

COMPARISON OF REDWOOD AND FLAT-GRAINED YELLOW-POPLAR

FOR CORES IN FURNITURE PANELS

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COMPARISON OF REDWOOD AND FLAT-GRAINED YELLOW-POPLAR

FOR CORES IN FURNITURE PANELS¹

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Summary

Vertical-grained redwood compares favorably with flat-grained yellow-poplar as core material for high-quality furniture panels. Under the conditions tested, panels with vertical-grained redwood cores remained flatter and developed fewer and smaller face ridges and grooves with changes in moisture content, than panels with flat-grained redwood or yellow-poplar cores. Although panels with flat-grained yellow-poplar cores generally cupped more than panels with flat-grained redwood cores, the development of ridges and grooves was less for the yellow-poplar cores. Core strips as wide as 10 inches, and including bands of sapwood, had no detrimental effects where vertical-grained redwood was used. Flat-grained redwood core strips containing sapwood developed more and larger face grooves and ridges than panels with any of the other types of cores.

Experimental Work

The work here reported was done to compare redwood with yellow-poplar as core material for high-quality, five-ply furniture panels, and to compare redwood cores of various kinds with respect to flat and vertical grain, all heartwood, mixed heartwood and sapwood, and core width ranging from 2 to 10 inches. A secondary purpose was to compare hot-pressed and cold-pressed panels made with redwood cores.

¹The work here reported was done in cooperation with the Pacific Lumber Company.

²Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

Material

The experimental material³ consisted of 19 groups of four panels each, and four groups of two cores each. Table 1 gives a description of the group of panels, the gluing method, and the type of exposure.

Procedure

The panels were constructed of core strips $3/4$ inch thick, conditioned to a moisture content of approximately 7 percent, and $1/20$ -inch yellow-poplar cross bands and $1/28$ -inch birch face veneers conditioned to a moisture content of 4 percent. The cores were reconditioned to a moisture content of 7 percent, after being edge glued but before being dressed. After the cross bands and face veneers were glued on, the panels were reconditioned to 7 percent moisture content.

The edges of each panel were marked north, east, south, and west. The north and south marks were on the sides of the core strips and the east and west marks on the ends. When measurements or observations were made, the panels were placed in the normal position, or the north at the top and the west at the left. When in this position the upper face was called the "top" and the lower the "bottom." Points for the measurement of width, length, and cup were marked on all four edges, at the midpoints. The thickness at the northwest and southeast corners was measured at points about 4 inches in from both edges, by means of a jig.

After weighing and measuring for width, length, and thickness, as well as for cup in width and length, and for twist, they were shipped to a furniture factory for sanding, staining or bleaching, and finishing. The panels were returned to the Laboratory, weighed and measured, and placed in a conditioning chamber whose temperature and relative humidity were adjusted to obtain a wood moisture content of 6 percent. After attaining this moisture content, the panels were weighed and measured and placed in a room with controlled humidity until their moisture content was about 10 percent. After being weighed and measured at this moisture content, the panels were again brought to 6 percent.

The panels were placed on edge within a rack in the conditioning chambers, so that they were free to swell or shrink, and warp.

³For a detailed description of the lumber and veneer, and methods of conditioning, gluing, and fabricating the panels, refer to "Progress Report, Comparison of Redwood and Flat-grained Yellow-poplar Core Materials for Furniture Panels" by Edward C. Peck, Technologist, and M. L. Selbo, Chemical Engineer, July 11, 1949.

At 10 percent and at the final 6 percent equilibrium moisture content, the top face of each panel was viewed for surface irregularities by directing a beam of light along the panel at a small angle with the face. A white background was used to make the depressions and ridges more easily observed. The faces of 12 selected panels were photographed at both 10 and 6 percent moisture content, against a reflective background containing diagonal lines (Appendix).

Results of Tests

The results of the experiments are presented in tables 2 to 7 inclusive. No results are presented for panel groups Nos. 10A2, 6B, 7B, 8B, and 10B, which were exposed within the building, because the exposure of these panels and the four pairs of redwood cores is not yet completed. The data for group No. 15 are not included in the tables because the cores of the panels in this group were similar to those of group No. 10, except that they were thinner and every other core strip was end jointed with an Onsrud-type joint.

Swelling

Table 2 gives the amount of swelling, over a width of approximately 28-1/2 inches, with a change in moisture content from 6 to 10 percent. The panels with yellow-poplar cores swelled most, followed generally by those with flat-grained redwood cores. The panels with vertical-grained redwood cores swelled the least. The swelling of the cores and faces was restrained by the cross bands. On the basis of the mean shrinkage or swelling values for yellow-poplar in the tangential direction, and redwood in both the tangential and radial directions, the panels with yellow-poplar cores swelled 30 percent of the unrestrained swelling, those with vertical-grained redwood cores 47 percent, and those with flat-grained redwood cores 32 percent. All of these values are subject to correction, because the grain direction in the core strips was not truly tangential or radial. Assuming similar construction, the panels that swell most in width have the greatest potential for cupping in width. As may be seen from table 2, the swelling in width was often twice as great for the yellow-poplar as for the redwood.

The swelling in length, with a change from 6 to 10 percent in moisture content, was considerably less than the swelling in width, amounting to 0.021 inch in the panels with yellow-poplar cores and 0.017 inch in those with redwood cores. The swelling in length is the result of the lateral swelling of the yellow-poplar cross bands and the longitudinal swelling of the core and face veneers.

Cupping in Width

All values for cupping in width are given in table 3. The values are averages for the four panels in each of the groups. In addition the groups are given numbers indicating rank, which is inversely related to the magnitude of the cup values. The groups are arranged in the table in accordance with the numbers denoting total rank. Group No. 13, which heads the table, possesses the lowest number for total rank. The data in the table were based on cup measurements made after the panels were assembled and conditioned to a moisture content of 7 percent, and after having been finished and brought to moisture content values of 6, 10, and again 6 percent.

The cupping at 7 percent moisture content cannot be accounted for by the shrinking or swelling of the cores, because the core strips were conditioned to a moisture content of 7 percent before they were edge glued, and the glued-up cores were reconditioned to 7 percent moisture content before the cross bands and face veneers were glued to them. The cupping may have been caused by inaccurate machining of the edges of the core strips. If the edges were not truly perpendicular to the dressed face of the core strip, the effect would be cumulative across the width of the core, because both edges were jointed with the dressed face held against the vertical guide and the core strips were assembled with the dressed face downward in gluing up the core. Although the core strips were clamped in the flat position at the time of assembly and gluing, it is conceivable that the inaccurately machined edges would cause the core to cup when the clamps were loosened.

If the initial cupping was caused by inaccurately machined edges, the cores with the greatest number of joints, or with the narrower core strips, should have the greatest amount of cup. The data for the panels with redwood cores show that the wider the core strip, the less the initial cup.

The panels with 4-inch yellow-poplar cores, however, cupped more than two of the groups of panels with 2-inch redwood cores. The operation of gluing on the cross bands and face veneers may affect the amount of initial cup. The eight cores of the "B" groups, where no cross bands or face veneers were glued on, had an average initial cup in width of 0.051 inch, which is larger than the cup value for any group of panels. The application of pressure during gluing of the cross bands and face veneers may have had a tendency to flatten out the cores.

When the panels reached a moisture content of 6 percent, there was a general increase in the amount of cup. This increase was caused by the shrinkage of the core strips or the face veneers, combined with grain characteristics either in the core or in the cross bands that

would cause cupping. The effect of the face veneers can probably be discounted because they were carefully selected for straightness of grain, and generally have but slight effect on cupping of five-ply, lumber-core panels. The increase in the amount of cup was greater in the panels with flat-grained redwood cores than in those with vertical-grained redwood cores. There was a large increase in the amount of cupping in the panels with 4-inch yellow-poplar core strips, but a slight decrease in those with 2-inch yellow-poplar cores. The ranking of the groups is similar to that at a moisture content of 7 percent.

There was a general decrease in the amount of cup when the panels reached a moisture content of 10 percent. In three groups, however, the amount of cup increased. The decrease in cup was greater in these groups of panels which possessed large amounts of cup when at a moisture content of 6 percent. There are some changes in the ranking of the groups at this moisture content condition, although the position of the groups at the top is not changed materially.

