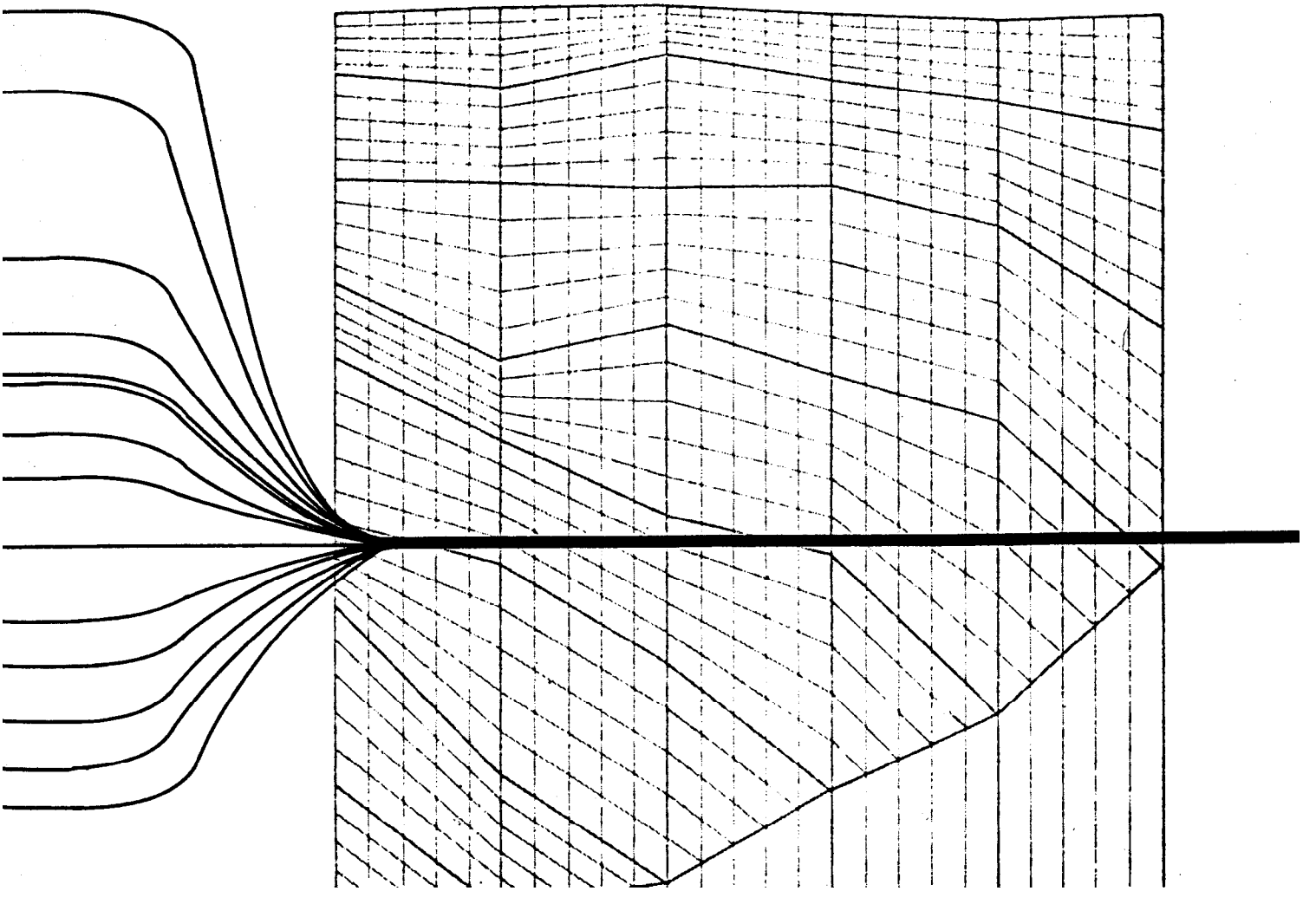
U. S. FOREST SERVICE
RESEARCH PAPER
FPL 81
SEPTEMBER 1967

Yields of Random-Width Dimension from 4/4 Hard Maple Lumber



ABSTRACT

Nomograms show how yields of panel stock of random widths from 4/4 hard maple lumber can be determined easily and quickly. From these, it is possible to detect the yield of a number of panel lengths in a lumber grade, and compare yields between the four top lumber grades.

Yields of Random- Width Dimension From 4/4 Hard Maple Lumber

By DAVID R. SCHUMANN and GEORGE H. ENGLERTH } Forest Products Technologists

FOREST PRODUCTS LABORATORY[1]
FOREST SERVICE
U. S. DEPARTMENT OF AGRICULTURE

Knowledge of expected yields for a specified cutting order is of considerable importance to users of hardwood lumber. Such information gives them a basis for selecting the most economical grade or grades of lumber to produce a specified set of cuttings, calculate material costs, and determine whether maximum yield is obtained during the cut-up operation.

Heretofore, it has been difficult, if not impossible, to determine the total yield or the yield of each individual length in a cutting order. Hence, it was not possible to make comparisons of yields and costs between grades. The results reported here remove the guesswork from yield prediction for panel stock.

The field work of collecting the representative sample of 4/4 hard maple lumber for the study and recording the type and location of the defects and characteristics in the boards was done at the Carbondale project location of the North Central Forest Experiment Station.[2,3] The number and footage of the boards by length class and grade are shown in table 1. Computer analysis and preparation of charts was performed at the Forest Products Laboratory.

A CDC 1604 computer was used to determine the yield of various-size cuttings from each of the four top lumber grades. This program is described elsewhere.[4] The following primary cutting lengths were used for the four different grades:

Lumber grade	Cutting length (inches)								
Firsts and Seconds				40	50	60	70	80	90
Selects				40	50	60	70	80	90
No. I Common		20	30	40	50	60	70		
No. 2 Common	IO	20	30	40					

[1]The Laboratory is maintained at Madison, Wis., in cooperation with the University of Wisconsin.

[2]Field Office at Carbondale, Ill.

