscut saw. The spacings of the gang crosscut saw (GCL's) are set to obtain the lengths of blanks required. I explain how this information on blanks and GCL is used to operate the rough mill to obtain the desired blanks in the required lengths.

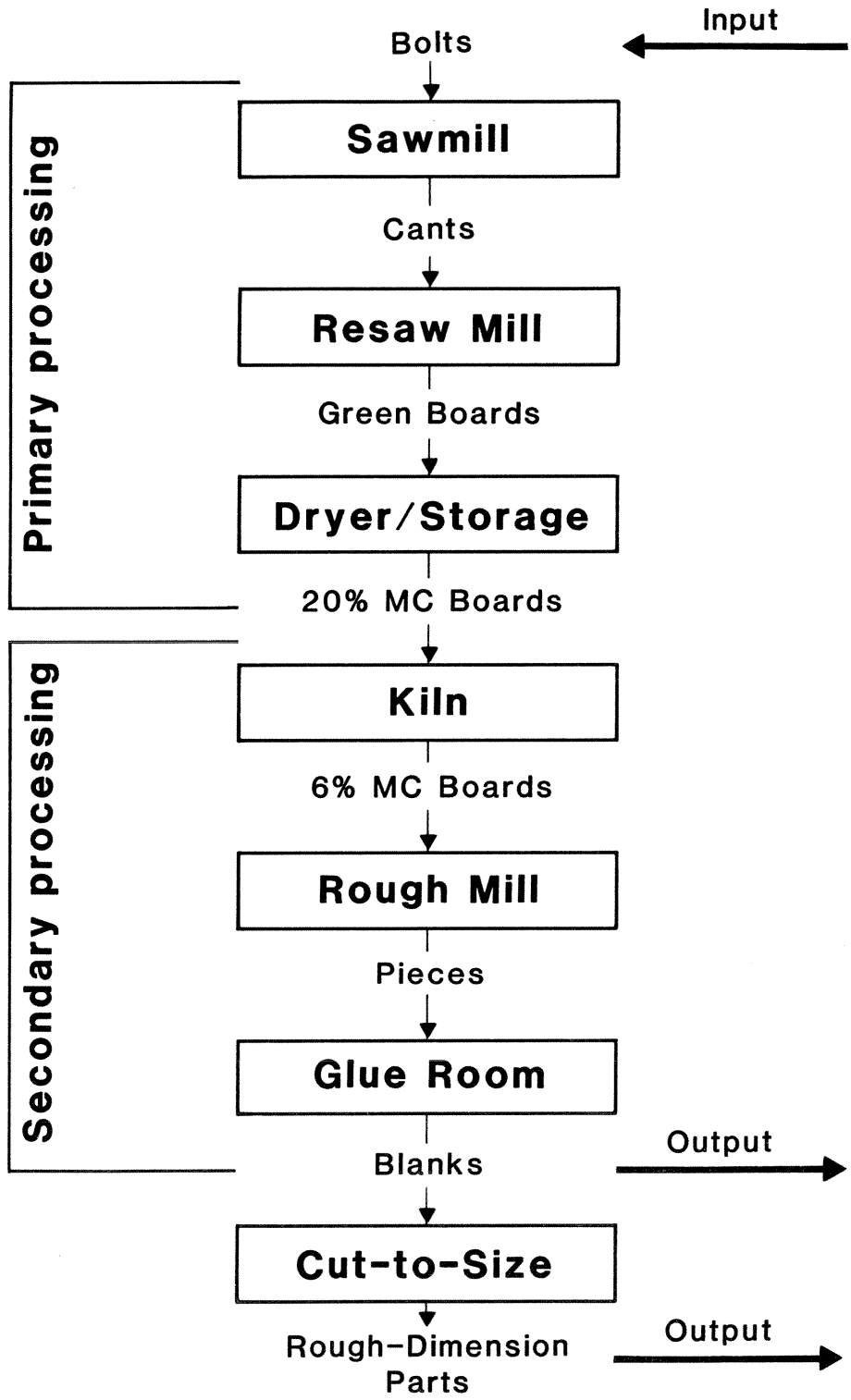

Figure 1.—Flowchart of System 6.

Blanks

Standard-size blanks are pieces of solid wood, free of objectionable defects, of standard lengths, edge-glued to standard-width panels. The standard sizes were derived by Araman et al. (1982). Blanks are made in four qualities, two widths, and six thicknesses. Not all qualities of blanks are made in both widths and in all thicknesses. There are only 13 blank quality/width/thickness combinations:

- Clear (C1F and C2F)[1] blanks: 26-inch width only; 5/8-, 3/4-, 4/4-, 5/4-, 6/4-, 8/4-inch thickness (six quality/width/thickness combinations).
- Frame[2] blanks: 20-inch width only; 4/4-, 5/4-, 6/4-, 8/4-inch thickness (four quality/width/thickness combinations).
- Core[3] blanks: 26-inch width only; 4/4-, 5/4-inch thickness (two quality/width/thickness combinations).
- Interior[4] blanks: 20-inch width only; 4/4-inch thickness only (one quality/width/thickness combination).

There are 148 quality/width/thickness/length combinations. The following tabulation shows the lengths of standard-size blanks, by quality, width, and thickness:

Thickness	Clear (1 and 2 face) Quality (26-inch width)												
5/8	13	15	17	18	22	26	31	36	42				
3/4	14	17	18	22	25	29	31	35	41	47	58	86	
4/4	15	18	21	25	29	33	38	45	50	60	75	100	
5/4	15	18	21	25	29	33	38	45	50	60	75	100	
6/4	15	18	21	25	28	32	35	40	45	50	60	70	85
8/4	15	18	21	25	28	32	35	40	45	50	60	70	90
Thickness	**Core Quality (26-inch width)**												
4/4	15	18	21	23	26	29	34	40	50	60	70	90	
5/4	15	18	21	23	26	29	34	40	50	60	70	85	
Thickness	**Frame Quality (20-inch width)**												
4/4	13	17	19	22	24	27	29	33	44	54	70	80	100
5/4	15	18	20	23	25	28	33	45	55	65	80	90	100
6/4	14	18	21	24	28	31	34	40					
8/4	12	16	19	21	24	28	30	40					
Thickness	**Interior Quality (20-inch width)**												
4/4	15	18	21	25	29	34	40	50	60	70	95		

[1]C1F (clear-one-face): This material shall be clear on one face, both edges, and both ends, and shall otherwise comply with clear-two-face quality except that the reverse face may contain defects of sound quality (from Hardwood Dimension Manufacturers Association 1961). C2F (clear-two-face): This material shall be clear on both faces, the edges, and the ends except that sapwood, slight streaks, and small burls or swirls and light stain are permitted (HDMA 1961).

[2]Frame quality: No defects within 1 inch of either end. Defects within each piece are limited to one-half the piece width with no more than one such defect per foot of piece length. Wane may not be on more than one edge, may not be more than half the piece thickness, and may not extend more than half the piece length. No shake or split longer than 1 inch permitted. Rot and unsound wood not permitted (HDMA 1961).

[3]Interior quality: No defects within 1 inch of either end. Defects within each piece are limited to one-half the piece width with no more than one such defect per foot of piece length. No shake or split longer than 1 inch permitted. Rot and unsound wood not permitted (HDMA 1961).

[4]Core quality: This material shall be sound on both faces admitting tight sound knots, small worm holes, slight surface checks, or their equivalent (HDMA 1961).

In operating the System 6 rough mill, only 1 of the 13 quality/thickness/width combinations is made at a time and all of the standard lengths are made. As an example, clear-quality blanks that are 26 inches wide and 4/4 inches thick would be made in all 12 lengths in one rough mill run. The same 12 lengths are used when changing to the production of clear-quality blanks that are 26 inches wide and 5/4 inches thick. The rough-mill setup would not have to be changed when switching from 4/4 to 5/4 clear blank production. The only change would be to substitute 5/4 for 4/4 input boards.

Of the 13 standard quality/width/thickness combinations, 2 combinations, 4/4 and 5/4 clear blanks, have the same 12 lengths. The 6/4 and 8/4 clear-blank combinations have the same lengths except for the longest length. This is true for the two core quality combinations. These similarities allow us to combine the 13 blank quality/width/thickness combinations into 10 quality/width/length combinations.

These 10 combinations are designated A through J for convenience. The rough mill will be operated with only one of these combinations at a time. Nine such rough-mill operating combinations are needed to provide all of the blanks required by the furniture industry; three combinations are needed for the kitchen cabinet blanks (Tables 1-2).

Table 1.—Rough-mill operating blank quality/width/length combinations for furniture industry blanks (A is most used, B is next most used, etc.)

Thickness (inches)	Clear quality (26-inch width)	Frame quality (20-inch width)	Interior quality (20-inch width)	Core quality (26-inch width)
5/8	G	NR[a]	NR	NR
3/4	NR	NR	NR	NR
4/4	A	B	D	E
5/4	A	F	NR	E
6/4	C	I	NR	NR
8/4	C	H	NR	NR

[a]Not required.

Table 2.—Rough-mill operating blank quality/width/length combinations for kitchen cabinet industry blanks (A is most used, D is next most used, J is least used)

Thickness (inches)	Clear quality (26-inch width)	Frame quality (20-inch width)	Interior quality (20-inch width)	Core quality (20-inch width)
5/8	NR[a]	NR	NR	NR
3/4	J	NR	NR	NR
4/4	A	NR	D	NR
5/4	A	NR	NR	NR
6/4	NR	NR	NR	NR
8/4	NR	NR	NR	NR

[a]Not required.

The Rough Mill

A System 6 rough mill (Fig. 2) is much different from a conventional rough mill used to convert high-quality hardwood lumber to rough-dimension parts. In the System 6 rough mill all boards are used to make blanks. First, rapid and efficient automated breakdown of the boards (gang crosscutting is followed by gang ripping) removes the major defects. Manual techniques then are used to remove all of the remaining objectionable defects.

A multiple-saw gang crosscut is used to make one to four pieces from each board. The spacing between saws depends on the lengths of blanks that are to be made. The outer saws are used to trim the ends of those best boards that contain one long length cutting. Medium-quality boards contain a cutting that is longer than half the board length but shorter than a long cutting. The outer saws and one inner saw are used to cut these boards to one medium piece and one short piece. The remaining are low-quality boards. The 6-foot ones are crosscut to three short pieces and the 8-foot ones to four short pieces.

Pieces from the gang crosscut saw are accepted if they contain at least a minimum-size cutting (1½ inches wide by shortest blank length to be made). Only one cutting is made from each piece. To speed processing and make the operator's decisions easier, we recommend cutting-width increments no smaller than ½ inch. We use five cutting widths: 1½, 2, 2½, 3, and 3½ inches. Each piece to be gang sawed is inspected to choose its better edge. Then the piece is placed in one of five pockets on the gang-rip table. The ¼-inch edge cut (better edge) and the width cut to remove defects are made at the same time. Pieces from the gang ripsaw have edges of glue-joint quality.