When the panels were dried from 10 to 6 percent moisture content, the amount of cup increased, in general, until the cup values were approximately equal to those at the first 6 percent moisture-content condition. Group No. 5 was the only group that did not respond in this fashion.

The last column of table 3 giving the sums of the ranking numbers for the four conditions at which the amount of cup in width was measured, shows the arrangement of the groups according to amount of cup.

The cupping data can be analyzed in various ways. The ranking in table 3 penalizes those groups of panels which had relatively large amounts of cup at the start. If the initial amount of cup is eliminated from consideration in the ranking, and only the difference between the initial cup and that at 6 percent moisture content (final) and the difference between the initial cup and that at 10 percent moisture content are used, the ranking of the groups of panels is according to the following tabulation:

<u>Group No.</u>	<u>Type of core</u>	<u>Total rank</u>
11	8VH, R.	5
12	8VH&S, R.	5
10	6VH, R.	5
13	10VH, R.	9
1	2VH, R.	11
3	2FH&S, Y.P.	11
4	2FH&S, R.	12
6	4VH&S, R.	14
2	2FH, R.	16
5	4VH, R.	16

<u>Group No.</u>	<u>Type of core</u>	<u>Total rank</u>
7	4FH, R.	16
14	RVH, R.	17
8	4FH&S, R.	19
9	4FH&S, Y.P.	23

When the amount of cup at 10 percent moisture content and that at the final 6 percent condition are subtracted from the initial amount of cup, the panels with wide vertical-grained redwood cores stand at the head of the list. The position of group No. 10, 6-inch vertical-grained redwood, is improved over that in table 3.

The data for cupping are of value in comparing the panels with the different types of cores, and are a measure of their ability to remain flat under changes in moisture content. In general, those panels with cores of vertical-grained redwood cupped the least. The cupping of the panels with flat-grained redwood cores was approximately equal to that of panels with flat-grained yellow-poplar cores, if allowance is made for the greater initial cup in the panels with the yellow-poplar cores. The inclusion of sapwood in flat-grained redwood core strips increased the amount of cupping somewhat, but with vertical-grained redwood, sapwood appeared to have no appreciable effect. Although the panels with 2-inch flat-grained heartwood and sapwood yellow-poplar cores cupped only moderately, panels with similar core strips 4 inches in width cupped appreciably more than the other panels.

Although the amount of cupping is of value for the purpose of comparison, it probably is of no great importance from a commercial standpoint. The greatest amount of cup measured in any individual panel was 0.2 inch. This was the distance from a straightedge placed on the edges, to the point of greatest concavity, over a distance of about 28-1/2 inches. As a consequence, all of the types of cores used probably would be satisfactory for use in furniture panels, insofar as cupping is concerned. To accomplish comparable results in commercial operations, equal care in conditioning the core stock and the glued-up cores would be required.

Cupping in Length

Values for cupping in the length of the panels are given in table 4. As in table 3 the groups are placed in the order of the magnitude of their total rank numbers. All values for cup in length are relatively low, and there are no large actual differences among the various groups. As a consequence, a detailed analysis of these values appears to be unnecessary. Cupping in the lengthwise direction is affected more by the presence of irregular grain and bands of abnormal wood than by the type of core strips.

The groups in table 4 are arranged in an order that bears a resemblance to that in table 3. Groups Nos. 13, 11, and 12 head the list, while groups Nos. 3 and 9 are near the foot. In general, the panels with wide vertical-grained redwood cores cupped least in length.

Cupping in Width and Length

Table 5 gives a summary of the cupping data, in that it gives the rank of the different groups of panels on the basis of cup in both width and length. An analysis of the data in this table does not change the conclusions already reached regarding cupping.

Surface Quality

The presence or absence of surface irregularities in the form of ridges and grooves is an important factor in determining the quality of furniture panels. This is particularly true with reference to large panels with a high-gloss finish placed in a horizontal position such as tops of tables or other articles. When viewed in reflected light against a background, ridges and grooves are highly conspicuous and their presence is cause for rejection in high-quality furniture. Ruling out sunken glue joints, caused by dressing the core before eliminating the moisture added during edge gluing, the ridges and grooves are generally caused by differences in shrinking or swelling among different parts of the core. This may be brought about by differences in grain direction among the various core strips, areas of distorted grain, the presence of knots, strips of wood with abnormal or subnormal shrinkage or swelling characteristics, differences in shrinking or swelling characteristics between adjacent core strips, the position of the annual rings of adjacent strips with reference to the glue line, and differences in the moisture content of the various core strips at the time the cores are dressed. Proper conditioning of the glued-up cores before final machining will eliminate differences in moisture content at the time of dressing. All of the other factors are inherent to the core material, although some, such as knots and badly distorted grain, can be eliminated or minimized by proper trimming of the stock.

Because of the various things that can cause surface ridges and grooves, and because many of them were represented in the cores of the experimental panels, it was expected that the surfaces of the panels would develop irregularities when they underwent changes in moisture content.

When the panels reached a moisture content of 10 percent, and again when they reached the final condition of 6 percent, the surfaces were viewed in reflected light against a white background. At a moisture

content of 10 percent the major grooves and ridges were counted and located while the moderate to slight were noted and recorded. On the basis of the number and severity of the grooves and ridges, each panel was given a rating of "E," excellent, "G," good, "F," fair, and "P," poor, with the addition of pluses and minuses. When viewed at a moisture content of 6 percent the panels were given a direct rating based on the opinion of two observers. These ratings are given in table 6. In addition to the ratings, the groups of panels are given a ranking number.

The panels having cores of wide, vertical-grained, all-heart redwood have an average quality rating of good or better. The group with cores of 4-inch vertical-grained heartwood and sapwood redwood also has an average quality rating of better than good. The groups with the poorest average quality ratings have flat-grained redwood heartwood and sapwood cores. The panels with narrow core strips or more glue lines, have generally lower average quality ratings than those with wider core strips. The panels with yellow-poplar cores are poorer than those having wide vertical-grained redwood cores, but better than those with flat-grained redwood cores.

The ridges or grooves appeared most pronounced at the joints between the core strips. It is at these joints that the differences due to different shrinkage or swelling characteristics of adjacent strips are manifest, and also ridges or grooves caused by shrinking or swelling in combination with the angles of the annual rings to the glue line. This latter condition is more prevalent with flat-grained core strips than it is with vertical-grained core strips. In cores where the annual rings in adjacent strips formed a V at the joint, a ridge usually developed at the bottom of the V when the moisture content increased and a depression when the moisture content decreased. In vertical-grain stock if the strips are truly vertical-grained, the angle of the rings to the glue line is zero. In commercially designated vertical grain, however, there are parts of the strips where the annual rings make an angle of 45° or less with the faces. Figure 1 illustrates the condition for both flat-sawn and vertical-grained strips, where the annual rings are so placed, with reference to the glue line, that swelling or shrinking causes grooves or depressions that show on the faces of the panels. Where the annual rings form a peak, a ridge develops during swelling, accompanied by a groove on the opposite face of the panel. During shrinking the positions of the grooves and ridges are interchanged.

The manner of viewing the panels made it possible to detect numerous slight ridges and grooves that would ordinarily remain unnoticed. Irregularities were magnified, and extremely slight ones could be detected by moving the eye up and down so that the image of the background was caused to move back and forth across the polished face of the panel. Because of this, there is a question as to whether or not

the panels that were given an average quality rating of poor would not be suitable for commercial use. Photographs of selected panels, taken with reflected light against a lined background, are included in the appendix.

The panels of group No. 15, whose cores were similar to those of group No. 10 but were about 1/16 inch thinner and contained Onsrud end joints, were a trifle inferior to those of group No. 10 in surface quality. Although the position of some of the end joints could be detected on the faces by viewing in reflected light, the manifestations were not conspicuous. The indications are that this type of joint can be used in cores for high-quality furniture panels if moisture content is adequately controlled.