[3]Dunmire, Daniel E. and Englerth, George H. Development of a Computer Method for Predicting Lumber Cutting Yields. U.S. Forest Service Research Paper NC-I5, I967. North Central Forest Experiment Station, St. Paul, Minn.

[4]Wodzinski, Claudia and Hahm, Eldona. A Computer Program to Determine Yields of Lumber. Forest Products Laboratory Unnumbered report, March 1966.

Shorter length cuttings may be expected in the lower lumber grades, so the primary cutting lengths for these were less.

This report gives the yields of random-width and l-l/a-inch-wide dimension from 4/4 hard maple lumber for the Firsts and Seconds (FAS), Selects, No. 1 Common, and No. 2 Common standard lumber grades.[5] The results apply to clear-one face dimension from lumber kiln dried to 6 percent moisture content. Although the information was obtained from hard maple lumber, the results may apply also to other hardwood species graded according to the standard rules. Work is under way to determine this.

It should be emphasized that these results apply to kiln-dried lumber. As such, loss from warp, cup, end checks, and similar drying defects are accounted for in the yield figures. Also, loss from rip and crosscut saw kerfs are taken into consideration. Thus, the yields are realistic and should be obtainable under good seasoning and cut-up practice. The following loss in yield was attributed to kerf in the different lumber grades:

Lumber grade	Kerf (Pct.)
Firsts and Seconds	5.2
Selects	5.6
No. I Common	6.6
No. 2 Common	6.9

Table I.--Number and board measure of 4/4 hard maple boards used to obtain yields by lumber grade and board length classes

Board length class	Number of boards				Board measure (kiln-dried material)			
	FAS	Selects	No. I Common	No. 2 Common	FAS	Selects	No. I Common	No. 2 Common
Ft.					Bd. ft.	Bd. ft.	Bd. ft.	Bd. ft.
4-5	--	--	41	50	--	--	107	112
6-7	--	30	57	49	--	131	226	165
8-9	24	31	54	56	152	191	281	271
10-11	24	32	52	58	182	222	337	351
12-13	24	32	58	61	213	265	443	463
14-15	24	28	60	47	246	259	522	409
16	24	27	52	42	293	283	544	413
All lengths	120	180	374	363	1,086	1,351	2,460	2,184
Totals	1,037				7,081			

[5]National Hardwood Lumber Association. Rules for the Measurement and Inspection of Hardwood and Cypress Lumber. NHLA Assoc., Chicago, Ill., 1967.

These figures are the averages of the actual kerf losses when cutting each of the various primary cutting lengths. Lower lumber grades can and usually do contain more defects than higher grades. More defects require more cuts and, consequently, the amount of kerf increases with the lower lumber grades.

PREDICTING YIELDS

An overall view of total yields and primary cuttings[6] for the four lumber grades is shown in figure 1. The lengths of the primary cuttings had only slight influence on the total yield in a lumber grade, because increased yields of the shorter secondary cuttings compensated for the lower yields of the longer primary cuttings. The secondary cuttings included those with a minimum length of 10 inches in all four lumber grades. The total yield, of course, will be less if the minimum length of the secondary cuttings is more than 10 inches.

A total yield of about 77 percent may be expected in the FAS grade, about 73 percent in the Select grade, about 71 percent for No. 1 Common, and about 62 percent for No. 2 Common.

As shown in figure 1, the yields of the primary cuttings decrease with an increase in the primary length. For example, in the FAS grade, a yield of 60 percent may be obtained when cutting for 40-inch lengths, but 49 percent when cutting for 90-inch lengths. By comparison, in the Select grade a 54 percent yield may be expected for the 40-inch primary cuttings, and about 36 percent in the 90-inch lengths. A yield of about 47 percent may be expected when cutting for 40-inch lengths in the No. 1 Common grade, and only about 32 percent in the No. 2 Common grade.

Similar comparisons in yields of primary cuttings can be made for other lengths in the four grades as well as comparisons in total yields between the four grades.

The difference between the total yield and that of the primary cutting may be expected in secondary cuttings 10 inches and longer.

The curves were not completed beyond 70 inches for primary cuttings in the No. 1 Common nor beyond 40 inches for the No. 2 Common grade because of the low expected yield in these grades. It would be uneconomical to cut for longer primary lengths in these grades. On the other hand, the curves were made to include 20 inches for the No. 1 Common grade, and 10 inches for the No. 2 Common grade.

Cuttings are seldom 10-inch multiples in length. In figure 1, one can read percentage yields to 1/2-inch length intervals. For example, a primary yield of 42 percent may be expected for random-width cuttings 46-1/2 inches long from No. 1 Common.

In figure 2, one can read the primary yield in approximate number of cuttings. For instance, a yield of about 890 cuttings per thousand board feet may be expected when cutting for 46-1/2-inch-long by 1-1/2-inch-wide cuttings in the No. 1 Common grade.

The actual yield for this situation may be calculated more closely in this manner:

A yield of 42 percent is equivalent to 420 surface feet per thousand board feet of lumber (0.42 x 1000). A cutting of the size 46-1/2 by 1-1/2 inches contains 0.484 surface feet $\left(\frac{46.5 \times 1.5}{144}\right)$. Then $\frac{420}{0.484}$ equals a yield of 868 cuttings of this size in a thousand board feet of lumber.

Likewise, the number of secondary cuttings per thousand board feet can be calculated in the same manner. Assume that a yield of 13.5 percent of a secondary cutting 34 by 1-1/2 inches in size also can be obtained in the No. 1 Common grade. This size cutting contains 0.354 surface feet $\left(\frac{34 \times 1.5}{144}\right)$. Then $\frac{0.135 \times 1000}{0.354}$ equals a yield of 381 cuttings per thousand board feet. Assume that the next secondary cutting is 20 by 1-1/2 inches and has a yield of 9.8 percent. This size cutting contains 0.208 surface feet, so $\frac{0.098 \times 1000}{0.208}$ equals a yield of 471 cuttings per thousand board feet.