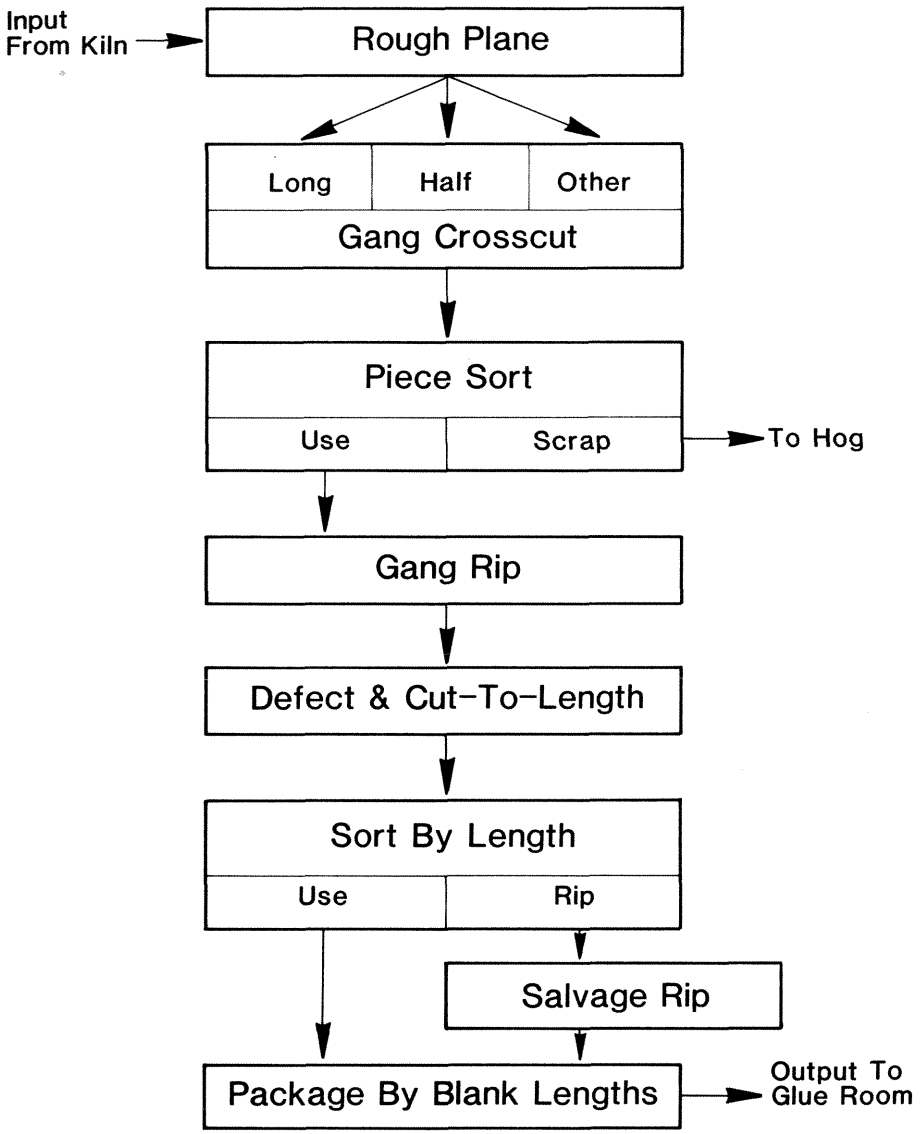

Figure 2.—Flowchart of System 6 rough mill.

Next, we 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. There may still be some defects that need to be removed. A manually controlled crosscut saw is used to remove end defects and cut pieces to blank lengths. A manually controlled glue-joint ripsaw is used for salvage ripcuts when required.

Gang-Crosscut Lengths

In System 6 all boards are used to make blanks. Most of these short (6 or 8 feet long), narrow (3¼ or 4 inches) boards are of poor quality. We have an automated method, gang crosscutting followed by gang ripping, to remove the majority of defects from the boards (Reynolds and Gatchell 1982).

The gang-crosscut saw is the heart of the System 6 rough mill (Figs. 3-4). This saw has four blades to be used to crosscut a 6-foot board and five blades to be used to crosscut an 8-foot board. The spacing between the saws and the position of saws for cutting (up to miss, down to cut) determine the lengths of pieces made when the board is crosscut. All crosscuts on a board are made in one pass through the machine.

The spacings between the sawblades, the GCL's, are chosen to obtain pieces in the most needed lengths. The spacings between the saws are set at the beginning of a run and are not changed during a run. When the two outside saws are down (in a cutting position) and the other saws are up, one long piece is made from each board. When a third saw is lowered, each board is cut into two pieces. When all of the saws are lowered, each board is cut into three pieces (6-foot boards) or to four pieces (8-foot boards).

Because requirements for quantities of blanks per length change according to market demands, many different sets of saw spacings are needed. I show how the saw spacings and saw positions are derived by using an example of gang-crosscut lengths for clear-quality, 26-inch-wide, 4/4-inch-thick blanks.

In the example, blanks longer than 72 inches are not needed so we use 6-foot boards. Blanks 72, 45, 25, and 21 inches long are in the greatest demand. We cut for these lengths on the gang-crosscut saw. The other blanks—60, 50, 38, 33, 29, 18, and 15 inches long—(see tabulation on page 2) are obtained at the cut-to-length saw when defects are trimmed off.

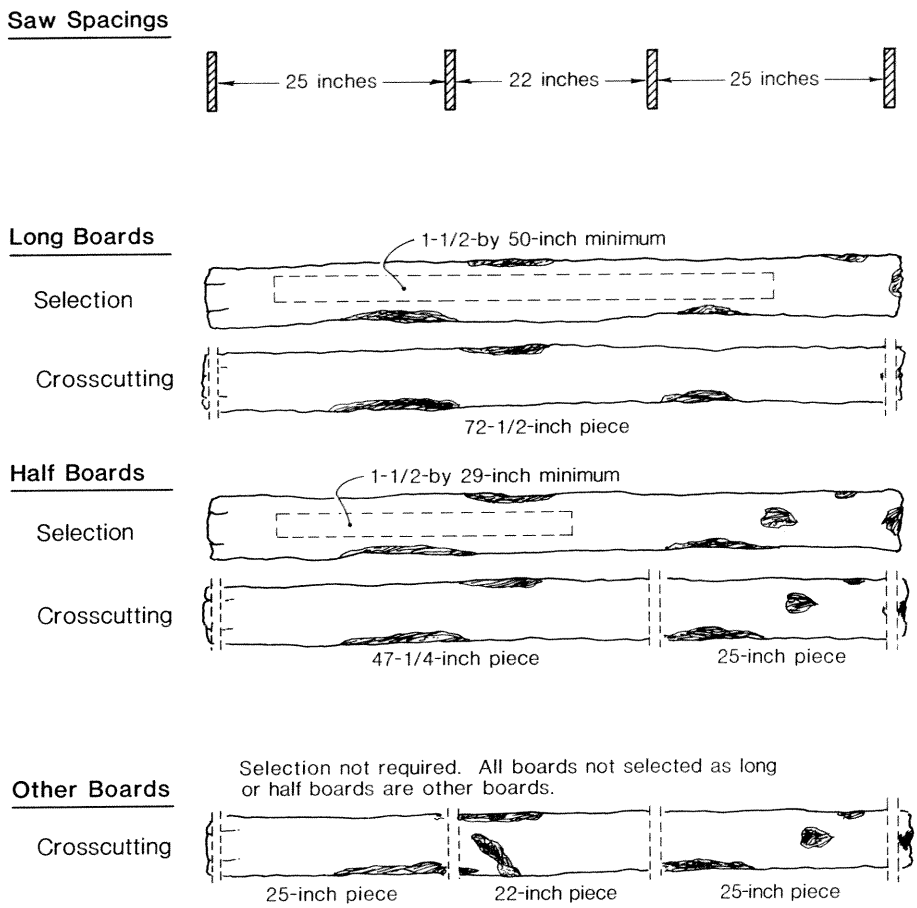

Figure 3.—Gang crosscutting (pictured is GCL 6A1 on 4-inch by 6-foot boards).

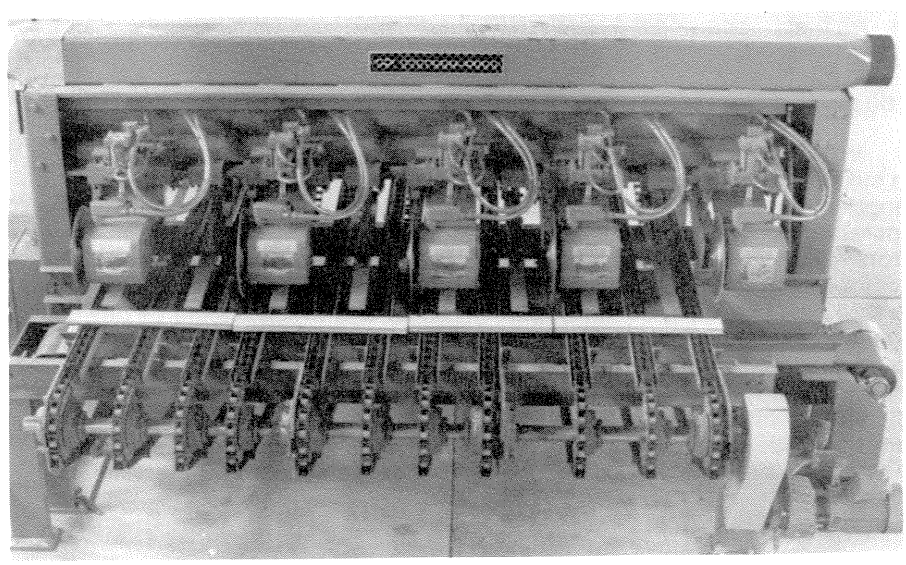

Figure 4.—System 6 gang-crosscut saw (outfeed side).

The first saw, on the right hand side facing the infeed side of the machine, is never moved (Fig. 3). The second saw is placed 25 inches from the first, the third 22 inches from the second, the fourth 25 inches from the third. The fifth saw is not used. With saws 1 and 4 down and 2 and 3 up, the 6-foot boards are crosscut to one full length piece. With saws 1, 2, and 4 down, the boards are crosscut to one 25-inch piece and one 47¼-inch piece. One-quarter-inch kerf sawblades are used. With all saws down, two 25-inch pieces and one 22-inch piece are made.

Pieces leaving the gang-crosscut saw are ripped and crosscut to remove defects. The 72½-inch pieces can be made to 72-inch and shorter lengths. The 47¼-inch pieces can be made to 45-inch and shorter lengths. The 22-inch pieces can be made to 21-inch and shorter pieces. In all cases, the longest possible length clear pieces are made.