Cold-glued vs. Hot-glued

The cross bands and face veneers of three groups of panels, 5A, 7A, and 10A₁, were glued with a cold-setting glue. In all other respects these panels were similar to groups 5, 7, and 10. The comparative data for swelling and cupping in width and for the quality of the face are given in table 7.

The panels in which a cold-setting glue was used were flatter than the others in the initial stage. At moisture content values of 6 and 10 percent, the amount of cupping was similar for both types of panels. The hot-glued panels had higher quality ratings, based on face ridges and grooves, than the cold-glued panels, although the differences were not great.

Miscellany

Other data, such as shrinking and swelling in length and thickness, and amount of twist, were collected but were not used in the comparison of the groups of panels with the various types of cores. These data, together with all the other data, are given in the Appendix.

Appendix

The data for each individual panel at the initial condition of about 7 percent moisture content before sanding and finishing, and at about 6 percent, 10 percent, and after returning to about 6 percent, are given in tables 8 to 11, inclusive.

Figures 2 to 14 show photographs of the top faces of selected panels at moisture-content values of about 6 and 10 percent. The irregularities in the reflected lines indicate ridges and grooves, ridges to the left and grooves to the right.

Table 1.--Type of construction, method of gluing cross bands and faces, and type of exposure of lumber-core panels

Group No.	Core data				Gluing method	Type of exposure
	Species	Type of	Width of	Type of		
		grain	core	wood		
		:	strip	:		
			Inches			
1	Redwood	V ¹	2	H ²	Hot press	Cont. ³
2	do.	F	2	H	do.	do.
3	Yellow-poplar	F	2	H&S	do.	do.
4	Redwood	F	2	H&S	do.	do.
5	do.	V	4	H	do.	do.
6	do.	V	4	H&S	do.	do.
7	do.	F	4	H	do.	do.
8	do.	F	4	H&S	do.	do.
9	Yellow-poplar	F	4	H&S	do.	do.
10	Redwood	V	6	H	do.	do.
11	do.	V	8	H	do.	do.
12	do.	V	8	H&S	do.	do.
13	do.	V	10	H	do.	do.
14	do.	V	2-10	H	do.	do.
			random			
⁴ 15	do.	V	6	H	do.	do.
5A	do.	V	4	H	Cold press	do.
7A	do.	F	4	H	do.	do.
10A ₁	do.	V	6	H	do.	do.
10A ₂	do.	V	6	H	do.	Building ²
6B	Redwood	V	4	H&S	(5)	do.
7B	do.	F	4	H	(5)	do.
8B	do.	F	4	H&S	(5)	do.
10B	do.	V	6	H	(5)	do.

¹"V" vertical, "F" flat.

²"H" all heartwood, "H&S" containing some sapwood.

³"Cont." exposed to controlled moisture content cycles; "Building" exposed to conditions within the laboratory, room conditions.

⁴Every other core strip end-jointed with Onsrud type of joint.

⁵Coresh only, no cross bands or face veneers.

Table 2.--Swelling in width of furniture panels with redwood and yellow-poplar cores, in changing from 6 to 10 percent moisture content

Group No.	Type of core ¹	Swelling in width
		<u>Inch</u>
9	: 4FH&S, Yellow-poplar	: ² 0.100
3	: 2FH&S, Yellow-poplar	: .071
2	: 2FH, Redwood	: .059
12	: 8VH&S, Redwood	: .056
7	: 4FH, Redwood	: .055
4	: 2FH&S, Redwood	: .052
11	: 8VH, Redwood	: .051
8	: 4FH&S, Redwood	: .049
13	: 10VH, Redwood	: .047
14	: RVH, Redwood	: .047
5	: 4VH, Redwood	: .045
1	: 2VH, Redwood	: .044
10	: 6VH, Redwood	: .042
6	: 4VH&S, Redwood	: .037

¹Descriptive symbols: F, flat grain; V, vertical grain; H, heartwood; S, sapwood.

²Average for the four panels of each group.

Table 3.--Cupping in width of furniture panels with
redwood and yellow-poplar cores

Group: No.	Type of core ¹	Moisture content phase								:Total :rank
		:7 percent ² :		6 percent :		:10 percent :		6 percent :		
		: Cup :	:Rank:	: Cup :	:Rank:	: Cup :	:Rank:	: Cup :	:Rank:	
		: : In. :	:	: : In. :	:	: : In. :	:	: : In. :	:	
13	: 10VH, Redwood	:0.009 :	1 :	:0.013 :	1 :	:0.016 :	2 :	:0.013 :	1 :	5
11	: 8VH, Redwood	: .015 :	2 :	:.020 :	2 :	:.013 :	1 :	:.018 :	2 :	7
12	: 8VH&S, Redwood	: .020 :	5 :	:.025 :	3 :	:.020 :	3 :	:.025 :	3 :	14
2	: 2FH, Redwood	: .019 :	4 :	:.029 :	4 :	:.029 :	6 :	:.031 :	4 :	18
1	: 2VH, Redwood	: .027 :	6 :	:.037 :	7 :	:.022 :	4 :	:.036 :	6 :	19
5	: 4VH, Redwood	: .020 :	5 :	:.020 :	2 :	:.031 :	8 :	:.031 :	4 :	19
6	: 4VH&S, Redwood	: .020 :	5 :	:.035 :	6 :	:.016 :	2 :	:.036 :	6 :	19
8	: 4FH&S, Redwood	: .017 :	3 :	:.029 :	4 :	:.036 :	9 :	:.031 :	4 :	20
14	: RVH, Redwood	: .017 :	3 :	:.037 :	7 :	:.024 :	4 :	:.039 :	7 :	21
10	: 6VH, Redwood	: .031 :	7 :	:.034 :	5 :	:.030 :	7 :	:.035 :	5 :	24
3	: 2FH&S, Yellow-poplar	.046 :	9 :	:.043 :	8 :	:.027 :	5 :	:.045 :	8 :	30
7	: 4FH, Redwood	: .038 :	8 :	:.050 :	9 :	:.027 :	5 :	:.049 :	9 :	31
9	: 4FH&S, Yellow-poplar	.048 :	11 :	:.079 :	11 :	:.024 :	4 :	:.081 :	11 :	37
4	: 2FH&S, Redwood	: .047 :	10 :	:.053 :	10 :	:.038 :	10 :	:.055 :	10 :	40

¹Descriptive symbols: F, flat grain; V, vertical grain; H, heartwood; S, sapwood.

²Initial condition, before applying finish.

Table 4.--Cupping in length of furniture panels with redwood and yellow-poplar cores

Group No.	Type of core ¹	Moisture content phase								:Total :rank
		:7 percent ²		:6 percent		:10 percent		:6 percent		
		:Cup	:Rank:	:Cup	:Rank:	:Cup	:Rank:	:Cup	:Rank:	
		: <u>In.</u>	:	: <u>In.</u>	:	: <u>In.</u>	:	: <u>In.</u>	:	
11	:8VH,Redwood	:0.007	:3	:0.008	:2	:0.005	:1	:0.004	:2	:8
13	:10VH,Redwood	:.010	:5	:.006	:1	:.010	:3	:.003	:1	:10
12	:8VH&S,Redwood	:.006	:2	:.011	:4	:.008	:2	:.006	:4	:12
14	:RVH,Redwood	:.003	:1	:.012	:5	:.013	:6	:.008	:6	:18
1	:2VH,Redwood	:.011	:6	:.010	:3	:.010	:3	:.008	:6	:18
7	:4FH,Redwood	:.014	:8	:.011	:4	:.011	:4	:.005	:3	:19
8	:4FH&S,Redwood	:.008	:4	:.012	:5	:.014	:7	:.007	:5	:21
10	:6VH,Redwood	:.014	:8	:.014	:6	:.012	:5	:.009	:7	:26
4	:2FH&S,Redwood	:.017	:11	:.010	:3	:.014	:7	:.008	:6	:27
6	:4VH&S,Redwood	:.011	:6	:.016	:8	:.011	:4	:.013	:9	:27
2	:2FH,Redwood	:.011	:6	:.016	:8	:.013	:6	:.014	:10	:30
9	:4FH&S,Yellow-poplar:	:.013	:7	:.016	:8	:.016	:9	:.010	:8	:32
3	:2FH&S,Yellow-poplar:	:.015	:9	:.015	:7	:.015	:8	:.013	:9	:33
5	:4VH,Redwood	:.016	:10	:.017	:9	:.014	:7	:.015	:11	:37

¹Descriptive symbols: F, flat grain; V, vertical grain; H, heartwood; S, sapwood.