It is obvious that the length of the primary cutting influences the yields of each of the subsequent cuttings. The yields of these subsequent cuttings can be read directly from figures 3 to 6 inclusive for the various grades. Yield percentages can be determined for any number of these subsequent cuttings, and com-

[6] The terms "cuttings" and "dimension" are used interchangeably herein.

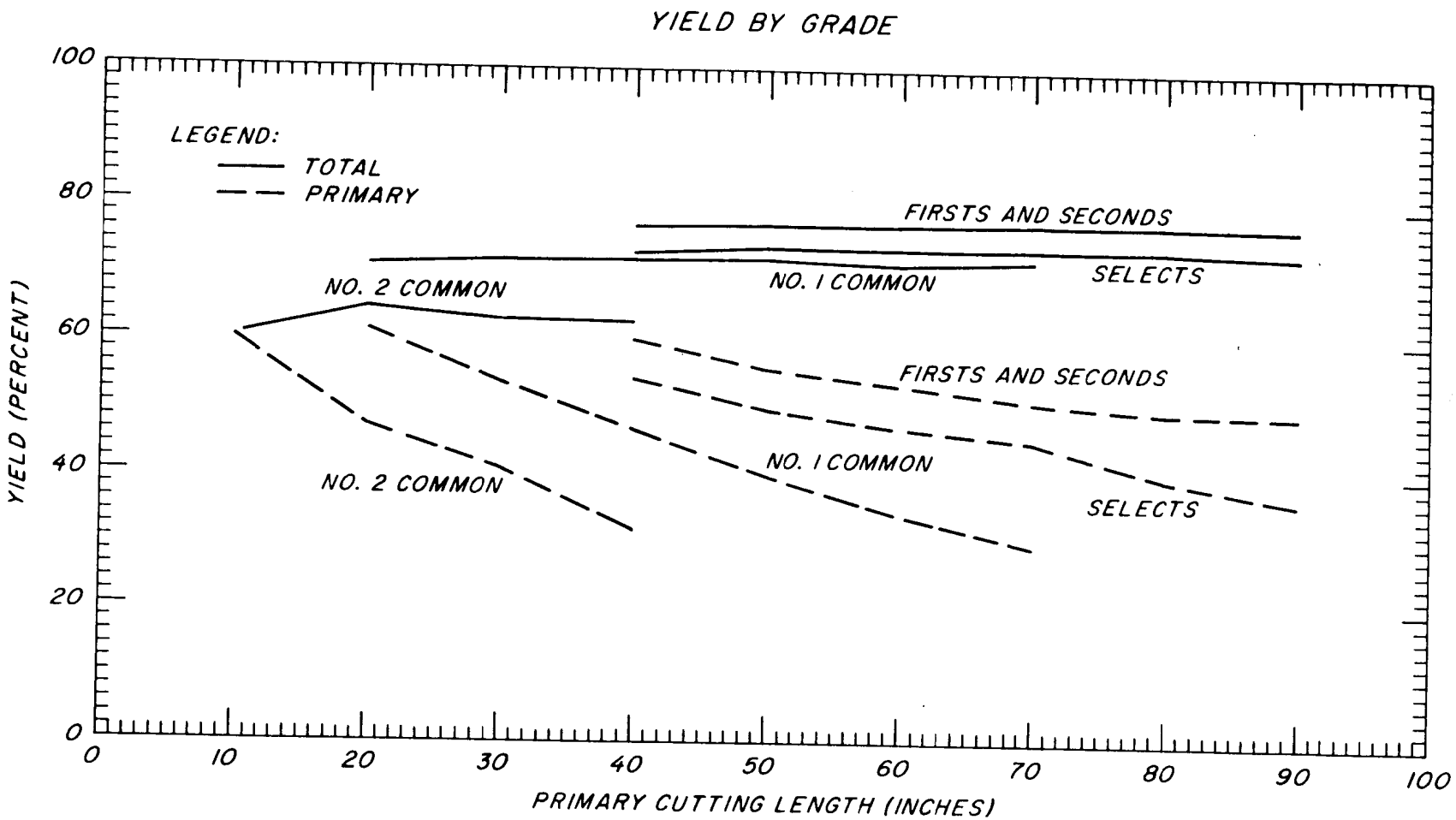


Figure 1.--Total and primary yield in percent of clear-one face cuttings, random width with 1-1/2-inch minimum, from 4/4 hard maple lumber.