Four examples of gang-crosscut length were derived for each of the 10 rough-mill operating blank quality/width/thickness combinations. Two examples are for 6-foot boards and two are for 8-foot boards. These examples are shown in Appendix I.

Knowing which blanks are to be made in what quantities and having the gang-crosscut saw spacings set, we can begin operating the rough mill.

Rough-Mill Operations

With the gang-crosscut saw set to cut boards into the desired piece lengths, the rough mill is ready for operation (Fig. 2). The machine operators take their instructions from the appropriate operating specification (A through J) in Appendix I. For purposes of explanation, I describe the rough-mill operations necessary to make clear-two-face (C2F) quality, 26-inch, 4/4 blanks in the 12 standard lengths (Appendix I, Operating Combination A). Six-foot-long boards are used. The gang-crosscut saw is set according to GCL1 for 6-foot boards (6A1) as in the previous section.

Packages of 6-foot boards are brought from the dry kiln to the rough mill. These 4/4 boards are fed into the rough planer where they are hit-and-miss planed on both sides to 1.000 inch. The boards then go to the gang-crosscut saw one at a time.

Each board is examined to determine if a long- or a medium-length cutting can be obtained. The operating specifications give the length of cutting required. In the C2F example, a board that will yield a 1½- by 50-inch clear cutting or larger is designated a "long" board. If a 1½- by 29-inch cutting or larger cutting can be obtained (but not a 1½- by 50-inch cutting), the board is given the "half" designation. All other boards not meeting the long and half designations are considered "other" boards.

The long boards are end trimmed only, the half boards are made to two pieces, and the other boards are made to three pieces (6-foot boards) or four pieces (8-foot boards). In the example, the long boards are end trimmed with saws 1 and 4 to one piece 72½ inches long (Fig. 3). The half boards are cut to one 47¼-inch and to one 25-inch piece with saws 1, 2, and 4. The other boards are cut to three pieces, 25, 22, and 25 inches long, with saws 1, 2, 3, and 4.

The gang-crosscut saw can be used in two ways. When the saw is equipped with an electronic memory, each board can be crosscut individually. As a board is put onto the infeed chains, buttons controlling the saws (up to miss, down to cut) are pushed. The memory notes which saws should be up and which should be down so that they are controlled correctly as the board passes through the saw area.

When an electronic memory is not available, a sorting technique is used. The saws are set (up to miss, down to cut) for the other boards. As these boards are identified, they are fed through the gang-crosscut saw. In the example, saws 1, 2, 3, and 4 would be down and the other boards would be cut to a 25-, a 22-, and a 25-inch piece. The long boards would be set aside in one pile and the half boards in another. When it is convenient, board planing (Fig. 2) would be stopped. The saws would be changed to cut the half boards. In the example, saws 1, 2, and 4 would be down. Following the crosscutting of the half board, the long boards would be trimmed. In the example, saws 1 and 4 would be down. After all of the long boards have been sent through the gang-crosscut saw, the planer is started and the cycle is repeated.

Pieces leaving the gang-crosscut saw are sorted so that only those with a clear area of 1½ by 15 inches are sent on to the gang ripsaw.

The operator of the gang ripsaw examines each piece to determine the better edge and determines how wide a clear piece can be ripped from that edge. He then puts the piece into the appropriate infeed pocket with the better edge against the fence. Since there are only five infeed pockets corresponding to 1½-, 2-, 2½-, 3-, or 3½-inch ripping widths, the operator soon becomes proficient in recognizing the correct ripping width. The operator always should be optimistic. We have found that the blank yield is best when 25 percent of the pieces must be salvage ripped to remove edge defects missed at the gang ripsaw.

Pieces leaving the gang ripsaw go to the defecting saws. In the example, the 72½, 47¼, or 22-inch pieces are trimmed to 72, 45, and 21 inches, respectively. Pieces with end defects are trimmed to the longest possible standard length. In this example, all 11 lengths—72, 60, 50, 45, 38, 33, 29, 25, 21, 18, and 15—are used. Pieces with edge defects are sent to the sal-

vage ripsaw. We always maximize for length as a 1½- by 60-inch piece (90 square inches) is more valuable than a 2- by 45-inch piece (also 90 square inches). Only one trimmed piece is made from each piece entering the defecting step. Multiple pieces may increase total yield but fewer long pieces would be made.

Pieces leave the defecting step and go to the sort-by-length step. The clear pieces are sorted by length regardless of width. Pieces with edge defects are sent to the salvage ripsaw. At the salvage ripsaw pieces are made 1½, 2, 2½, or 3 inches wide while the edge defects are removed. Pieces 1½ inches wide with edge defects are scrapped.

This concludes the rough mill processing. The rough kiln-dried boards enter the rough mill where they are cut to standard-size pieces (free of objectionable defects) ready for edge gluing to blank width.

The System 6 rough mill can be operated in a manner similar to that of a conventional rough mill. A GCL is selected and the gang crosscut is set up. All standard blank lengths are set on the defecting saw stops. Production is as described and yield by length is monitored. When enough pieces have been made in a given length, that length is deleted. When all blank requirements are met, the run is stopped. An improvement in this System 6 technique would be to switch to a different GCL, in the same operating combination series, when the most needed length requirements are satisfied.

A better manner for controlling System 6 rough mill production is available. The yields of blanks per GCL must be known before production. These data can be obtained by test or by previous experience with the single GCL processing control technique. The yield data per GCL together with the blank requirements per length are used as input data to the LP (linear programing) program S60PT (Appendix II).

The LP output shows the minimum quantity of boards to be processed by each GCL to obtain the required blanks. The only rough-mill change needed when changing GCL's is in the spacings of the gang-crosscut saw. The greatest advantage in operating the rough mill in this optimal GCL combination mode is that the mill runs without interruption. Production of pieces by length is not monitored and there is no deletion of piece lengths at the defecting saw. Production stops when the specified quantities of boards have been used.

S60PT shows the number of longer blanks in excess of requirements. The computer output shows how the excess longer blanks are to be crosscut to shorter blanks to meet requirements. The optimal yield is based on the total required blank production after crosscutting is done.

In comparing the use of the single GCL processing control technique with the combination of GCL techniques, Reynolds and Araman (1983) found that combinations of GCL's gave 3.0 to 12.5 percent better yields of required blanks than a single GCL.

Literature Cited

Araman, Philip A.; Gatchell, Charles J.; Reynolds, Hugh W. **Meeting the solid wood needs of the furniture and cabinet industries: standard size hardwood blanks.** Res. Pap. NE-494. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station; 1982. 27 p.

Hardwood Dimension Manufacturers Association. **Rules for measurement and inspection of hardwood dimension parts, hardwood interior trim and mouldings, and hardwood stair treads and risers.** 5th ed. (revised). Nashville, TN: Hardwood Dimension Manufacturers Association; 1961.

Reynolds, Hugh W.; Araman, Philip A. **System 6: Making frame-quality blanks from white oak thinnings.** Res. Pap. NE-520. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station; 1983. 9 p.

Reynolds, Hugh W.; Araman, Philip A.; Gatchell, Charles J.; Hansen, Bruce G. **System 6 used to make kitchen cabinet C2F blanks from small-diameter, low-grade red oak.** Res. Pap. NE-525. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station; 1983. 11 p.

Reynolds, Hugh W.; Gatchell, Charles J. **Marketing low-grade hardwoods for furniture stock—a new approach.** Res. Pap. NE-444. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station; 1979. 7 p.

Reynolds, Hugh W.; Gatchell, Charles J. **New technology for low-grade hardwood utilization: System 6.** Res. Pap. NE-504. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Experiment Station; 1982. 8 p.

Appendix I

Operating Combination A

Clear (C1F and C2F) quality for 26-inch-wide, 4/4- and 5/4-inch-thick blanks
Standard lengths: 15, 18, 21, 25, 29, 33, 38, 45, 50, 60, 75, 100 inches

Rough plane:
4/4 boards 1.000 inch 5/4 boards 1.250 inches
hit-and-miss 2 sides

Gang crosscut:
GCL1 for 6-foot boards (6A1) full length, 45-, 25-, 21-inch blanks needed
Saw spacings (right to left):
1-2 25 inch, 2-3 22 inch, 3-4 25 inch, 5 not used
"Long" boards:
1½- by 50-inch minimum clear-quality area
Saws 1 and 4 down, 2 and 3 up; one 72½-inch piece
"Half" boards:
1½- by 29-inch minimum clear-quality area on right end
Saws 1, 2, and 4 down and 3 up; one 47¼- and one 25-inch piece
"Other" boards:
All boards not meeting "long" or "half" criteria
Saws 1, 2, 3, and 4 down; two 25-inch pieces and one 22-inch piece
GCL2 for 6-foot boards (6A2) full length, 38-, 33-, 21-, 18-inch blanks needed
Saw spacings (right to left):
1-2 33 inch, 2-3 18 inch, 3-4 21 inch, 4 not used
"Long" boards:
1½- by 45-inch minimum clear-quality area
Saws 1 and 4 down, 2 and 3 up; 72½-inch piece
"Half" boards:
1½- by 29-inch minimum clear-quality area on right end
Saws 1, 2, and 4 down, 3 up; one 39¼ and one 33-inch piece
"Other" boards:
All boards not meeting "long" or "half" criteria
Saws 1, 2, 3, and 4 down; one 33-, one 21-, and one 18-inch piece
GCL1 for 8-foot boards (8A1) full length, 60-, 38-, 33-, 25-inch blanks needed
Saw spacings (right to left):
1-2 33 inch, 2-3 25 inch, 3-5 38 inch, 4 not used
"Long" boards:
1½- by 75-inch minimum clear-quality area
Saws 1 and 5 down, 2 and 3 up; one 96½-inch piece
"Half" boards:
1½- by 45-inch minimum clear-quality area on right end
Saws 1, 2, and 5 down, 3 up; one 63½- and one 33-inch piece
"Other" boards:
All boards not meeting "long" or "half" criteria
Saws 1, 2, 3, and 5 down; one 38-, one 33-, and one 25-inch piece
GCL2 for 8-foot boards (8A2) full length, 50-, 45-, 25-, 21-inch blanks needed
Saw spacings (right to left):
1-2 25 inch, 2-3 21 inch, 3-4 25 inch, 4-5 25 inch
"Long" boards:
1½- by 60-inch minimum clear-quality area
Saws 1 and 5 down, 2, 3, and 4 up; one 96¾-inch piece
"Half" boards:
1½- by 29-inch minimum clear-quality area on either end
Saws 1, 3, and 5 down, 2 and 4 up; one 46½- and one 50½-inch piece
"Other" boards:
All boards not meeting "long" or "half" criteria
Saws 1, 2, 3, 4, and 5 down; three 25-inch pieces and one 21-inch piece

Piece sort:
Use any piece with a 1½- by 15-inch clear-quality area

Gang rip:
Rip to 1½-, 2-, 2½-, 3-, or 3½-inch width to remove edge defects to obtain clear-quality pieces

Defect and cut-to-length:
For 6-foot boards, set length stops at 15, 18, 21, 25, 29, 33, 38, 45, 50, 60, and 72 inches
For 8-foot boards, set length stops at 15, 18, 21, 25, 29, 33, 38, 45, 50, 60, 75, and 96 inches
Trim end defects to obtain clear-quality pieces while cutting to these standard lengths. Maximize length yield.