²Initial condition, before applying finish.

Table 5.--Summary of ranking of groups of panels
on the basis of cupping in width and
in length. Taken from tables 3 and 4

Group No..	Type of core ¹	Rank ²
11	:8VH,Redwood	15
13	:10VH,Redwood	15
12	:8VH&S,Redwood	26
1	:2VH,Redwood	37
14	:RVH,Redwood	39
8	:4FH&S,Redwood	41
6	:4VH&S,Redwood	46
2	:2FH,Redwood	48
7	:6VH,Redwood	50
10	:4FH,Redwood	50
5	:4VH,Redwood	56
3	:2FH&S, Yellow-poplar	63
4	:2FH&S,Redwood	67
9	:4FH&S, Yellow-poplar	69

¹Descriptive symbols: F, flat grain; V, vertical grain; H, heartwood; S, sapwood.

²Sum of rank numbers in tables 3 and 4.

Table 6.--Surface quality of furniture panels with redwood and yellow-poplar cores, at moisture-content conditions of 10 and 6 percent

Group: No. :	Type of core ¹	Quality rating	Rank
:	:	10 : 6 : Average:	:
:	:	percent:percent:	:
-----	-----	-----	-----
13	:10VH,Redwood	: E- : G+ : G+ :	1
11	:8VH,Redwood	: G+ : G+ : G+ :	2
6	:4VH&S,Redwood	: G+ : G : G+ :	3
14	:RVH,Redwood	: E- : F+ : G :	4
5	:4VH,Redwood	: G+ : F+ : G :	5
10	:6VH,Redwood	: F+ : G+ : G :	5
3	:2FH&S,Yellow-poplar	: F+ : G : G- :	6
12	:8VH&S,Redwood	: G : F+ : G- :	6
9	:4FH&S,Yellow-poplar	: G : F : F+ :	7
7	:4FH,Redwood	: F+ : F+ : F+ :	8
1	:2VH,Redwood	: F+ : F : F :	9
2	:2FH,Redwood	: F+ : F : F :	9
8	:4FH&S,Redwood	: F- : F : F- :	10
4	:2FH&S,Redwood	: P+ : F- : P+ :	11

¹Descriptive symbols: F, flat grain; V, vertical grain; H, heartwood; S, sapwood.

Table 7.--Comparison of swelling, cupping in width, and quality of face, of furniture panels with similar redwood cores, one-half of which were cross-banded and veneered with a hot-setting glue and the other half by a cold-setting glue

Group No.	Type of core ¹	Swelling at 10 percent moisture content	Cupping in width				Quality of face
			Initial	10 percent	6 percent		
		In.	In.	In.	In.		
25	4VH	0.045	0.020	0.031	0.031		G
35A	do.....	.046	.013	.038	.027		F+
7	4FH	.055	.038	.027	.049		F+
7A	do.....	.048	.012	.043	.012		F
10	6VH	.042	.038	.030	.035		G
10A	do.....	.040	.009	.028	.043		F+

¹Descriptive symbols: F, flat grain; V, vertical grain; H, heartwood.

²Hot-setting glue.

³Cold-setting glue.

Table 8.--Weight, dimensions, cup, and twist of panels with redwood and with yellow-poplar cores at a moisture content of about 7 percent (initial)

Panel No. ¹	Weight	Width	Length	Thickness		Cup		Twist
				"c" ²	"d" ²	Width ⁴	Length ⁴	
	Grams	Inches	Inches	Inch	Inch	Inch	Inch	Inch
1-1	5,562	28.523	28.527	0.912	0.908	0.002	-0.014	0.07
1-2	5,550	28.525	28.524	.906	.909	.065	.021	.00
1-3	5,472	28.524	28.528	.918	.909	.039	-.007	.02
1-4	5,468	28.529	28.528	.916	.904	.002	.002	.00
2-1	5,741	28.509	28.524	.915	.905	-.034	-.017	.00
2-2	5,433	28.522	28.522	.916	.907	-.008	-.018	.01
2-3	5,846	28.530	28.525	.908	.911	.003	.001	.00
2-4	5,589	28.526	28.519	.914	.909	-.032	-.008	.00
3-1	6,844	28.463	28.481	.913	.908	.080	.025	.00
3-2	6,885	28.457	28.468	.916	.913	.038	.020	.03
3-3	6,977	28.478	28.473	.909	.916	-.018	.000	.04
3-4	6,927	28.463	28.471	.912	.912	-.047	-.015	.00
4-1	5,456	28.510	28.522	.913	.904	.038	.013	.00
4-2	5,511	28.523	28.522	.907	.913	.008	.031	.03
4-3	5,490	28.522	28.522	.912	.901	-.115	-.019	.00
4-4	5,484	28.521	28.522	.912	.909	.026	.004	.05
5-1	5,761	28.493	28.500	.907	.908	.009	.002	.02
5-2	5,906	28.499	28.494	.911	.914	.023	-.018	.00
5-3	5,698	28.501	28.500	.910	.907	.002	-.022	.00
5-4	6,218	28.498	28.502	.911	.905	-.045	-.020	.00
6-1	5,133	28.498	28.502	.902	.914	.036	-.015	.01
6-2	5,600	28.506	28.506	.909	.909	-.014	-.015	.00
6-3	4,926	28.495	28.499	.916	.903	-.004	-.003	.00
6-4	4,912	28.501	28.498	.906	.910	.026	-.009	.00
7-1	5,960	28.525	28.524	.911	.915	.036	-.008	.01
7-2	5,570	28.528	28.525	.909	.911	.019	-.012	.00
7-3	5,298	28.523	28.522	.909	.911	.063	.017	.05
7-4	5,878	28.523	28.522	.912	.911	-.033	.018	.02
8-1	5,454	28.504	28.499	.907	.911	-.024	-.013	.00
8-2	5,697	28.495	28.502	.912	.912	.001	.003	.00
8-3	5,855	28.497	28.500	.911	.913	-.036	-.016	.00
8-4	5,109	28.493	28.500	.919	.901	.007	.000	.00

Table 8.--Weight, dimensions, cup, and twist of panels with redwood and with yellow-poplar cores at a moisture content of about 7 percent
(initial) (continued)

Panel No. ₁	Weight	Width	Length	Thickness		Cup		Twist
				"c" ₂	"d" ₂	Width ₄	Length ₄	
	Grams	Inches	Inches	Inch	Inch	Inch	Inch	Inch
9-1	6,933	28.461	28.480	0.919	0.911	-0.017	-0.017	0.03
9-2	6,695	28.461	28.470	.905	.914	-.132	-.014	.00
9-3	6,716	28.468	28.471	.913	.907	.000	.000	.05
9-4	6,530	28.477	28.474	.911	.905	-.041	.022	.03
10-1	5,747	28.530	28.527	.910	.913	-.010	-.010	.00
10-2	5,479	28.625	28.522	.918	.904	-.021	-.008	.00
10-3	5,161	28.531	28.529	.910	.908	.041	.020	.03
10-4	5,590	28.532	28.523	.913	.909	-.051	-.017	.00
11-1	6,097	28.525	28.524	.910	.915	.002	.000	.00
11-2	6,559	28.526	28.529	.914	.911	.002	.005	.00
11-3	6,144	28.527	28.527	.911	.910	.017	.000	.00
11-4	6,557	28.530	28.519	.914	.914	.039	.022	.04
12-1	5,661	28.511	28.506	.908	.914	.000	.007	.01
12-2	5,392	28.502	28.510	.911	.903	-.041	-.013	.00
12-3	5,624	28.495	28.501	.916	.908	.033	.000	.00
12-4	5,529	28.495	28.501	.908	.904	.005	.002	.00
13-1	5,368	28.523	28.529	.914	.909	.009	.014	.01
13-2	5,517	28.525	28.525	.908	.916	.014	.007	.02
13-3	5,595	28.525	28.535	.911	.914	.007	.000	.00
13-4	5,006	28.527	28.526	.905	.914	.006	-.018	.02
14-1	5,524	28.494	28.500	.913	.909	.003	-.003	.00
14-2	5,632	28.501	28.507	.909	.913	.002	.000	.00
14-3	5,376	28.497	28.501	.912	.910	-.026	-.006	.00
14-4	5,530	28.501	28.500	.911	.909	-.038	-.002	.00
15-1	5,146	28.526	28.527	.845	.845	.058	.000	.04
15-2	5,119	28.520	28.523	.849	.838	-.070	-.008	.00
15-3	5,459	28.522	28.518	.846	.846	.003	.000	.00
15-4	5,182	28.520	28.523	.851	.848	-.040	.000	.00
5A-1	5,748	28.522	28.529	.918	.919	-.044	.003	.00
5A-2	5,547	28.519	28.529	.920	.920	.000	.007	.00
5A-3	5,707	28.523	28.528	.918	.916	.003	.012	.00
5A-4	5,078	28.522	28.526	.916	.919	.006	.005	.00