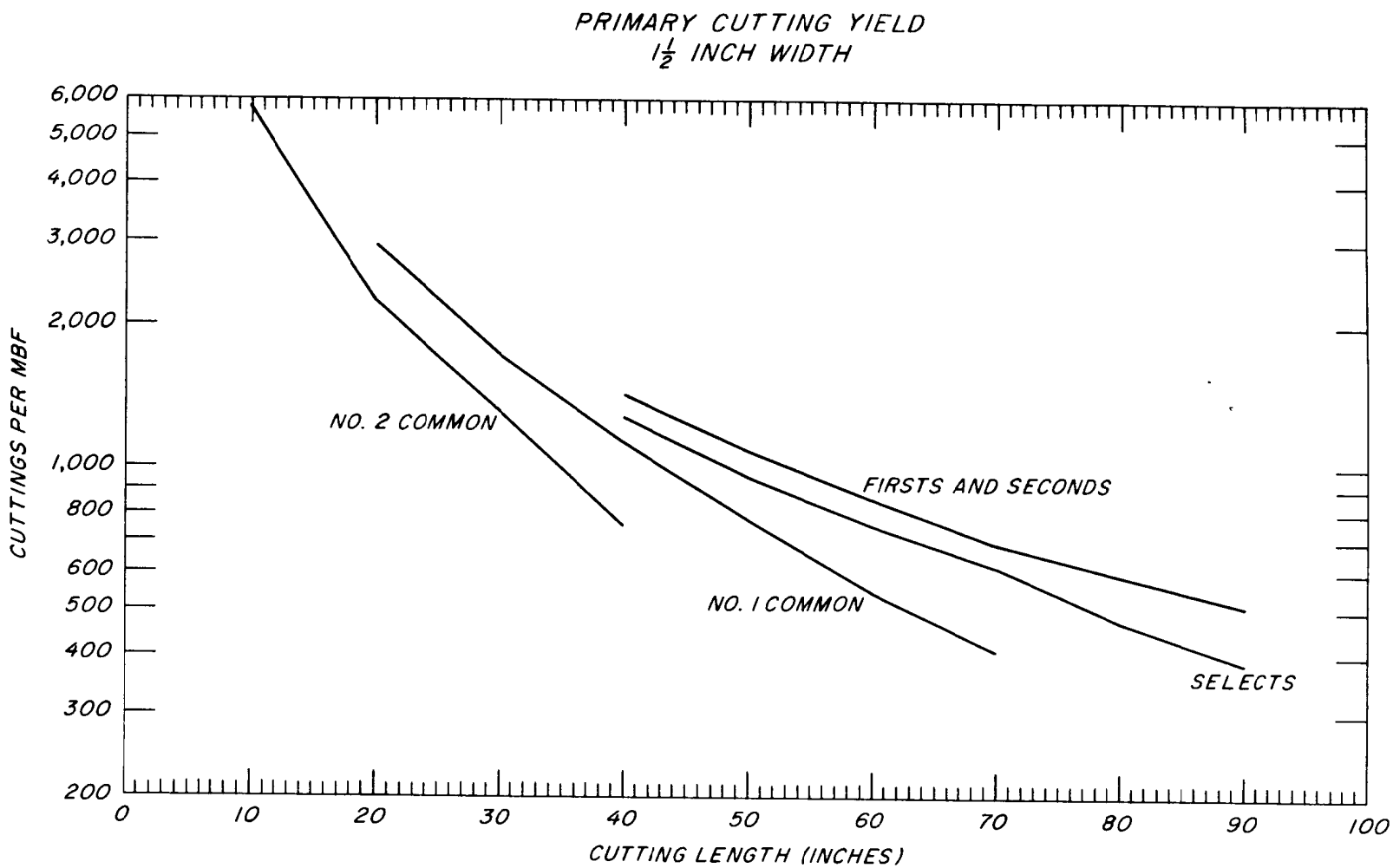


Figure 2.--Primary yield of clear-one face cuttings, random width with 1-1/2-inch minimum, from 4/4 hard maple lumber.

M 133 313

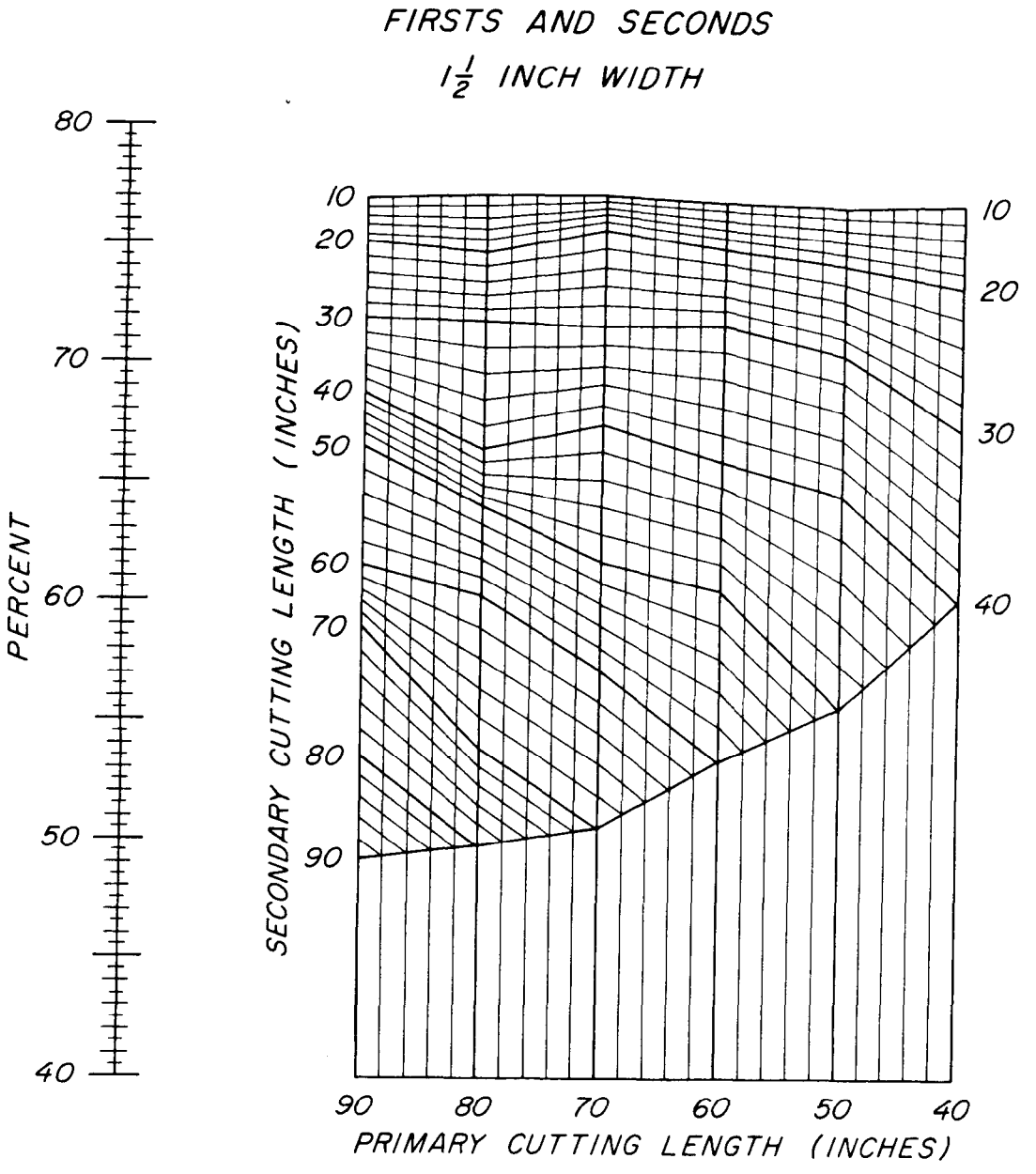


Figure 3.--First and Second grade nomogram: percent yield of clear-one face cuttings, I-l/2-inch minimum width, from 4/4 hard maple lumber.