Sort by length:
Sort to piece lengths, no sorting by width. Pieces with edge defects are sent to the salvage ripsaw.

Salvage ripsaw:
Pieces with edge defects are ripped to make clear-quality pieces 1½, 2, 2½, or 3 inches wide.

Operating Combination B

Frame quality for 20-inch-wide, 4/4-inch-thick blanks
Standard lengths: 13, 17, 19, 22, 24, 27, 29, 33, 44, 54, 70, 80, 100 inches

Rough plane:
4/4 boards 1.000 inch hit-and-miss 2 sides

Gang crosscut:
GCL1 for 6-foot boards (6B1) full length, 44- and 24-inch blanks needed
Saw spacings (right to left):
1-2 24 inch, 2-3 24 inch, 3-4 24 inch, 5 not used
"Long" boards:
1½- by 54-inch minimum frame-quality area
Saws 1 and 4 down, 2 and 3 up; one 72½-inch piece
"Half" boards:
1½- by 27-inch minimum frame-quality area on right end
Saws 1, 2, and 4 down and 3 up; one 48¼- and one 24-inch piece
"Other" boards:
All boards not meeting "long" or "half" criteria
Saws 1, 2, 3, and 4 down; three 24-inch pieces
GCL2 for 6-foot boards (6B2) full length, 33-, 22-, and 13-inch blanks needed
Saw spacings (right to left):
1-2 13 inch, 2-3 23 inch, 3-4 36 inch, 5 not used
"Long" boards:
1½- by 44-inch minimum frame-quality area
Saws 1 and 5 down and 2 and 3 up; one 72½-inch piece
"Half" boards:
1½- by 24-inch minimum frame-quality area on right end
Saws 1, 3, and 4 down and 2 up; one 36¼- and one 36-inch piece
"Other" boards:
All boards not meeting "long" or "half" criteria
Saws 1, 2, 3, and 4 down; one 36-, one 23-, and one 13-inch piece

GCL1 for 8-foot boards (8B1) full length, 54-, 33-, and 29-inch blanks needed
Saw spacings (right to left):
1-2 30 inch, 2-3 33 inch, 3-5 33 inch, 4 not used
"Long" boards:
1½- by 70-inch minimum frame-quality area
Saws 1 and 4 down, 2 and 3 up; one 96½-inch piece
"Half" boards:
1½- by 27-inch minimum frame-quality area on right end
Saws 1, 3, and 5 down and 2 up; one 33¼- and one 33-inch piece
"Other" boards:
All boards not meeting "long" or "half" criteria
Saws 1, 2, 3, and 5 down; two 33-inch pieces and one 30-inch piece
GCL2 for 8-foot boards (8B2) full length, 44-, and 24-inch blanks needed
Saw spacings (right to left):
1-2 24 inch, 2-3 24 inch, 3-4 24 inch, 4-5 24 inch
"Long" boards:
1½- by 54-inch minimum frame-quality area
Saws 1 and 5 down and 2, 3, and 4 up; one 96¾-inch piece
"Half" boards:
1½- by 27-inch minimum frame-quality area on right end
Saws 1, 3, and 5 down, 2 and 4 up; two 48¼-inch pieces
"Other" boards:
All boards not meeting "long" or "half" criteria
Saws 1, 2, 3, 4, and 5 down; four 24-inch pieces

Piece sort:
Use any piece with a 1½- by 13-inch frame-quality area

Gang rip:
Rip to 1½-, 2-, 2½-, 3-, or 3½-inch width to remove edge defects to obtain frame-quality pieces

Defect and cut-to-length:
For 6-foot boards, set length stops at 13, 17, 19, 22, 24, 27, 29, 33, 44, 54, and 72 inches
For 8-foot boards, set length stops at 13, 17, 19, 22, 24, 27, 29, 33, 44, 54, 70, 80, and 96 inches
Trim end defects to obtain frame-quality pieces while cutting at these standard lengths. Maximize length yield.

Sort by length:
Sort to piece lengths, no sorting by width. Pieces with edge defects are sent to the salvage ripsaw.

Salvage ripsaw:
Pieces with edge defects are ripped to make frame-quality pieces 1½, 2, 2½, or 3 inches wide.

Operating Combination C

Clear (C1F and C2F) quality for 26-inch-wide, 6/4- and 8/4-inch-thick blanks
Standard lengths: 15, 18, 21, 25, 28, 32, 35, 40, 45, 50, 60, 70, 90 inches

Rough plane:
6/4 boards 1.500 inches 8/4 boards 2.000 inches
hit-and-miss 2 sides

Gang crosscut:
GCL1 for 6-foot boards (6C1) full length, 45-, 25-, and 21-inch blanks needed
Saw spacings (right to left):
1-2 25 inch, 2-3 22 inch, 3-4 25 inch, 5 not used
"Long" boards:
1½- by 50-inch minimum clear-quality area
Saws 1 and 4 down and 2 and 3 up; one 72½-inch piece
"Half" boards:
1½- by 35-inch minimum clear-quality area on right end
Saws 1, 2, and 4 down and 3 up; one 47¼- and one 25-inch piece
"Other" boards:
All boards not meeting "long" or "half" criteria
Saws 1, 2, 3, and 4 down; two 25-inch pieces and one 22-inch piece
GCL2 for 6-foot boards (6C2) full length, 40-, 32-, 21-, and 18-inch blanks needed
Saw spacings (right to left):
1-2 32 inch, 2-3 18 inch, 3-4 22 inch, 5 not used
"Long" boards:
1½- by 45-inch minimum clear-quality area
Saws 1 and 4 down and 2 and 3 up; one 72½-inch piece
"Half" boards:
1½- by 35-inch minimum clear-quality area on right end
Saws 1, 2, and 4 down and 3 up; one 40¼- and one 32-inch piece
"Other" boards:
All boards not meeting "long" or "half" criteria
Saws 1, 2, 3, and 4 down; one 32-inch, one 22-inch, and one 18-inch piece
GCL1 for 8-foot boards (8C1) full length, 60- and 32-inch blanks needed
Saw spacings (right to left):
1-2 32 inch, 2-3 32 inch, 3-5 32 inch, 4 not used
"Long" boards:
1½- by 70-inch minimum clear-quality area
Saws 1 and 5 down and 2 and 3 up; one 96½-inch piece
"Half" boards:
1½- by 35-inch minimum clear-quality area on right end
Saws 1, 2, and 5 down and 3 up; one 64¼- and one 32-inch piece
"Other" boards:
All boards not meeting "long" or "half" criteria
Saws 1, 2, 3, and 5 down; three 32-inch pieces
GCL2 for 8-foot boards (8C2) full length, 50-, 45-, 25-, and 21-inch blanks needed
Saw spacings (right to left):
1-2 25 inch, 2-3 21 inch, 3-4 25 inch, 4-5 25 inch
"Long" boards:
1½- by 60-inch minimum clear-quality area
Saws 1 and 5 down and 2, 3, and 4 up; one 96¾-inch piece
"Half" boards:
1½- by 29-inch minimum clear-quality area on right end
Saws 1, 3, and 5 down and 2 and 4 up; one 46¼- and one 50-inch piece
"Other" boards:
All boards not meeting "long" or "half" criteria
Saws 1, 2, 3, 4, and 5 down; three 25-inch pieces and one 21-inch piece

Piece sort:
Use any piece with a 1½- by 15-inch clear-quality area

Gang rip:
Rip to 1½-, 2-, 2½-, 3-, or 3½-inch width to remove edge defects to obtain clear-quality pieces

Defect and cut-to-length:
For 6-foot boards, set length stops at 15, 18, 21, 25, 28, 32, 40, 45, 50, 60, and 72 inches
For 8-foot boards, set length stops at 15, 18, 21, 25, 28, 32, 40, 45, 50, 60, 70, and 90 inches
Trim end defects to obtain clear-quality pieces while cutting at these standard lengths. Maximize length yield.

Sort by length:
Sort to piece lengths, no sorting by width. Pieces with edge defects are sent to the salvage ripsaw.

Salvage ripsaw:
Pieces with edge defects are ripped to make clear-quality pieces 1½, 2, 2½, or 3 inches wide.

Operating Combination D

Interior quality for 20-inch-wide, 4/4-inch-thick blanks
Standard lengths: 15, 18, 21, 25, 29, 34, 40, 50, 60, 70, and 95 inches

Rough plane:
4/4 boards 1.000 inch hit-and-miss 2 sides

Gang crosscut:
GCL1 for 6-foot boards (6D1) full length, 50-, 25-, and 21-inch blanks needed
Saw spacings (right to left):
1-2 25 inch, 2-3 25 inch, 3-4 22 inch, 5 not used
"Long" boards:
1½- by 60-inch minimum interior-quality area
Saws 1 and 4 down and 2 and 3 up; one 72½-inch piece
"Half" boards:
1½- by 29-inch minimum interior-quality area on right end
Saws 1, 3, and 4 down and 2 up; one 50¼- and one 22-inch piece
"Other" boards:
All boards not meeting "long" or "half" criteria
Saws 1, 2, 3, and 4 down; two 25-inch pieces and one 22-inch piece
GCL2 for 6-foot boards (6D2) full length, 40-, 29-, 25-, and 18-inch blanks needed
Saw spacings (right to left):
1-2 29 inch, 2-3 18 inch, 3-4 25 inch, 5 not used
"Long" boards:
1½- by 50-inch minimum interior-quality area
Saws 1 and 4 down and 2 and 3 up; one 72½-inch piece
"Half" boards:
1½- by 34-inch minimum interior-quality area on right end
Saws 1, 2, and 4 down and 3 up; one 43¼- and one 29-inch piece
"Other" boards:
All boards not meeting "long" or "half" criteria
Saws 1, 2, 3, and 4 down; one 29-, one 25-, and one 18-inch piece
GCL1 for 8-foot boards (8D1) full length, 60-, 34-, and 25-inch blanks needed
Saw spacings (right to left):
1-2 34 inch, 2-3 25 inch, 3-5 37 inch, 4 not used
"Long" boards:
1½- by 70-inch minimum interior-quality area
Saws 1 and 5 down and 2 and 3 up; one 96½-inch piece
"Half" boards:
1½- by 40-inch minimum interior-quality area on right end
Saws 1, 2, and 5 down and 3 up; one 62¼- and one 34-inch piece
"Other" boards:
All boards not meeting "long" or "half" criteria
Saws 1, 2, 3, and 5 down; one 37-, one 34-, and one 25-inch piece
GCL2 for 8-foot boards (8D2) full length, 50-, 40-, 25-, and 21-inch blanks needed
Saw spacings (right to left):
1-2 25 inch, 2-3 21 inch, 3-4 25 inch, 4-5 25 inch
"Long" boards:
1½- by 60-inch minimum interior-quality area
Saws 1 and 5 down and 2, 3, and 4 up; one 96¾-inch piece
"Half" boards:
1½- by 29-inch minimum interior-quality area on right end
Saws 1, 3, and 5 down and 2 and 4 up; one 50¼- and one 46¼-inch piece
"Other" boards:
All boards not meeting "long" or "half" criteria
Saws 1, 2, 3, 4, and 5 down; three 25-inch pieces and one 21-inch piece

Piece sort:
Use any piece with a 1½- by 15-inch interior-quality area

Gang rip:
Rip to 1½-, 2-, 2½-, 3-, or 3½-inch width to remove edge defects to obtain interior-quality pieces

Defect and cut-to-length:
For 6-foot boards, set length stops at 15, 18, 21, 25, 29, 34, 40, 50, 60, and 72 inches
For 8-foot boards, set length stops at 15, 18, 21, 25, 29, 34, 40, 50, 60, 70, and 95 inches
Trim end defects to obtain interior-quality pieces while cutting at these standard lengths. Maximize length yield.