Table 8.--Weight, dimensions, cup, and twist of panels with redwood and with yellow-poplar cores at a moisture content of about 7 percent
(initial) (continued)

Panel No. ¹	Weight	Width	Length	Thickness		Cup		Twist
				"c" ²	"d" ³	Width ⁴	Length ⁴	
	<u>Grams</u>	<u>Inches</u>	<u>Inches</u>	<u>Inch</u>	<u>Inch</u>	<u>Inch</u>	<u>Inch</u>	<u>Inch</u>
7A-1	6,026	28.517	28.521	0.920	0.914	0.011	-0.025	0.03
7A-2	5,551	28.524	28.521	.918	.919	.010	.003	.00
7A-3	6,524	28.519	28.524	.921	.922	.004	.012	.03
7A-4	5,946	28.517	28.523	.919	.920	.024	.004	.03
10A ₁ -1	5,985	28.513	28.526	.921	.919	-.033	.000	.10
10A ₁ -2	5,591	28.506	28.528	.917	.920	.000	.006	.00
10A ₁ -3	5,812	28.517	28.526	.918	.917	.000	.004	.03
10A ₁ -4	5,863	28.513	28.523	.924	.922	.004	.009	.05

¹For group descriptions refer to table 1 in main body of report.

²Measured near northwest corner.

³Measured near southeast corner.

⁴Positive values measured in "top" face, negative values measured on "bottom" face.

Table 9.--Weight, dimensions, cup, and twist of panels with redwood and with yellow-poplar cores, at a moisture content of 6 percent

Panel No. <u>1</u>	Weight	Width	Length	Thickness		Cup		Twist
				"c" <u>2</u>	"d" <u>2</u>	Width <u>4</u>	Length <u>4</u>	
	<u>Grams</u>	<u>Inches</u>	<u>Inches</u>	<u>Inch</u>	<u>Inch</u>	<u>Inch</u>	<u>Inch</u>	<u>Inch</u>
1-1	5,562	28.506	28.517	0.908	0.904	0.013	-0.010	0.06
1-2	5,551	28.507	28.516	.903	.904	.072	.018	.00
1-3	5,486	28.505	28.518	.915	.904	.049	.000	.00
1-4	5,475	28.504	28.513	.911	.900	-.015	-.010	.02
2-1	5,752	28.495	28.510	.907	.901	-.049	-.025	.00
2-2	5,446	28.497	28.507	.913	.903	-.018	-.024	.02
2-3	5,858	28.511	28.516	.905	.908	-.023	-.008	.00
2-4	5,604	28.505	28.513	.912	.908	-.025	-.008	.00
3-1	6,814	28.448	28.469	.908	.906	.064	.019	.00
3-2	6,884	28.442	28.451	.914	.912	.034	.022	.02
3-3	6,973	28.462	28.469	.907	.913	-.024	-.005	.23
3-4	6,930	28.436	28.464	.910	.910	-.050	-.015	.05
4-1	5,483	28.499	28.517	.912	.899	.022	.000	.04
4-2	5,510	28.505	28.505	.904	.910	.014	.017	.06
4-3	5,507	28.500	28.512	.908	.899	-.149	-.017	.03
4-4	5,485	28.499	28.510	.905	.902	.025	-.006	.11
5-1	5,789	28.477	28.488	.907	.908	-.010	-.008	.03
5-2	5,932	28.478	28.488	.909	.915	.024	-.025	.02
5-3	5,723	28.478	28.488	.910	.906	-.012	.000	.03
5-4	6,237	28.475	28.486	.910	.903	-.034	-.036	.02
6-1	5,155	28.470	28.483	.902	.912	.044	-.035	.02
6-2	5,618	28.481	28.492	.914	.907	-.019	-.027	.02
6-3	4,950	28.470	28.480	.915	.901	-.052	.000	.02
6-4	4,938	28.478	28.479	.905	.908	.023	.000	.02
7-1	6,009	28.505	28.514	.909	.914	.061	-.010	.02
7-2	5,594	28.510	28.517	.907	.907	.033	-.013	.00
7-3	5,313	28.495	28.511	.907	.904	.070	.016	.08
7-4	5,883	28.507	28.516	.911	.908	-.034	.005	.02
8-1	5,474	28.476	28.485	.907	.909	-.060	-.015	.04
8-2	5,707	28.470	28.490	.913	.908	.006	-.018	.00
8-3	5,880	28.473	28.489	.911	.912	-.034	-.004	.00
8-4	5,147	28.474	28.479	.919	.900	.017	-.009	.00

Table 9.--Weight, dimensions, cup, and twist of panels with redwood and with yellow-poplar cores, at a moisture content of 6 percent
(continued)

Panel No. ¹	Weight	Width	Length	Thickness		Cup		Twist
				"c" ²	"d" ²	Width ⁴	Length ⁴	
	Grams	Inches	Inches	Inch	Inch	Inch	Inch	Inch
9-1	6,971	28.439	28.473	0.918	0.911	-0.017	-0.022	0.03
9-2	6,694	28.431	28.465	.901	.914	-.200	-.013	.02
9-3	6,694	28.439	28.464	.909	.904	.013	-.011	.02
9-4	6,525	28.444	28.470	.911	.902	-.084	.018	.01
10-1	5,755	28.518	28.521	.907	.908	-.007	-.005	.01
10-2	5,483	28.513	28.514	.911	.901	-.019	-.011	.00
10-3	5,163	28.505	28.517	.904	.903	.034	.022	.00
10-4	5,595	28.513	28.512	.904	.902	-.077	-.019	.00
11-1	6,082	28.504	28.516	.904	.907	.011	.007	.01
11-2	6,566	28.494	28.515	.912	.907	.000	.004	.02
11-3	6,152	28.503	28.510	.911	.908	.020	-.003	.01
11-4	6,554	28.515	28.512	.910	.910	.048	.019	.05
12-1	5,691	28.494	28.498	.907	.910	.005	.003	.04
12-2	5,414	28.481	28.499	.908	.903	-.039	-.027	.00
12-3	5,653	28.477	28.490	.915	.907	.038	.004	.08
12-4	5,545	28.473	28.486	.910	.903	.016	.008	.03
13-1	5,380	28.481	28.515	.912	.903	.015	.009	.02
13-2	5,515	28.514	28.507	.902	.909	.017	.003	.02
13-3	5,604	28.497	28.521	.907	.911	.009	.000	.02
13-4	5,017	28.508	28.512	.903	.910	.012	-.013	.00
14-1	5,546	28.478	28.492	.912	.907	-.043	-.009	.00
14-2	5,650	28.486	28.493	.907	.910	.013	.022	.00
14-3	5,403	28.482	28.491	.912	.909	-.031	-.007	.03
14-4	5,562	28.484	28.490	.910	.908	-.060	-.011	.00
15-1	5,174	28.504	28.517	.843	.842	.077	-.011	.07
15-2	5,140	28.501	28.510	.845	.838	-.092	-.003	.01
15-3	5,467	28.507	28.510	.844	.843	.009	.005	.00
15-4	5,195	28.497	28.512	.849	.844	-.056	-.005	.00
5A-1	5,800	28.525	28.532	.917	.917	-.044	.000	.03
5A-2	5,581	28.521	28.530	.918	.918	-.017	.006	.02
5A-3	5,768	28.526	28.529	.919	.917	-.024	.009	.02
5A-4	5,141	28.526	28.528	.917	.919	.004	.003	.02