M 133 314

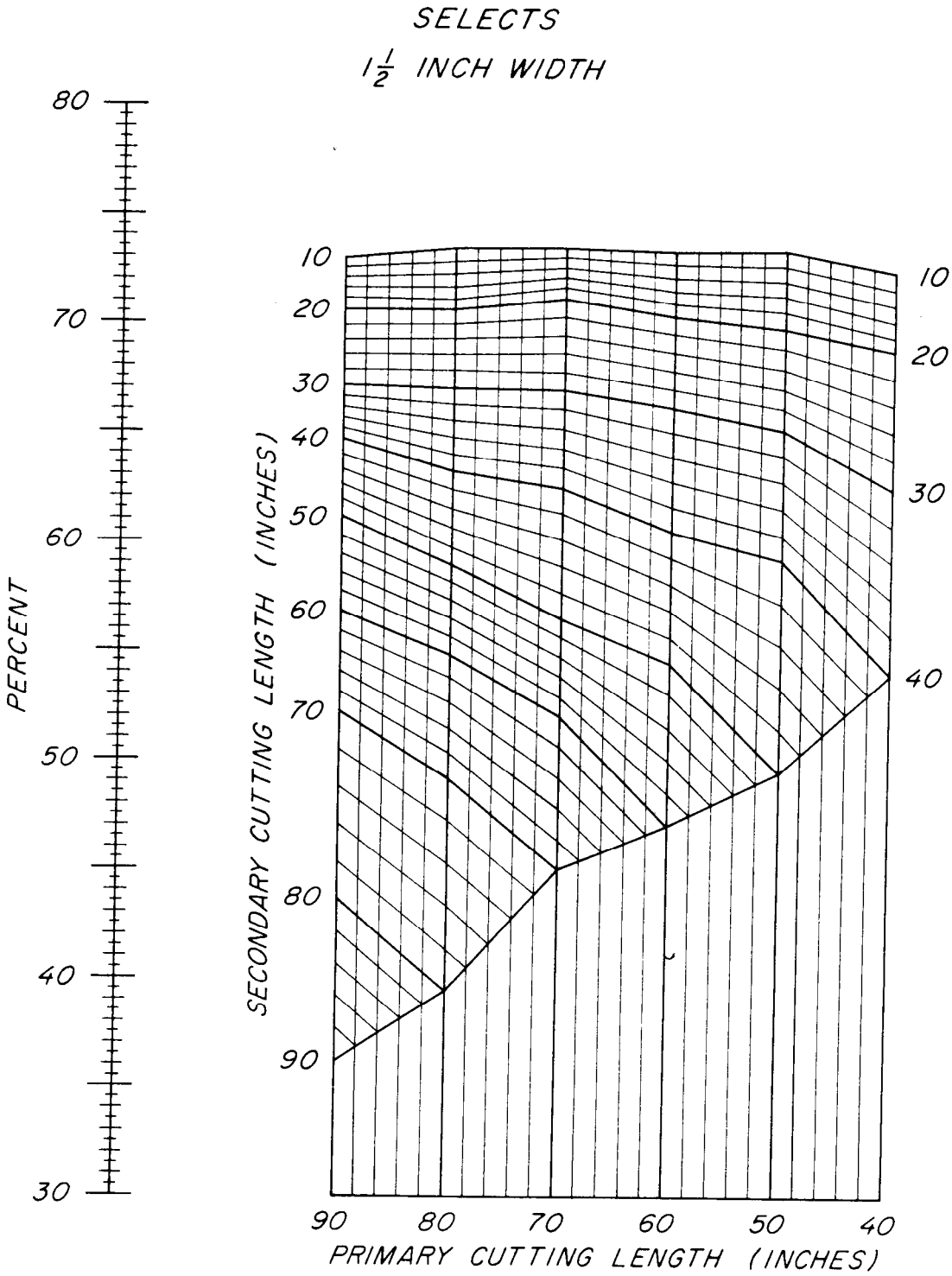


Figure 4.--Select grade nomogram: percent yield of clear-one face cuttings, I-l/2-inch minimum width, from 4/4 hard maple lumber. M I33 3I5