Sort by length:
Sort to piece lengths, no sorting by widths. Pieces with edge defects are sent to the salvage ripsaw.

Salvage ripsaw:
Pieces with edge defects are ripped to make interior-quality pieces 1½, 2, 2½, or 3 inches wide.

Operating Combination E

Core quality for 26-inch-wide, 4/4-inch-thick blanks
Standard lengths: 15, 18, 21, 23, 26, 29, 34, 40, 50, 60, 70, 95 inches

Rough plane:
4/4 boards 1.000 inch hit-and-miss 2 sides

Gang crosscut:
GCL1 for 6-foot boards (6E1) full length, 50-, 26-, 23-, and 21-inch blanks needed
Saw spacings (right to left):
1-2 21 inch, 2-3 23 inch, 3-4 28 inch, 5 not used
"Long" boards:
1½- by 60-inch minimum core-quality area
Saws 1 and 4 down and 2 and 3 up; one 72½-inch piece
"Half" boards:
1½- by 29-inch minimum core-quality area on right end
Saws 1, 2, and 4 down and 3 up; one 51¼- and one 21-inch piece
"Other" boards:
All boards not meeting "long" or "half" criteria
Saws 1, 2, 3, and 4 down; one 28-, one 23-, and one 21-inch piece
GCL2 for 6-foot boards (6E2) full length, 34- and 18-inch blanks needed
Saw spacings (right to left):
1-2 34 inch, 2-3 18 inch, 3-4 20 inch, 5 not used
"Long" boards:
1½- by 40-inch minimum core-quality area
Saws 1 and 4 down and 2 and 3 up; one 72½-inch piece
"Half" boards:
1½- by 34-inch minimum core-quality area on right end
Saws 1, 2, and 4 down and 3 up; one 38¼- and one 34-inch piece
"Other" boards:
All other boards not meeting "long" or "half" criteria
Saws 1, 2, 3, and 4 down; one 34-, one 20-, and one 18-inch piece
GCL1 for 8-foot boards (8E1) full length, 60-, 34-, and 26-inch blanks needed
Saw spacings (right to left):
1-2 34 inch, 2-3 26 inch, 3-5 36 inch, 4 not used
"Long" boards:
1½- by 70-inch minimum core-quality area
Saws 1 and 5 down and 2 and 3 up; one 96½-inch piece
"Half" boards:
1½- by 40-inch minimum core-quality area on right end
Saws 1, 2, and 5 down and 3 up; one 62¼- and one 34-inch piece
"Other" boards:
All boards not meeting "long" or "half" criteria
Saws 1, 2, 3, and 5 down; one 36-, one 34-, and one 26-inch piece
GCL2 for 8-foot boards (8E2) full length, 50-, 40-, 26-, 23-, and 21-inch blanks needed
Saw spacings (right to left):
1-2 23 inch, 2-3 21 inch, 3-4 26 inch, 4-5 26 inch
"Long" boards:
1½- by 60-inch minimum core-quality area
Saws 1 and 5 down and 2, 3, and 4 up; one 96¾-inch piece
"Half" boards:
1½- by 29-inch minimum core-quality area on right end
Saws 1, 3, and 5 down and 2 and 4 up; one 52¼- and one 44¼-inch piece
"Other" boards:
All boards not meeting "long" or "half" criteria
Saws 1, 2, 3, 4, and 5 down; two 26-inch pieces, one 23-, and one 21-inch piece

Piece sort:
Use any piece with a 1½- by 15-inch core-quality area

Gang rip:
Rip to 1½-, 2-, 2½-, 3-, or 3½-inch width to remove edge defects to obtain core-quality pieces

Defect and cut-to-length:
For 6-foot boards, set length stops at 15, 18, 21, 23, 26, 29, 34, 40, 50, 60, and 72 inches
For 8-foot boards, set length stops at 15, 18, 21, 23, 26, 29, 34, 40, 50, 60, 70, and 95 inches
Trim end defects to obtain core-quality pieces while cutting at these standard lengths. Maximize length yield.

Sort by length:
Sort to piece lengths, no sorting by widths. Pieces with edge defects are sent to the salvage ripsaw.

Salvage ripsaw:
Pieces with edge defects are ripped to make core-quality pieces 1½, 2, 2½, or 3 inches wide.

Operating Combination F

Frame quality for 20-inch-wide, 5/4-inch-thick blanks
Standard lengths: 15, 18, 20, 23, 25, 28, 33, 45, 55, 65, 80, 90, and 100 inches

Rough plane:
5/4 boards 1.250 inches hit-and-miss 2 sides

Gang crosscut:
GCL1 for 6-foot boards (6F1) full length, 45-, 25-, and 23-inch blanks needed
Saw spacings (right to left):
1-2 25 inch, 2-3 24 inch, 3-4 23 inch, 5 not used
"Long" boards:
1½- by 55-inch minimum frame-quality area
Saws 1 and 4 down and 2 and 3 up; one 72½-inch piece
"Half" boards:
1½- by 28-inch minimum frame-quality area on right end
Saws 1, 2, and 4 down and 3 up; one 47¼- and one 25-inch piece
"Other" boards:
All boards not meeting "long" or "half" criteria
Saws 1, 2, 3, and 4 down; one 25-, one 24-, and one 23-inch piece
GCL2 for 6-foot boards (6F2) full length, 33-, 20-, and 18-inch blanks needed
Saw spacings (right to left):
1-2 33 inch, 2-3 18 inch, 3-4 21 inch, 5 not used
"Long" boards:
1½- by 45-inch minimum frame-quality area
Saws 1 and 4 down and 2 and 3 up; one 72½-inch piece
"Half" boards:
1½- by 33-inch minimum frame-quality area on right end
Saws 1, 2, and 4 down and 3 up; one 39¼- and one 33-inch piece
"Other" boards:
All other boards not meeting "long" or "half" criteria
Saws 1, 2, 3, and 4 down; one 33-, one 21-, and one 18-inch piece
GCL1 for 8-foot boards (8F1) full length, 65-, 33-, and 28-inch blanks needed
Saw spacings (right to left):
1-2 30 inch, 2-3 33 inch, 3-5 33 inch, 4 not used
"Long" boards:
1½- by 80-inch minimum frame-quality area
Saws 1 and 5 down and 2 and 3 up; one 96½-inch piece
"Half" boards:
1½- by 45-inch minimum frame-quality area on right end
Saws 1, 2, and 5 down and 3 up; one 66¼- and one 30-inch piece
"Other" boards:
All other boards not meeting "long" or "half" criteria
Saws 1, 2, 3, and 5 down; two 33-inch pieces and one 30-inch piece
GCL2 for 8-foot boards (8F2) full length, 45-, 25-, and 23-inch blanks needed
Saw spacings (right to left):
1-2 23 inch, 2-3 25 inch, 3-4 23 inch, 4-5 25 inch
"Long" boards:
1½- by 55-inch minimum frame-quality area
Saws 1 and 5 down and 2, 3, and 4 up; one 96¾-inch piece
"Half" boards:
1½- by 28-inch minimum frame-quality area on right end
Saws 1, 3, and 5 down and 2 and 4 up; two 48¼-inch pieces
"Other" boards:
All boards not meeting "long" or "half" criteria
Saws 1, 2, 3, 4, and 5 down; two 25- and two 23-inch pieces

Piece sort:
Use any piece with a 1½- by 15-inch frame-quality area

Gang rip:
Rip to 1½-, 2-, 2½-, 3-, or 3½-inch width to remove edge defects to obtain frame-quality pieces

Defect and cut-to-length:
For 6-foot boards, set length stops at 15, 18, 20, 23, 25, 28, 33, 45, 55, 65, and 72 inches
For 8-foot boards, set length stops at 15, 18, 20, 23, 25, 28, 33, 45, 55, 65, 80, 90, and 96 inches
Trim end defects to obtain frame-quality pieces while cutting to these standard lengths. Maximize length yield.

Sort by length:
Sort to piece lengths, no sorting by widths. Pieces with edge defects are sent to the salvage ripsaw.

Salvage ripsaw:
Pieces with edge defects are ripped to make frame-quality pieces 1½, 2, 2½, or 3 inches wide.