Table 9.--Weight, dimensions, cup, and twist of panels with redwood and with yellow-poplar cores, at a moisture content of 6 percent
(continued)

Panel No. ¹	Weight	Width	Length	Thickness		Cup		Twist
				"c" ²	"d" ²	Width ⁴	Length ⁴	
	<u>Grams</u>	<u>Inches</u>	<u>Inches</u>	<u>Inch</u>	<u>Inch</u>	<u>Inch</u>	<u>Inch</u>	<u>Inch</u>
7A-1	6,065	28.521	28.522	0.917	0.912	0.005	-0.026	0.01
7A-2	5,620	28.527	28.521	.919	.919	.004	.000	.02
7A-3	6,565	28.520	28.525	.921	.917	.000	.009	.00
7A-4	6,011	28.519	28.525	.919	.916	.026	.007	.02
10A-1	6,032	28.515	28.528	.919	.917	-.020	.000	.04
10A-2	5,644	28.509	28.528	.917	.916	-.017	.007	.02
10A-3	5,850	28.519	28.529	.916	.914	.000	.000	.05
10A-4	5,879	28.515	28.524	.920	.911	.000	.012	.03

¹For group descriptions refer to table 1 in main body of report.

²Measured near northwest corner.

³Measured near southeast corner.

⁴Positive values measured on "top" face, negative values measured on "bottom" face.

Table 10.--Weight, dimensions, cup, and twist of panels with redwood and with yellow-poplar cores, at a moisture content of about 10 percent

Panel No. ¹	Weight	Width	Length	Thickness		Cup		Twist
				"c" ²	"d" ²	Width ⁴	Length ⁴	
	<u>Grams</u>	<u>Inches</u>	<u>Inches</u>	<u>Inch</u>	<u>Inch</u>	<u>Inch</u>	<u>Inch</u>	<u>Inch</u>
1-1	5,746	28.550	28.531	0.920	0.915	-0.008	-0.014	0.06
1-2	5,727	28.549	28.530	.910	.915	.042	.011	.00
1-3	5,663	28.549	28.533	.915	.914	.006	.008	.00
1-4	5,651	28.548	28.529	.919	.912	-.022	-.008	.00
2-1	5,935	28.546	28.528	.921	.913	-.019	-.011	.00
2-2	5,629	28.549	28.524	.921	.913	-.038	-.020	.00
2-3	6,050	28.571	28.530	.916	.920	-.027	-.012	.00
2-4	5,783	28.577	28.526	.920	.920	-.030	-.007	.00
3-1	7,080	28.518	28.490	.921	.917	.052	.020	.00
3-2	7,145	28.507	28.474	.927	.924	.028	.017	.03
3-3	7,232	28.528	28.490	.921	.925	-.004	-.010	.05
3-4	7,191	28.520	28.481	.922	.921	-.023	-.012	.03
4-1	5,677	28.547	28.535	.922	.911	.023	-.005	.00
4-2	5,699	28.544	28.536	.913	.916	-.020	.025	.03
4-3	5,698	28.558	28.540	.922	.910	-.079	-.025	.02
4-4	5,674	28.560	28.526	.919	.911	.028	.000	.00
5-1	5,961	28.523	28.501	.916	.917	-.022	-.006	.00
5-2	6,113	28.530	28.507	.918	.923	-.022	-.018	.00
5-3	5,900	28.529	28.502	.918	.913	-.015	-.007	.00
5-4	6,424	28.506	28.516	.918	.914	-.063	-.024	.00
6-1	5,327	28.512	28.504	.912	.921	.009	-.021	.02
6-2	5,800	28.509	28.508	.922	.917	-.026	-.017	.00
6-3	5,115	28.505	28.499	.926	.914	-.018	.000	.00
6-4	5,102	28.520	28.495	.915	.916	.012	-.004	.01
7-1	6,190	28.561	28.524	.916	.923	.027	-.010	.00
7-2	5,764	28.559	28.526	.917	.917	.014	-.010	.00
7-3	5,484	28.558	28.528	.916	.913	.050	.017	.07
7-4	6,062	28.580	28.530	.917	.915	.016	.008	.03
8-1	5,651	28.535	28.503	.918	.916	.037	-.018	.00
8-2	5,900	28.516	28.503	.920	.918	-.028	-.016	.00
8-3	6,073	28.524	28.507	.920	.921	-.047	-.009	.00
8-4	5,314	28.515	28.505	.928	.908	-.033	-.009	.00

Table 10.--Weight, dimensions, cup, and twist of panels with redwood and with yellow-poplar cores, at a moisture content of about 10 percent (continued)

Panel No. <u>1</u>	Weight	Width	Length	Thickness		Cup		Twist
				"c" <u>2</u>	"d" <u>2</u>	Width <u>4</u>	Length <u>4</u>	
	<u>Grams</u>	<u>Inches</u>	<u>Inches</u>	<u>Inch</u>	<u>Inch</u>	<u>Inch</u>	<u>Inch</u>	<u>Inch</u>
9-1	7,225	28.515	28.494	0.931	0.923	-0.022	-0.019	0.05
9-2	6,939	28.541	28.485	.914	.922	-.044	-.018	.00
9-3	6,942	28.538	28.485	.921	.915	-.014	-.008	.00
9-4	6,772	28.559	28.490	.921	.914	.015	.019	.00
10-1	5,942	28.558	28.539	.914	.919	-.017	-.005	.00
10-2	5,659	28.550	28.530	.924	.913	-.034	-.007	.00
10-3	5,332	28.547	28.534	.915	.915	.039	.019	.00
10-4	5,772	28.561	28.532	.917	.913	-.029	-.017	.00
11-1	6,270	28.555	28.533	.913	.915	-.020	-.003	.00
11-2	6,767	28.546	28.541	.921	.918	.003	.003	.00
11-3	6,344	28.558	28.526	.919	.918	.007	.000	.00
11-4	6,759	28.560	28.531	.920	.918	.020	.013	.03
12-1	5,885	28.546	28.514	.918	.922	-.014	.000	.03
12-2	5,586	28.536	28.518	.918	.910	-.031	-.024	.00
12-3	5,830	28.528	28.503	.926	.915	.013	.000	.02
12-4	5,723	28.538	28.503	.920	.914	-.022	-.008	.00
13-1	5,553	28.534	28.530	.921	.914	.023	.015	.00
13-2	5,692	28.554	28.525	.914	.919	.013	.006	.00
13-3	5,795	28.554	28.536	.917	.920	.014	.000	.00
13-4	5,185	28.546	28.533	.912	.920	.013	.019	.00
14-1	5,724	28.532	28.509	.922	.915	-.025	-.011	.00
14-2	5,831	28.530	28.514	.911	.919	-.031	-.019	.00
14-3	5,569	28.526	28.507	.921	.916	-.018	-.011	.00
14-4	5,732	28.530	28.507	.919	.918	-.020	-.009	.00
15-1	5,341	28.560	28.534	.851	.849	.024	.008	.02
15-2	5,306	28.561	28.532	.854	.846	-.050	-.004	.00
15-3	5,640	28.547	28.529	.852	.850	-.015	.005	.00
15-4	5,357	28.542	28.531	.855	.851	-.012	-.010	.00
5A-1	5,982	28.571	28.548	.926	.927	-.038	.008	.02
5A-2	5,757	28.563	28.550	.930	.928	-.045	-.012	.00
5A-3	5,953	28.577	28.547	.926	.926	-.052	.013	.00
5A-4	5,299	28.572	28.545	.924	.928	.017	.000	.00

Table 10.--Weight, dimensions, cup, and twist of panels with redwood and with yellow-poplar cores, at a moisture content of about 10 percent (continued)

Panel No. ¹	Weight	Width	Length	Thickness		Cup		Twist
				"c" ²	"d" ³	Width ⁴	Length ⁴	
	Grams	Inches	Inches	Inch	Inch	Inch	Inch	Inch
7A-1	6,239	28.577	28.556	0.925	0.920	-0.066	-0.018	0.00
7A-2	5,783	28.580	28.547	.929	.924	.037	.004	.04
7A-3	6,754	28.558	28.551	.928	.925	-.042	.010	.00
7A-4	6,184	28.564	28.548	.927	.925	-.028	.000	.02
10A ₁ -1	6,211	28.556	28.551	.929	.924	-.033	.012	.02
10A ₁ -2	5,808	28.545	28.556	.926	.925	-.019	.012	.00
10A ₁ -3	6,017	28.561	28.550	.924	.922	-.041	.000	.00
10A ₁ -4	6,052	28.557	28.553	.928	.920	.018	.007	.01

¹For group descriptions refer to table 1 in main body of report.