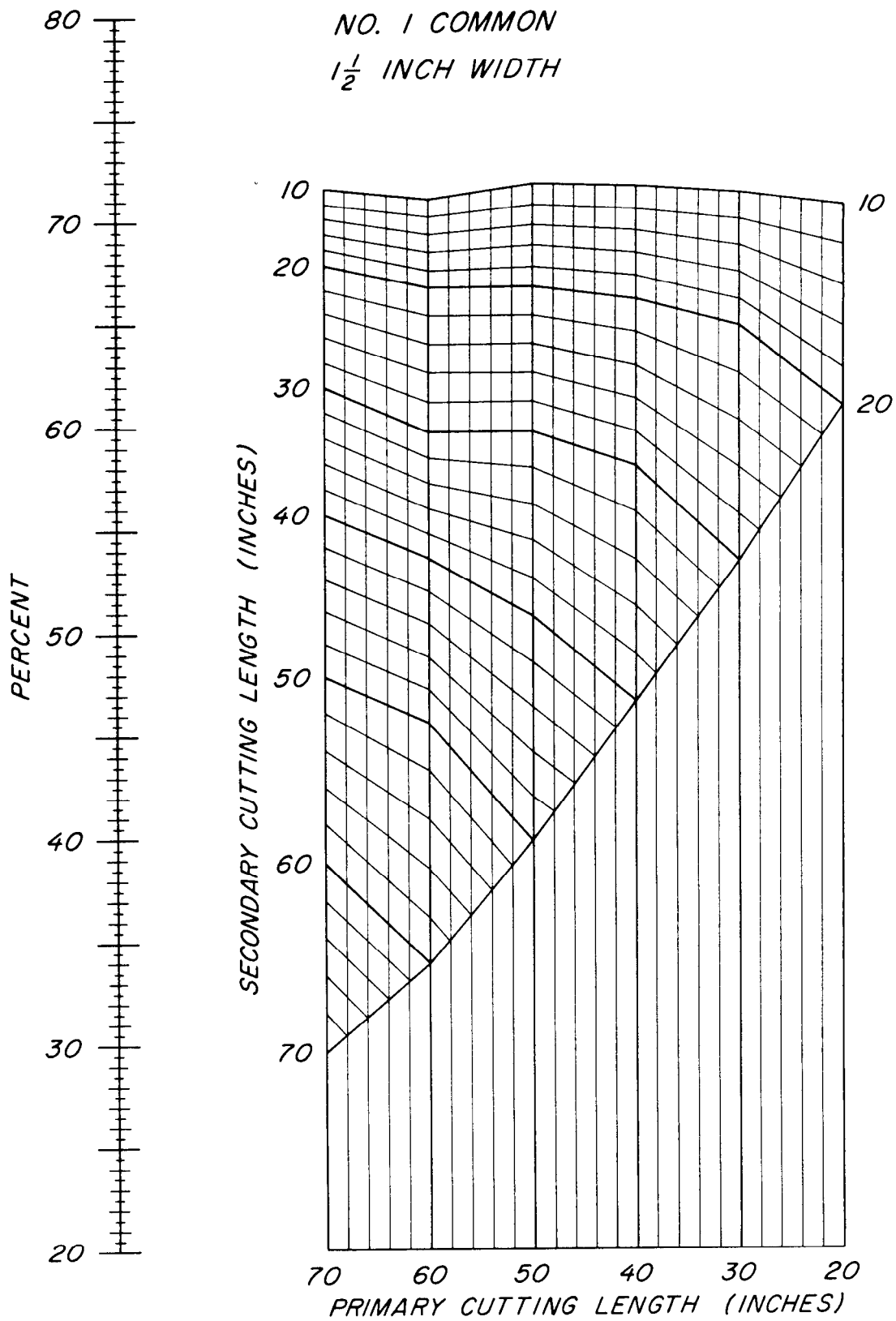


Figure 5.--No. I Common grade nomogram: percent yield of clear-one face cuttings, I-I/2-inch minimum width, from 4/4 hard maple lumber. M I33 3I6

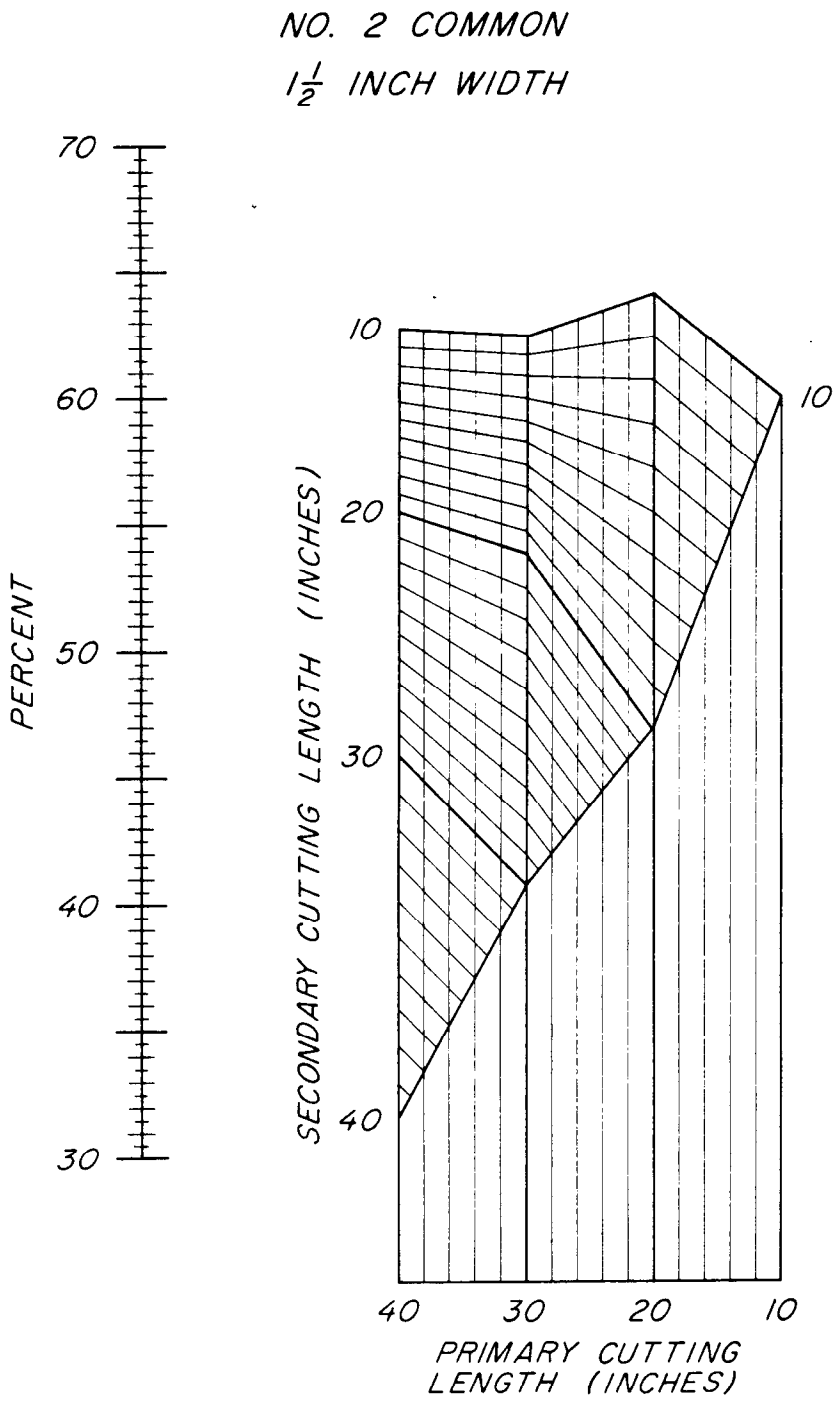


Figure 6.--No. 2 Common grade nomogram: percent yield of clear-one face cuttings, I-I/2-inch minimum width, from 4/4 hard maple lumber. M I33 3I7