Operating Combination G

Clear (C1F and C2F) quality for 26-inch-wide, 5/8-inch-thick blanks
Standard lengths: 13, 15, 17, 18, 22, 26, 31, 36, and 42 inches

Rough plane:
5/8 boards 0.625 inch hit-and-miss 2 sides

Gang crosscut:
GCL1 for 6-foot boards (6G1): 42-, 26-, and 22-inch blanks needed
Saw spacings (right to left):
1-2 22 inch, 2-3 24 inch, 3-4 26 inch, 5 not used
No "long" boards needed
"Half" boards:
1½- by 31-inch minimum clear-quality area on right end
Saws 1, 2, and 5 down and 3 up; one 50¼- and one 22-inch piece
"Other" boards:
All boards not meeting "half" criteria
Saws 1, 2, 3, and 4 down; one 26-, one 24-, and one 22-inch piece
GCL2 for 6-foot boards (6G2): 36- and 18-inch blanks needed
Saw spacings (right to left):
1-2 18 inch, 2-3 18 inch, 3-4 18 inch, 4-5 18 inch
No "long" boards needed
"Half" boards:
1½- by 22-inch minimum clear-quality area on either end
Saws 1, 3, and 4 down and 2 and 5 up; two 36¼-inch pieces
"Other" boards:
All boards not meeting "half" criteria
Saws 1, 2, 3, 4, and 5 down; four 18-inch pieces
GCL1 for 8-foot boards (8G1): 31-inch blanks needed
Saw spacings (right to left):
1-2 31 inch, 2-3 31 inch, 3-5 34 inch, 4 not used
No "long" or "half" boards needed
"Other" boards:
All boards
Saws 1, 2, 3, and 5 down; one 34-inch piece and two 31-inch pieces
GCL2 for 8-foot boards (8G2): 42-, 26-, and 22-inch blanks needed
Saw spacings (right to left):
1-2 22 inch, 2-3 22 inch, 3-4 26 inch, 4-5 26 inch
No "long" boards needed
"Half" boards:
1½- by 31-inch minimum clear-quality area on right end
Saws 1, 3, 4, and 5 down and 2 up; one 44¼-inch piece and two 26-inch pieces
"Other" boards:
All boards not meeting the "half" criteria
Saws 1, 2, 3, 4, and 5 down; two 26- and two 22-inch pieces

Piece sort:
Use any piece with a 1½- by 13-inch clear-quality area

Gang rip:
Rip to 1½-, 2-, 2½-, 3-, or 3½-inch width to remove edge defects to obtain clear-quality pieces

Defect and cut-to-length:
For 6- and 8-foot boards, set length stops at 13, 15, 17, 18, 22, 26, 31, 36, and 42 inches
Trim end defects to obtain clear-quality pieces while cutting to these standard lengths. Maximize length yield.

Sort by length:
Sort to piece lengths, no sorting by widths. Pieces with edge defects are sent to the salvage ripsaw.

Salvage ripsaw:
Pieces with edge defects are ripped to make clear-quality pieces 1½, 2, 2½, or 3 inches wide.

Operating Combination H

Frame quality for 20-inch-wide, 8/4-inch-thick blanks
Standard lengths: 12, 16, 19, 21, 24, 28, 30, and 34 inches

Rough plane:
8/4 boards 2.000 inches hit-and-miss 2 sides

Gang crosscut:
GCL1 for 6-foot boards (6H1): 34-, 24-, and 12-inch blanks needed
Saw spacings (right to left):
1-2 24 inch, 2-3 24 inch, 3-4 24 inch, 5 not used
No "long" boards needed
"Half" boards:
1½- by 28-inch minimum frame-quality area on right end
Saws 1, 2, and 4 down and 3 up; one 48¼- and one 24-inch piece
"Other" boards:
All boards not meeting "half" criteria
Saws 1, 2, 3, and 4 down; three 24-inch pieces
GCL2 for 6-foot boards (6H2): 34-, 19-, and 16-inch blanks needed
Saw spacings (right to left):
1-2 16 inch, 2-3 20 inch, 3-4 16 inch, 4-5 20 inch
No "long" boards needed
"Half" boards:
1½- by 21-inch minimum frame-quality area on either end
Saws 1, 3, and 5 down and 2 and 4 up; two 36¼-inch pieces
"Other" boards:
All boards not meeting the "half" criteria
Saws 1, 2, 3, 4, and 5 down; two 20- and two 16-inch pieces
GCL1 for 8-foot boards (8H1): 34- and 28-inch blanks needed
Saw spacings (right to left):
1-2 28 inch, 2-3 34 inch, 3-5 34 inch, 4 not used
No "long" or "half" boards needed
"Other" boards:
All boards
Saws 1, 2, 3, and 5 down; two 34-inch pieces and one 28-inch piece
GCL2 for 8-foot boards (8H2): 24-inch blanks needed
Saw spacings (right to left):
1-2 24 inch, 2-3 24 inch, 3-4 24 inch, 4-5 24 inch
No "long" or "half" boards needed
"Other" boards:
All boards
Saws 1, 2, 3, 4, and 5 down; four 24-inch pieces

Piece sort:
Use any piece with a 1½- by 12-inch frame-quality area

Gang rip:
Rip to 1½-, 2-, 2½-, 3-, or 3½-inch width to remove edge defects to obtain frame-quality pieces

Defect and cut-to-length:
For 6- and 8-foot boards, set length stops at 12, 16, 19, 21, 24, 28, 30, and 34 inches
Trim end defects to obtain frame-quality pieces while cutting to these standard lengths. Maximize length yields.

Sort by length:
Sort to piece lengths, no sorting by widths. Pieces with edge defects are sent to the salvage ripsaw.

Salvage ripsaw:
Pieces with edge defects are ripped to make frame-quality pieces 1½, 2, 2½, or 3 inches wide.

Operating Combination I

Frame quality for 20-inch-wide, 6/4-inch-thick blanks
Standard lengths: 14, 18, 21, 24, 28, 31, 34, and 40 inches

Rough plane:
6/4 boards 1.2500 inches hit-and-miss 2 sides

Gang crosscut:
GCL1 for 6-foot boards (6I1): 40-, 28-, and 21-inch blanks needed
Saw spacings (right to left):
1-2 30 inch, 2-3 21 inch, 3-4 21 inch, 5 not used
No "long" boards needed
"Half" boards:
1½- by 31-inch minimum frame-quality area on right end
Saws 1, 2, and 4 down and 3 up; one 42¼- and one 30-inch piece
"Other" boards:
All boards not meeting the "half" criteria
Saws 1, 2, 3, and 4 down; one 30-inch piece and two 21-inch pieces
GCL2 for 6-foot boards (6I2): 40-, 31-, 21-, and 18-inch blanks needed
Saw spacings (right to left):
1-2 31 inch, 2-3 21 inch, 3-4 20 inch, 5 not used
No "long" boards needed
"Half" boards:
1½- by 34-inch minimum frame-quality area on right end
Saws 1, 2, and 4 down and 3 up; one 41¼- and one 31-inch piece
"Other" boards:
All boards not meeting the "half" criteria
Saws 1, 2, 3, and 4 down; one 31-, one 21-, and one 20-inch piece
GCL1 for 8-foot boards (8I1): 34- and 31-inch blanks needed
Saw spacings (right to left):
1-2 31 inch, 2-3 31 inch, 3-5 34 inch, 4 not used
No "long" or "half" boards needed
"Other" boards:
All boards
Saws 1, 2, 3, and 5 down; one 34-inch piece and two 31-inch pieces
GCL2 for 8-foot boards (8I2): 40-, 28-, 24-, and 21-inch blanks needed
Saw spacings (right to left):
1-2 24 inch, 2-3 30 inch, 3-4 21 inch, 3-5 21 inch
No "long" boards needed
"Half" boards:
1½- by 31-inch minimum frame-quality area on right end
Saws 1, 2, 3, and 5 down and 4 up; one 42¼-, one 30-, and one 24-inch piece
"Other" boards:
All boards not meeting the "half" criteria
Saws 1, 2, 3, 4, and 5 down; one 30- and one 24-inch piece, and two 21-inch pieces

Piece sort:
Use any piece with a 1½- by 14-inch frame-quality area

Gang rip:
Rip to 1½-, 2-, 2½-, 3-, or 3½-inch width to remove edge defects to obtain frame-quality pieces

Defect and cut-to-length:
For 6- and 8-foot boards, set length stops at 14, 18, 21, 24, 28, 31, 34, and 40 inches
Trim end defects to obtain frame-quality pieces while cutting to these standard lengths. Maximize length yields.

Sort by length:
Sort to piece lengths, no sorting by widths. Pieces with edge defects are sent to the salvage ripsaw.

Salvage ripsaw:
Pieces with edge defects are ripped to make frame-quality pieces 1½, 2, 2½, or 3 inches wide.

Operating Combination J

Clear (C1F and C2F) quality for 26-inch-wide, 3/4-inch-thick blanks
Standard lengths: 14, 17, 19, 22, 25, 29, 31, 35, 41, 47, 58, and 86 inches

Rough plane:
3/4 boards 0.75 inch hit-and-miss 2 sides

Gang crosscut:
GCL1 for 6-foot boards (6J1): full length, 47-, 25-, and 22-inch blanks needed
Saw spacings (right to left):
1-2 22 inch, 2-3 25 inch, 3-4 25 inch, 5 not used
"Long" boards:
1½- by 58-inch minimum clear-quality area
Saws 1 and 4 down and 2 and 3 up; one 72½-inch piece
"Half" boards:
1½- by 29-inch minimum clear-quality area on right end
Saws 1, 2, and 4 down and 3 up; one 50¼- and one 27-inch piece
"Other" boards:
All boards not meeting "long" or "half" criteria
Saws 1, 2, 3, and 4 down; two 25-inch pieces and one 22-inch piece
GCL2 for 6-foot boards (6J2): full length, 35-, 22-, and 14-inch blanks needed
Saw spacings (right to left):
1-2 35 inch, 2-3 15 inch, 3-4 22 inch, 5 not used
"Long" boards:
1½- by 41-inch minimum clear-quality area
Saws 1 and 4 down and 2 and 3 up; one 72½-inch piece
"Half" boards:
1½- by 35-inch minimum clear-quality area on right end
Saws 1, 2, and 4 down and 3 up; one 37¼- and one 35-inch piece
"Other" boards:
All boards not meeting the "long" or "half" criteria
Saws 1, 2, 3, and 4 down; one 35-, one 22-, and one 15-inch piece
GCL1 for 8-foot boards (8J1): 86-, 58-, 35-, 31-, and 29-inch blanks needed
Saw spacings (right to left):
1-2 36 inch, 2-3 29 inch, 3-5 31 inch, 4 not used
"Long" boards:
1½- by 86-inch minimum clear-quality area
Saws 1 and 5 down and 2 and 3 up; one 96½-inch piece
"Half" boards:
1½- by 41-inch minimum clear-quality area on right end
Saws 1, 2, and 5 down and 3 up; one 60¼- and one 36-inch piece
"Other" boards:
All boards not meeting "long" or "half" criteria
Saws 1, 2, 3, and 5 down; one 36-, one 31-, and one 29-inch piece
GCL2 for 8-foot boards (8J2): 86-, 47-, 25-, and 22-inch blanks needed
Saw spacings (right to left):
1-2 23 inch, 2-3 25 inch, 3-4 23 inch, 4-5 25 inch
"Long" boards:
1½- by 58-inch minimum clear-quality area
Saws 1 and 5 down and 2, 3, and 4 up; one 96¾-inch piece
"Half" boards:
1½- by 29-inch minimum clear-quality area on right end
Saws 1, 3, and 5 down and 2 and 4 up; two 48¼-inch pieces
"Other" boards:
All boards not meeting "long" or "half" criteria
Saws 1, 2, 3, 4, and 5 down; two 25- and two 23-inch pieces

Piece sort:
Use any piece with a 1½- by 14-inch clear-quality area

Gang rip:
Rip to 1½-, 2-, 2½-, 3-, or 3½-inch width to remove edge defects to obtain clear-quality pieces

Defect and cut-to-length:
For 6-foot boards, set length stops at 14, 17, 19, 22, 25, 29, 31, 35, 41, 58, and 72 inches
For 8-foot boards, set length stops at 14, 17, 19, 22, 25, 29, 31, 35, 41, 58, and 86 inches
Trim end defects to obtain clear-quality pieces while cutting to these standard lengths. Maximize length yield.