²Measured near northwest corner.

³Measured near southeast corner.

⁴Positive values measured on "top" face, negative values measured on "bottom" face.

Table 11.--Weight, dimensions, cup, and twist of panels with redwood and with yellow-poplar cores at a moisture content of about 6 percent (final)

Panel No.	Weight	Width	Length	Thickness		Cup		Twist
				"c" ²	"d" ²	Width ⁴	Length ⁴	
	Grams	Inches	Inches	Inch	Inch	Inch	Inch	Inch
1-1	5,570	28.508	28.516	0.909	0.904	0.013	-0.008	0.05
1-2	5,556	28.508	28.514	.902	.903	.070	.015	.00
1-3	5,488	28.506	28.518	.916	.905	.046	.000	.00
1-4	5,478	28.505	28.511	.912	.901	-.014	-.008	.03
2-1	5,755	28.497	28.509	.909	.902	-.051	-.020	.00
2-2	5,448	28.499	28.506	.914	.903	-.017	-.021	.03
2-3	5,861	28.514	28.514	.906	.909	-.028	-.008	.00
2-4	5,610	28.507	28.511	.912	.907	-.027	-.005	.00
3-1	6,819	28.449	28.470	.908	.907	.068	.015	.00
3-2	6,884	28.442	28.450	.914	.913	.037	.018	.00
3-3	6,974	28.461	28.468	.906	.913	-.022	-.005	.28
3-4	6,929	28.435	28.462	.910	.911	-.051	-.013	.09
4-1	5,489	28.500	28.515	.912	.900	.020	.000	.02
4-2	5,516	28.503	28.505	.904	.910	.015	.014	.07
4-3	5,512	28.501	28.510	.908	.900	-.160	-.014	.08
4-4	5,493	28.503	28.510	.907	.903	.026	-.003	.00
5-1	5,794	28.475	28.488	.908	.909	.039	.005	.04
5-2	5,939	28.476	28.487	.908	.914	.028	-.020	.00
5-3	5,729	28.479	28.487	.911	.907	-.019	-.006	.00
5-4	6,243	28.475	28.485	.911	.904	-.036	-.029	.00
6-1	5,158	28.470	28.482	.905	.913	.048	-.029	.02
6-2	5,619	28.480	28.490	.915	.908	-.020	-.021	.00
6-3	4,951	28.468	28.479	.916	.903	-.050	.000	.02
6-4	4,939	28.477	28.478	.907	.909	.027	.000	.00
7-1	6,013	28.505	28.512	.911	.911	.063	-.003	.02
7-2	5,596	28.510	28.518	.909	.909	.028	-.010	.00
7-3	5,315	28.597	28.511	.909	.907	.071	.007	.00
7-4	5,891	28.508	28.514	.911	.909	-.034	.000	.04
8-1	5,478	28.476	28.484	.908	.911	-.060	-.014	.04
8-2	5,713	28.471	28.485	.914	.910	-.016	-.010	.00
8-3	5,887	28.471	28.490	.913	.914	-.036	-.003	.00
8-4	5,150	28.469	28.478	.920	.902	.012	-.002	.00

Table 11.--Weight, dimensions, cup, and twist of panels with redwood and with yellow-poplar cores at a moisture content of about 6 percent (final) (continued)

Panel No.	Weight	Width	Length	Thickness		Cup		Twist
				"c" ²	"d" ²	Width ¹	Length ¹	
	Grams	Inches	Inches	Inch	Inch	Inch	Inch	Inch
9-1	6,969	28.441	28.471	0.919	0.912	-0.017	-0.017	0.00
9-2	6,692	28.431	28.464	.902	.914	-.204	-.010	.07
9-3	6,695	28.441	28.465	.910	.906	.014	.000	.11
9-4	6,525	28.443	28.469	.910	.902	-.087	.012	.09
10-1	5,762	28.517	28.521	.908	.909	-.006	.000	.00
10-2	5,485	28.509	28.514	.913	.903	-.021	-.005	.00
10-3	5,169	28.507	28.517	.906	.906	.034	.015	.04
10-4	5,597	28.514	28.512	.907	.903	-.078	-.016	.00
11-1	6,087	28.505	28.515	.906	.908	.008	.000	.00
11-2	6,572	28.495	28.514	.914	.909	.000	.000	.00
11-3	6,159	28.499	28.510	.913	.909	.015	.000	.00
11-4	6,560	28.514	28.510	.911	.913	.050	.014	.05
12-1	5,698	28.495	28.496	.909	.913	.006	.000	.07
12-2	5,419	28.480	28.499	.910	.902	-.041	-.019	.00
12-3	5,661	28.475	28.487	.917	.909	.037	.000	.12
12-4	5,551	28.474	28.484	.912	.905	.014	-.003	.00
13-1	5,384	28.484	28.513	.914	.904	.016	.003	.00
13-2	5,515	28.514	28.506	.904	.911	.019	.000	.00
13-3	5,607	28.499	28.519	.910	.912	.006	.000	.02
13-4	5,024	28.507	28.510	.904	.912	.010	-.008	.00
14-1	5,553	28.480	28.488	.914	.909	-.049	-.005	.00
14-2	5,655	28.487	28.493	.909	.913	-.006	-.018	.06
14-3	5,411	28.483	28.490	.914	.910	-.030	-.003	.00
14-4	5,569	28.483	28.490	.912	.910	-.069	-.007	.00
15-1	5,181	28.503	28.515	.844	.844	.072	.008	.02
15-2	5,147	28.504	28.511	.847	.840	-.084	.000	.02
15-3	5,473	28.509	28.512	.844	.845	.005	.000	.07
15-4	5,198	28.500	28.512	.849	.844	-.050	.000	.00
5A-1	5,797	28.523	28.529	.918	.918	-.045	.002	.00
5A-2	5,576	28.518	28.528	.919	.920	-.017	.000	.00
5A-3	5,767	28.522	28.528	.920	.919	-.033	.008	.00
5A-4	5,137	28.525	28.527	.919	.920	-.011	.002	.03

Table 11.--Weight, dimensions, cup and twist of panels with redwood and with yellow-poplar cores at a moisture content of about 6 percent (final) (continued)