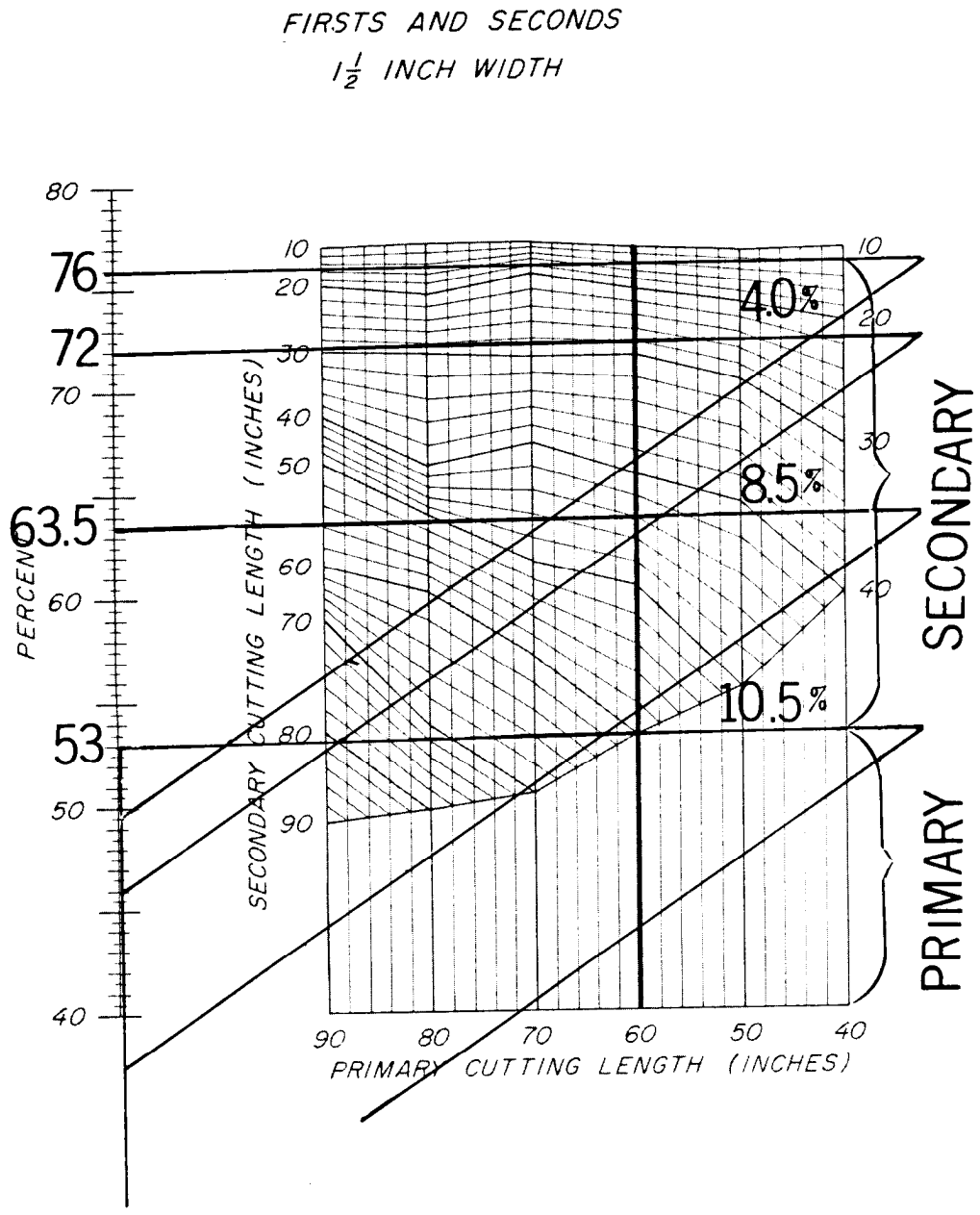


Figure 1.--Method for establishing percent yield of minimum-width, 1-1/2-inch primary and secondary cuttings in First and Second grade 4/4 hard maple lumber.

parisons can then be made between lumber grades.

Figures 3 to 6 are nomograms where yields can be calculated not only for the primary cutting but also for any number of secondary cuttings in a lumber grade, The left-hand vertical scale shows the yield in percent, while the horizontal scale shows lengths of the primary cuttings in inches. The slanting scales on the right show lengths of the subsequent or secondary cuttings. A transparent, plastic triangle provides a simple, easy way to read the yield percentages for the various lengths of cuttings.

USING THE NOMOGRAMS

An example of nomogram use is illustrated in figure 7 for the FAS grade. In this, the assumed length of the primary cutting is 60 inches, and those of the secondary cuttings 44, 28, and 15 inches,

Individual Steps:

1. Locate the length of the primary cutting of 60 inches at the bottom of the right-hand scale.
2. Position a vertical side of the transparent triangle parallel to the yield line and move the triangle up or down to where the horizontal side intersects with 60 and the lowest slanting line. It will be noted that 60 from the secondary cutting length also meets at this point.
3. Read the percent yield of 53. This is the value for the primary cutting length.
4. Move the triangle up to where 44 crosses the 60-inch primary cutting line, and read 63.5 from the percent scale.
5. The difference between 63.5 and 53 is 10.5, or the percent yield for the 44-inch length.
6. Move the triangle up to where 28 crosses the 60-inch primary line, and read 72 from the percent scale.
7. The difference between 72 and 63.5 is 8.5, or the percent yield for the 28-inch length.
8. Again, move the triangle up to where 15 crosses the 60-inch primary line, and read 76 from the percent scale.
9. The difference between 76 and 72 is 4, or the percent yield for the 15-inch length.
10. The total yield for these four lengths, of course, is 76 percent.