Sort by length:
Sort to piece lengths, no sorting by widths. Pieces with edge defects are sent to the salvage ripsaw.

Salvage ripsaw:
Pieces with edge defects are ripped to make clear-quality pieces 1½, 2, 2½, or 3 inches wide.

Appendix II

S60PT: Linear Programing Optimization

This version of S60PT is programed using MPS-III written by Ketron, Inc., 1700 N. Moore Street, Arlington, VA 22209. The program will run on computers that have the MPS-III compiler. This LP use is very limited in function as we only want to know the least board quantity needed to obtain the required blanks.

Three sets of data are required: the yield of blanks in each length by each GCL for the given board quality, the quantity of blanks required in each length for the given blank quality, and the yields when long blanks are trimmed to shorter blanks. All board inputs, all yield values by operating method, and all blank outputs are on a surface square-foot basis.

GCL Data Set

Each operating method data set is specific to:

- The board-quality level from a specific site or a specified sample.
- A single species from that site or sample.
- The GCL used to convert the rough dry boards to blanks.
- The lengths of blanks made by that GCL.

In System 6 research work, each GCL data set is determined by actual test. Dried boards are made to blanks of specified lengths by the operating method being tested. The yield values in each blank length make up the data set. Values are given in terms of square feet of blanks per square foot of boards used.

Blanks Requirement Data Set

Araman et al. (1982) studied the solid wood parts needs of the furniture and kitchen cabinet industries. The recommended sizes and qualities for standard-size hardwood blanks were made from these study data. When a furniture or cabinet company buys or makes blanks in these sizes and qualities, there should be no more than 10 percent end trim loss in making rough-dimension parts from blanks.

The quantity of blanks per length, thickness, and quality must be specified. The blanks requirement data set is given in terms of square feet per blank length for a total of 1,000 square feet of blanks. Only one blank quality and blank thickness may be used per data set.

Trim Method Data Sets

System 6 operating methods are not designed to make all blank lengths, nor could enough operating methods be developed that would produce all of the blanks needed in each length. Instead, the operating methods are designed to obtain as many long blanks as possible. The long blanks that are extras then can be trimmed back to make shorter blanks to fulfill requirements.

All possible combinations for making shorter blanks from longer blanks must be specified to allow the LP program to make the optimal choice. Trim-method data are given in the form of square feet of shorter blanks that can be made from a longer blank. As an example, 1 square foot of 70-inch-long blank can be trimmed to 0.771 square foot of 54-inch blank (54/70 = 0.771) plus 0.186 square foot of 13-inch blank (13/70 = 0.186). Kerf loss of the trimsaw is ignored and is considered part of the waste. To be consistent, therefore, a square foot of 44-inch blank can be trimmed to a square foot of 22-inch blank [(22 + 22)/44 = 1.0].

The trim-method data set must correspond to all the long blanks made and all the shorter lengths required. Additional trim-method data will lead to error with the program assuming some blanks are available that are not.

Card Deck

The card deck layout is shown in Figure 5.

JCL cards: The seven job control cards are given for the job and account numbers used by the author. All data starts in column 1.

```
//B0945HWR JOB 00510,REYNOLDS
/*ROUTE PRINT MVS1.RMT04
/*LONGKEY GATCHEL
/*PRIORITY PRIORITY
/*JOBPARM LINES=3
//STEP1 EXEC LP
//LP.SYSIN DD *
```

Program cards: The 15 program cards are given for the LP options used by the author. All data starts in column 10.

```
PROGRAM
INITIALZ
TITLE ('ANY TITLE UP TO COL-
  UMN 79')
```

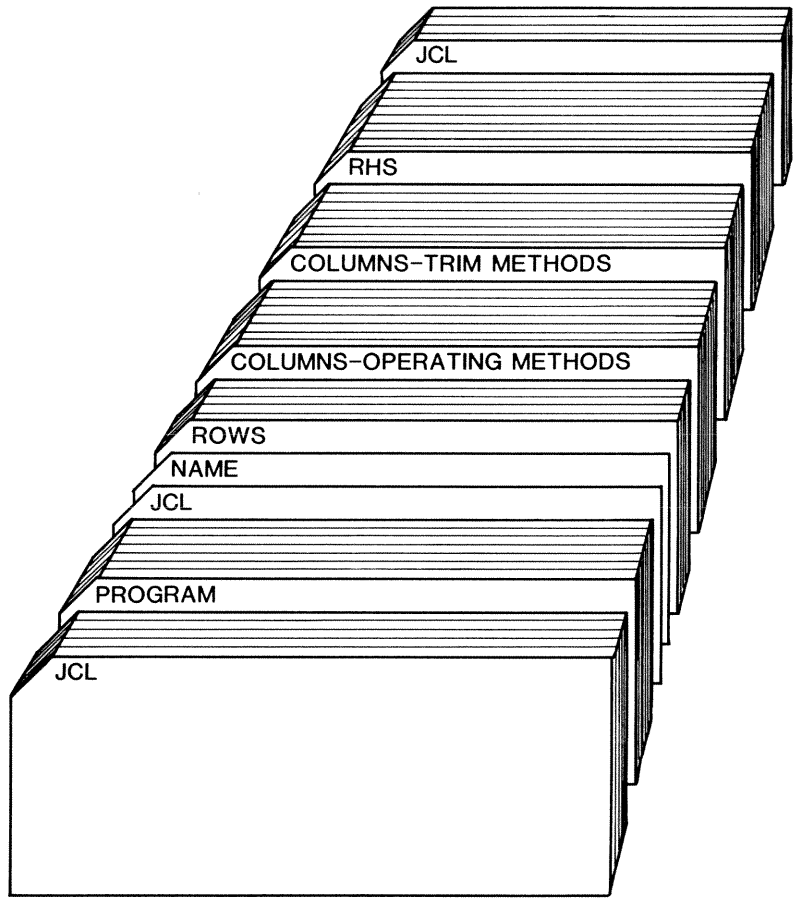

Figure 5.—Card deck layout.

```
MOVE (XDATA, 'NAME') Name can
   be eight characters and/or num-
   bers. No embedded blanks.
MOVE (XPBNAME, 'PBFILE')
CONVERT ('SUMMARY')
BCDOUT
MOVE (XOBJ, 'MINBOARD') The
   objective function is always
   named MINBOARD
MOVE (XRHS, 'REQD')
SETUP
```

JCL cards:

```
PICTURE
VARIFORM
SOLUTION
EXIT
PEND
```

Two cards are used to introduce the data sections. All data starts in column 1.

```
/*
//GO.SYSIN DD *
```

Name cards: Name card and any comment cards.

NAME (start in column 1) Name—start in column 15. Name can be eight characters and/or numbers. No embedded blanks.

*(Column 1) comment cards any character or number and period. These comments will not appear in the program listing or output.

Row cards: The first card is "ROWS" and each additional card gives one row, name, and the kind of row parameter on the RHS.

L = less than or equal to (for salvage blank lengths less than 20 inches).

G = greater than or equal to (for all required blank lengths except the salvage lengths).

N = objective function.

Blank length is used as the row name for all except the objective function, which is named MINBOARD. Example: BL/70 is name of the blank length 70-inch row.

Rows (start in column 1)

Parameter (N.L, or G in column 3). Name—start in column 5. Name can be eight characters and/or numbers and period. No embedded blanks.

There must be a row name for each blank length to be considered even though that length may not be made by any of the operating methods and can only be made by a trim method.

Column cards: OPERATING METHODS—The first card is "COLUMNS." Each additional columns card gives an operating method name in the LP matrix. In addition, two element values of the matrix data, not zero, are given by row, name, and value. All names and values are left justified. Zero matrix values do not have to be entered.

COLUMNS (start in column 1).

Operating Method Name	*Row Name*	*Element Value*	*Row Name*	*Element Value*
Operating method name	: card columns 5-12			
Row name	: card columns 15-22			
Matrix value	: card columns 25-36			
Row name	: card columns 40-47			
Matrix value	: card columns 50-61			

Column cards: TRIM METHODS. Each additional columns card gives a trim-method name in the LP matrix. The trim-method name is given with the length of the long blanks to be trimmed and the longest shorter length blank to be made. Example: TM70.54 is the trim method that takes 70-inch-long blanks and trims them to a 54-inch-long blank plus a 13-inch-long blank. The matrix element giving the long blank length is always −1.0 to show that this is a blank in excess of requirements. All names and values are left justified.

Trim Method Name	*Row Name*	*Element Value*	*Row Name*	*Element Value*
Trim method name	: card columns 5–12			
Row name	: card columns 15–22			
Element value	: card columns 25–36			
Row name	: card columns 40–47			
Element value	: card columns 50–61			

RHS cards: The first card is "RHS." Each additional card has the name column REQD. Two row names and matrix values are given per card. For those rows with G parameters, the value given is the square footage of blanks required, though more blanks of those lengths could be used. For those rows with L parameters, the value given is the maximum square footage of blanks permitted. All names and values are left justified.

RHS (Start in column 1).

REQD	*Row Name*	*Element Value*	*Row Name*	*Element Value*
	REQD	: card columns 5- 8		
	Row name	: card columns 15–22		
	Element value	: card columns 25–36		
	Row name	: card columns 40–47		
	Element value	: card columns 50–61		

JCL cards: Three additional cards are required to end the card deck.
Start in column 1.
ENDATA
/*
//

Example

We used System 6 technology to make 4/4 frame blanks from low-grade white oak thinnings (Reynolds and Araman 1983). Four GCL's were tested using all boards. Yields were high for each operating method, and the optimal yield using all four operating methods to obtain the required blanks was very good. We then made additional tests using these four GCL's with only those boards below No. 3A Common grade. In this example we show the operating methods optimization for the second series of tests to obtain 1,000 square feet of required blanks. The LP matrix is shown in Figure 6. The four GCL's are labeled OME-OMH.

The first three pages show the input card deck. The computer run was named "FRAME 4." In the "ROWS" section we specified that "MINBOARD" was the objective function (row parameter "N"). Blanks 70 to 22 inches long should have at least the square footage shown in the "RHS" (row parameter "G") section. Blanks 19 to 13 inches long should not exceed the square footage shown in the "RHS" section (row parameter "L"). Here we ran into trouble.

When only the poorest boards are used, more salvage length blanks (19, 17, 13 inches long) are made compared to using all boards. We exceeded the 40-square-foot limit of required 13-inch blanks before enough 54-inch-long blanks were made. The LP program shut down when the 40-square-foot limit of 13-inch blanks had been made. So we increased the quantity of salvage length blanks by 900 square feet and ran the program again. Now all blanks were made and an optimization was reached.