Additional Suggestions:

Because the yield of the secondary lengths depends on the yield of the primary lengths, one should always stay on the primary length line when determining the yields of secondary lengths.

The percent yield may also be converted to the number of l-l/a-inch cuttings per thousand board feet as shown in a previous example.

The same method is used to find the percent yield of the various lengths from the Select lumber grade in figure 4, from the No. 1 Common grade in figure 5, and from the No. 2 Common grade in figure 6.

YIELDS AND COSTS

As an example of the use of the nomograms in determining the yields and costs between grades, information on four sizes of panels and one length of a 1-1/2-inch-wide cutting are shown in table 2. The 60- by 30-inch panels are made up of random-width (1-1/2-inch minimum) cuttings, each 60 inches long. For the primary cutting length of 60 inches, a yield of 53.2 percent may be obtained from the FAS grade, 47.0 percent from the Selects, and 33.9 percent from the No. 1 Common. The yields of the subsequent or secondary sizes are shown for each grade. One would not expect to cut 60- and 44-inch lengths from the No. 2 Common, but yields for lengths 28 inches and less are shown for this grade. The percent yield multiplied by a thousand is the same as the number of board feet obtained per thousand board feet for each panel size and cutting.

The number of panels per thousand board feet in each grade was determined by dividing the panel size into the yield, expressed in board feet. For example, the primary panel size of 60 by 30 inches contains 12.5 square feet of surface area $\left(\frac{60 \times 30}{144} = 12.5\right)$. At a yield of 53.2 percent, 42.6 panels $\left(\frac{0.532 \times 1000}{12.5} = 42.6\right)$ of this size will be obtained for every thousand board feet cut.

The published figures per thousand board feet of 4/4 hard maple as of July 1967, were $270 for the FAS grade, $250 for Selects, $185 for No. 1 Common, and $85 for No. 2 Common. It was assumed that drying and handling costs per

thousand board feet for FAS would be $50, that for Selects $55, that for No. 1 Common $60, and $65 for No. 2 Common. This would amount to $320, $305, $245, and $150 for the four grades, respectively. These assumed costs will vary with individual plants, and they do not include cut-up, overhead, or other miscellaneous costs.

On that assumed basis, however, the FAS would cost $0.418 per board foot $\left(\frac{\$320 \text{ total cost per MBF}}{766 \text{ total feet per MBF}} = \$0.418\right)$, Selects $0.419, No. 1 Common $0.349, and No. 2 Common $0.247.

Knowing the surface area and cost per surface foot, it is a simple matter to obtain the cost per panel for each grade. The 12.5 square feet of the 60- by 30-inch panel multiplied by cost per board foot ($0,418), gives a cost of $5.22 for the FAS grade of lumber. The cost per piece of the other sizes for the different grades is shown in table 2. Generally, however, the cost per board foot should be higher than the average for the longer lengths.

It is readily seen, by comparing the three longest panels, that the lowest cost is obtained from the No. 1 Common grade. Still lower costs may be obtainable if the No. 2 Common grade is used for lengths 28 inches and less, providing the order calls for a greater number of these smaller sizes than would be obtained from the No. 1 Common grade.

The amount of lumber for an order may be determined by dividing the pieces of the largest size obtainable per thousand board feet into the number of pieces needed for the order. Here it is necessary to consider that more pieces of the smaller sizes may be called for than were obtainable from the remaining material. This additional lumber may be obtained from the same or a lower grade. The amount would be determined by finding the yield from the charts, calculating the number per thousand board feet, and dividing this into the number of pieces still required to fill the order.

SUMMARY

The nomograms for each of the FAS, Selects, No. 1 Common, and No. 2 Common grades give a simple but accurate method for determining yields of clear-one face random-width cuttings from 4/4 hard maple lumber. Yields can be determined for any number and any combination of lengths and panel widths. Comparisons can then be made for yields between grades so that the most economical grade or mixture of grades can be used. With the use of these charts and a little figuring, a plant cutting only 10,000 board feet per 8-hour shift may save several hundred dollars a day in material costs. An example is given for such comparison.

This is the first of two reports on yields from 4/4 hard maple lumber. The second report will present charts for yield determination of specific widths of dimension from 1-1/2 to 6 inches wide. In addition, studies are under way to determine whether the charts apply to other hardwood species graded by the Standard rules.

☆ U.S. GOVERNMENT PRINTING OFFICE 1975-650-257/56

Table 2.--Example of yields and costs for four sizes of clear-one face panels and one length of 1-1/2-inch-wide cuttings from four grades of 4/4 hard maple lumber[2]

Panel or piece size			FAS			Selects			No. 1 Common			No. 2 Common		
Length	Width	Surface area	Yield	Pieces per 1,000 board feet	Cost per piece	Yield	Pieces per 1,000 board feet	Cost per piece	Yield	Pieces per 1,000 board feet	Cost per piece	Yield	Pieces per 1,000 board feet	Cost per piece
In.	In.	Sq. ft.	Pct.		Dol.	Pct.		Dol.	Pct.		Dol.	Pct.		Dol.
60	30	12.500	53.2	42.6	5.22	47.0	37.6	5.24	33.9	27.1	4.36	--	--	--
44	27-1/2	8.403	10.5	12.5	3.51	11.1	13.2	3.52	16.5	19.6	2.93	--	--	--
28	17	3.306	8.6	26.0	1.38	8.8	26.6	1.39	10.8	32.7	1.15	41.9	126.7	.82
15	12	1.250	3.6	28.8	.52	4.9	39.2	.52	7.8	62.4	.44	15.7	125.6	.31
12	1-1/2	.125	0.7	56.0	.05	1.0	80.0	.05	1.2	96.0	.04	3.2	256.0	.03
Total yield			76.6			72.8			70.2			60.8		
Cost per board foot					$0.418			$0.419			$0.349			$0.247

[1] Based on lumber costs of $320 per MBF for FAS, $305 for Selects, $245 for No. 1 Common, and $150 for No. 2 Common.

[2] The top horizontal line of values deals with primary cuttings and succeeding ones with secondary cuttings. For No. 2 Common the 28-inch line is primary.