The program output is shown on page 27. Under "Section 1 Rows" printout, the minimum board input is 1,760 square feet. The exact quantity of blanks 70 to 22 inches required was made. Originally, we wanted no more than 50 square feet of 19-inch blanks, and we got only 47 square feet. Originally, we wanted no more than 25 square feet of 17-inch blanks, and we got only 12 square feet. Originally, we wanted no more than 40 square feet of 13-inch blanks, but we had to accept 41 square feet to obtain all of the 70- to 22-inch-long blanks required.

Under the "Section 2 Columns" printout, the board quantities for each operating method are shown. Operating method E would use 487 square feet of boards, operating method F 494 square feet, operating method G 582 square feet, and operating method H 197 square feet. Not all blank lengths are made with these four operating methods, but enough additional long blanks are made to allow trimming to shorter blanks. Trim method 70.54 was used to convert 108 square feet of 70-inch blanks to 54- and 13-inch blanks. Trim method 44.22 was used to convert 19 square feet of 44-inch blanks to 22-inch blanks. Trim method 33.29 was used to convert 88 square feet of 33-inch blanks to 29-inch blanks. Trim method 33.27 was used to convert 151 square feet of 33-inch blanks to 27-inch blanks. The quantity of blanks so obtained are included in the "Section 1 Rows" printout. No other trim methods were used.

Columns → RHS

Rows ↓

	OME	OMF	OMG	OMH	TM 70.54	TM 70.44	TM 70.33	TM 70.29	TM 70.27	TM 70.24	TM 70.22	TM 54.44	TM 27.24	TM 27.22	TM 24.22	REQD
MIN BOARD N	1.0	1.0	1.0	1.0												
BL70 G	0.161	0.138			-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0					39.0
BL54 G					0.771							-1.0				83.0
BL44 G	0.209					0.629						0.815				83.0
BL33 G		0.283	0.462				0.943									169.0
BL29 G			0.059					0.829								112.0
BL27 G		0.085							0.771				-1.0	-1.0		166.0
BL24 G			0.043	0.498		0.343				0.686			0.889		-1.0	123.0
BL22 G	0.166			0.052						0.314	0.943			0.815	0.917	110.0
BL19 L	0.019	0.040	0.017	0.042												950.0
BL17 L	0.013	0.003	0.001	0.019												925.0
BL13 L	0.020	0.009	0.005	0.021	0.186				0.186							940.0

Figure 6.—Linear programing matrix.

```
//B0945HWR JOB 00510,REYNOLDS
/*ROUTE PRINT MVS1.RMT04
/*LONGKEY GATCHEL
/*PRICRITY PRIORITY
/*JOBPARM LINES=3
//STEP1  EXEC  LP
//LP.SYSIN DD  *
         PROGRAM
         INITIALZ
         TITLE('SYSTEM 6 OPERATING METHODS OPTIMIZATION FRAME 4')
         MOVE(XDATA,'FRAME4')
         MOVE(XPBNAME,'PBFILE')
         CONVERT('SUMMARY')
         BCDOUT
         MOVE(XOBJ,'MINBOARD')
         MOVE(XRHS,'REQD')
         SETUP
         PICTURE
         VARIFORM
         SOLUTION
         EXIT
         PEND
/*
//GO.SYSIN DD *
NAME          FRAME4
*STUDY 57 E,F,G,H OM  ALL TM BG BOARDS ONLY EXTRA SHORT LENGTHS
ROWS
  N MINBOARD
  G BL70
  G BL54
  G BL44
  G BL33
  G BL29
  G BL27
  G BL24
  G BL22
  L BL19
  L BL17
  L BL13
```

```
COLUMNS
    OME       MINBOARD  1.0       BL70      0.161
    OME       BL44      0.209     BL22      0.166
    OME       BL19      0.019     BL17      0.013
    OME       BL13      0.020
    OMF       MINBOARD  1.0       BL70      0.138
    OMF       BL33      0.283     BL27      0.085
    OMF       BL19      0.040     BL17      0.003
    OMF       BL13      0.009
    OMG       MINBOARD  1.0       BL33      0.462
    OMG       BL29      0.059     BL24      0.043
    OMG       BL19      0.017     BL17      0.001
    OMG       BL13      0.005
    OMH       MINBOARD  1.0       BL24      0.498
    OMH       BL22      0.052     BL19      0.042
    OMH       BL17      0.019     BL13      0.021
    TM70.54   BL70      -1.0      BL54      0.771
    TM70.54   BL13      0.186
    TM70.44   BL70      -1.0      BL44      0.629
    TM70.44   BL24      0.343
    TM70.33   BL70      -1.0      BL33      0.943
    TM70.29   BL70      -1.0      BL29      0.829
    TM70.27   BL70      -1.0      BL27      0.771
    TM70.27   BL13      0.186
    TM70.24   BL70      -1.0      BL24      0.686
    TM70.24   BL22      0.314
    TM70.22   BL70      -1.0      BL22      0.943
    TM54.44   BL54      -1.0      BL44      0.815
    TM54.33   BL54      -1.0      BL33      0.611
    TM54.33   BL19      0.352
    TM54.29   BL54      -1.0      BL29      0.537
    TM54.29   BL24      0.444
    TM54.27   BL54      -1.0      BL27      1.0
    TM54.24   BL54      -1.0      BL24      0.889
    TM54.22   BL54      -1.0      BL22      0.815
```

```
    TM44.33    BL44       -1.0          BL33       0.750
    TM44.29    BL44       -1.0          BL29       0.659
    TM44.29    BL13       0.295
    TM44.27    BL44       -1.0          BL27       0.614
    TM44.27    BL17       0.386
    TM44.24    BL44       -1.0          BL24       0.545
    TM44.24    BL19       0.432
    TM44.22    BL44       -1.0          BL22       1.0
    TM33.29    BL33       -1.0          BL29       0.879
    TM33.27    BL33       -1.0          BL27       0.820
    TM33.24    BL33       -1.0          BL24       0.727
    TM33.22    BL33       -1.0          BL22       0.667
    TM29.27    BL29       -1.0          BL27       0.931
    TM29.24    BL29       -1.0          BL24       0.828
    TM29.22    BL29       -1.0          BL22       0.759
    TM27.24    BL27       -1.0          BL24       0.889
    TM27.22    BL27       -1.0          BL22       0.815
    TM24.22    BL24       -1.0          BL22       0.917
RHS
    REQD       BL70       39.0          BL54       83.0
    REQD       BL44       83.0          BL33       169.0
    REQD       BL29       112.0         BL27       166.0
    REQD       BL24       123.0         BL22       110.0
    REQD       BL19       950.0         BL17       925.0
    REQD       BL13       940.0
ENDATA
/*
//
```

SYSTEM 6 OPERATING METHODS OPTIMIZATION FRAME 4

SECTION 1 - ROWS

NUMBER	...ROW..	AT	...ACTIVITY...	SLACK ACTIVITY	..LOWER LIMIT.	..UPPER LIMIT.	.DUAL ACTIVITY
1	MINBOARD	BS	1759.97076	1759.97076-	NONE	NONE	1.00000
2	BL70	LL	39.00000	.	39.00000	NONE	2.36906-
3	BL54	LL	83.00000	.	83.00000	NONE	3.07271-
4	BL44	LL	83.00000	.	83.00000	NONE	1.64955-
5	BL33	LL	169.00000	.	169.00000	NONE	1.74074-
6	BL29	LL	112.00000	.	112.00000	NONE	1.98036-
7	BL27	LL	166.00000	.	166.00000	NONE	2.12285-
8	BL24	LL	123.00000	.	123.00000	NONE	1.83579-
9	BL22	LL	110.00000	.	110.00000	NONE	1.64955-
10	BL19	BS	47.17715	902.82285	NONE	950.00000	.
11	BL17	BS	12.13836	912.86164	NONE	925.00000	.
12	BL13	BS	41.25840	898.74160	NONE	940.00000	.

SYSTEM 6 OPERATING METHODS OPTIMIZATION FRAME 4

SECTION 2 - COLUMNS

NUMBER	.COLUMN.	AT	...ACTIVITY...	..INPUT COST..	..LOWER LIMIT.	..UPPER LIMIT.	.REDUCED COST.
13	OME	BS	487.38305	1.00000	.	NONE	.
14	OMF	BS	494.08499	1.00000	.	NONE	.
15	OMG	BS	581.74584	1.00000	.	NONE	.
16	OMH	BS	196.75689	1.00000	.	NONE	.
17	TM70.54	BS	107.65240	.	.	NONE	.
18	TM70.44	LL	.	.	.	NONE	.70181
19	TM70.33	LL	.	.	.	NONE	.72754
20	TM70.29	LL	.	.	.	NONE	.72734
21	TM70.27	LL	.	.	.	NONE	.73234
22	TM70.24	LL	.	.	.	NONE	.59174
23	TM70.22	LL	.	.	.	NONE	.81353
24	TM54.44	LL	.	.	.	NONE	1.72832
25	TM54.33	LL	.	.	.	NONE	2.00912
26	TM54.29	LL	.	.	.	NONE	1.19416
27	TM54.27	LL	.	.	.	NONE	.94986
28	TM54.24	LL	.	.	.	NONE	1.44069
29	TM54.22	LL	.	.	.	NONE	1.72832
30	TM44.33	LL	.	.	.	NONE	.34400
31	TM44.29	LL	.	.	.	NONE	.34450
32	TM44.27	LL	.	.	.	NONE	.34612
33	TM44.24	LL	.	.	.	NONE	.64905
34	TM44.22	BS	18.86306	.	.	NONE	.
35	TM33.29	BS	88.36973	.	.	NONE	.
36	TM33.27	BS	151.22290	.	.	NONE	.
37	TM33.24	LL	.	.	.	NONE	.40612
38	TM33.22	LL	.	.	.	NONE	.64048
39	TM29.27	LL	.	.	.	NONE	.00399
40	TM29.24	LL	.	.	.	NONE	.46033
41	TM29.22	LL	.	.	.	NONE	.72835
42	TM27.24	LL	.	.	.	NONE	.49083
43	TM27.22	LL	.	.	.	NONE	.77846
44	TM24.22	LL	.	.	.	NONE	.32315

Reynolds, Hugh W. **System 6: Rough-mill operating manual.** Res. Pap. NE-542. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station; 1984. 27 p.

Includes operating instructions for the System 6 rough mill. Techniques are shown for making standard-size blanks, in all lengths, for each of 13 blank quality/width/thickness combinations.

ODC 836.1:847.1/2

Keywords: Low-grade utilization; hardwood dimension

☆ U.S. GOVERNMENT PRINTING OFFICE: 1984—705-029/503

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