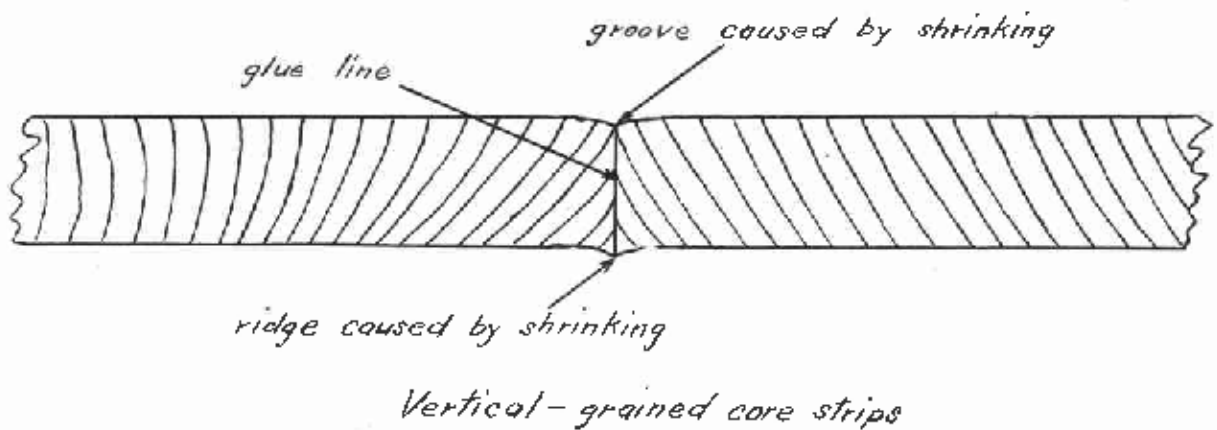
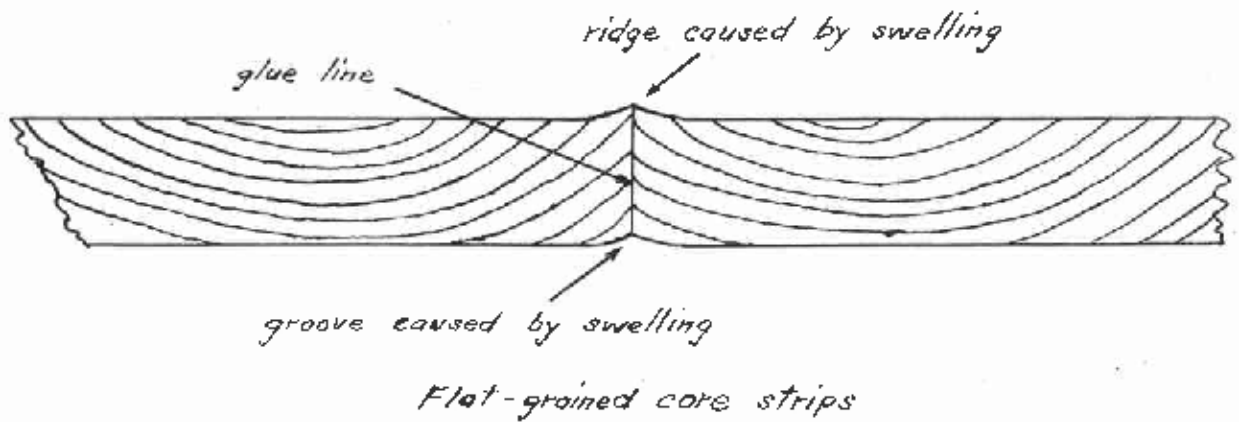
Panel No. ¹	Weight	Width	Length	Thickness		Cup		Twist
				"c" ²	"d" ³	Width ⁴	Length ⁴	
	<u>Grams</u>	<u>Inches</u>	<u>Inches</u>	<u>Inch</u>	<u>Inch</u>	<u>Inch</u>	<u>Inch</u>	<u>Inch</u>
7A-1	6,062	28.518	28.521	0.919	0.914	-0.009	-0.028	0.02
7A-2	5,617	28.525	28.521	.921	.920	-.007	.000	.00
7A-3	6,562	28.517	28.522	.922	.918	.000	.006	.04
7A-4	6,005	28.516	28.523	.921	.919	.030	.000	.01
10A ₁ -1	6,031	28.514	28.526	.921	.919	-.027	.000	.00
10A ₁ -2	5,636	28.508	28.527	.918	.918	-.020	.004	.00
10A ₁ -3	5,847	28.518	28.528	.918	.915	-.004	.000	.00
10A ₁ -4	5,878	28.514	28.523	.921	.912	.003	.003	.00

¹For group descriptions refer to table 1 in main body of report.

²Measured near northwest corner.

³Measured near southeast corner.

⁴Positive values measured on "top" face, negative values measured on "bottom" face.



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Figure 1.--Sketch showing how shrinking and swelling of the core strips, in combination with the angle of the annual rings to the glue joint, cause the formation of grooves and ridges in the panel faces.

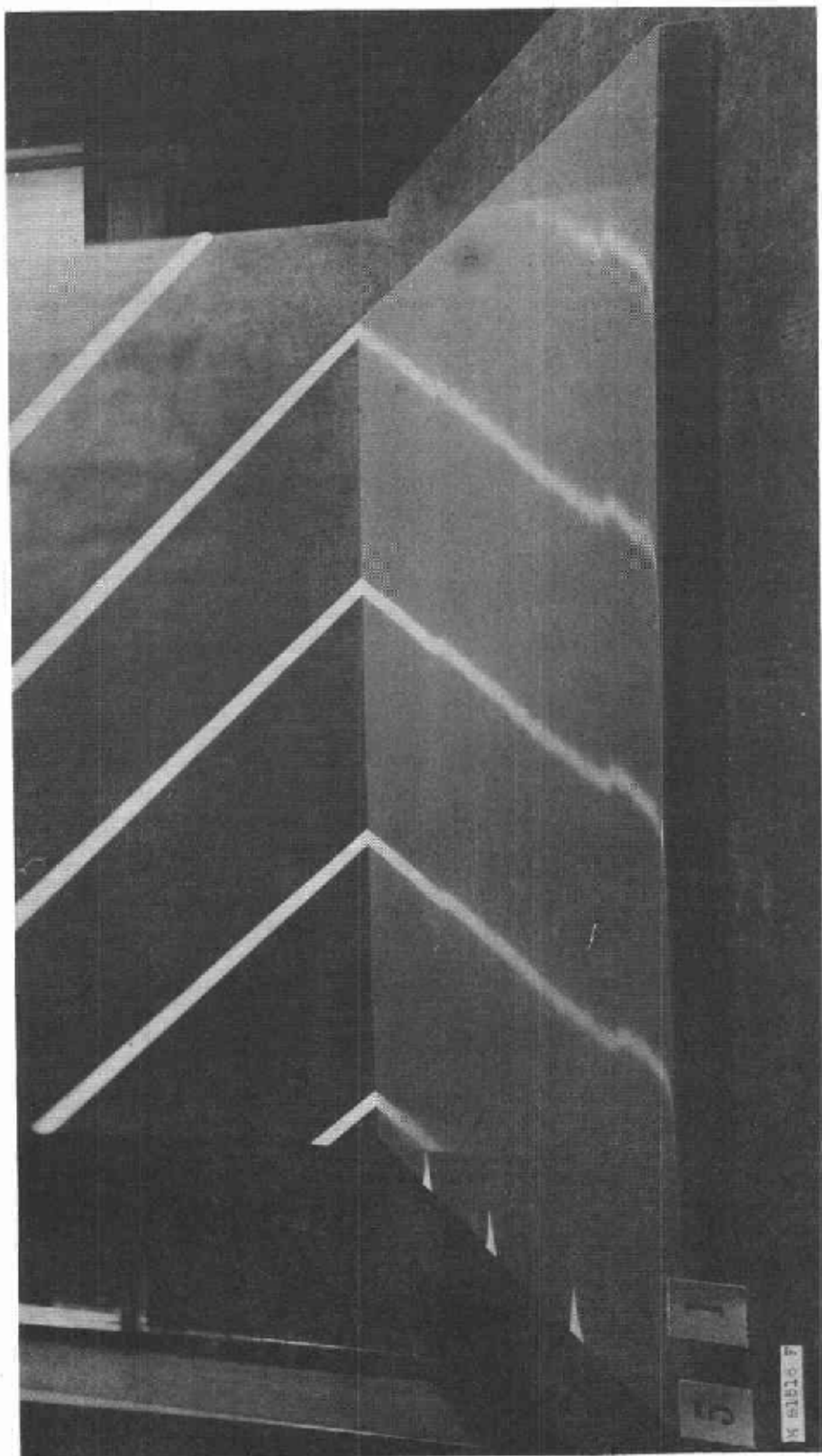


Figure 2.--Top face of panel with core of 4-inch-wide strips of vertical-grained, all-heart redwood, photographed at a moisture content of about 6 percent. Note two distinct grooves as indicated by waves in bands of reflected light.

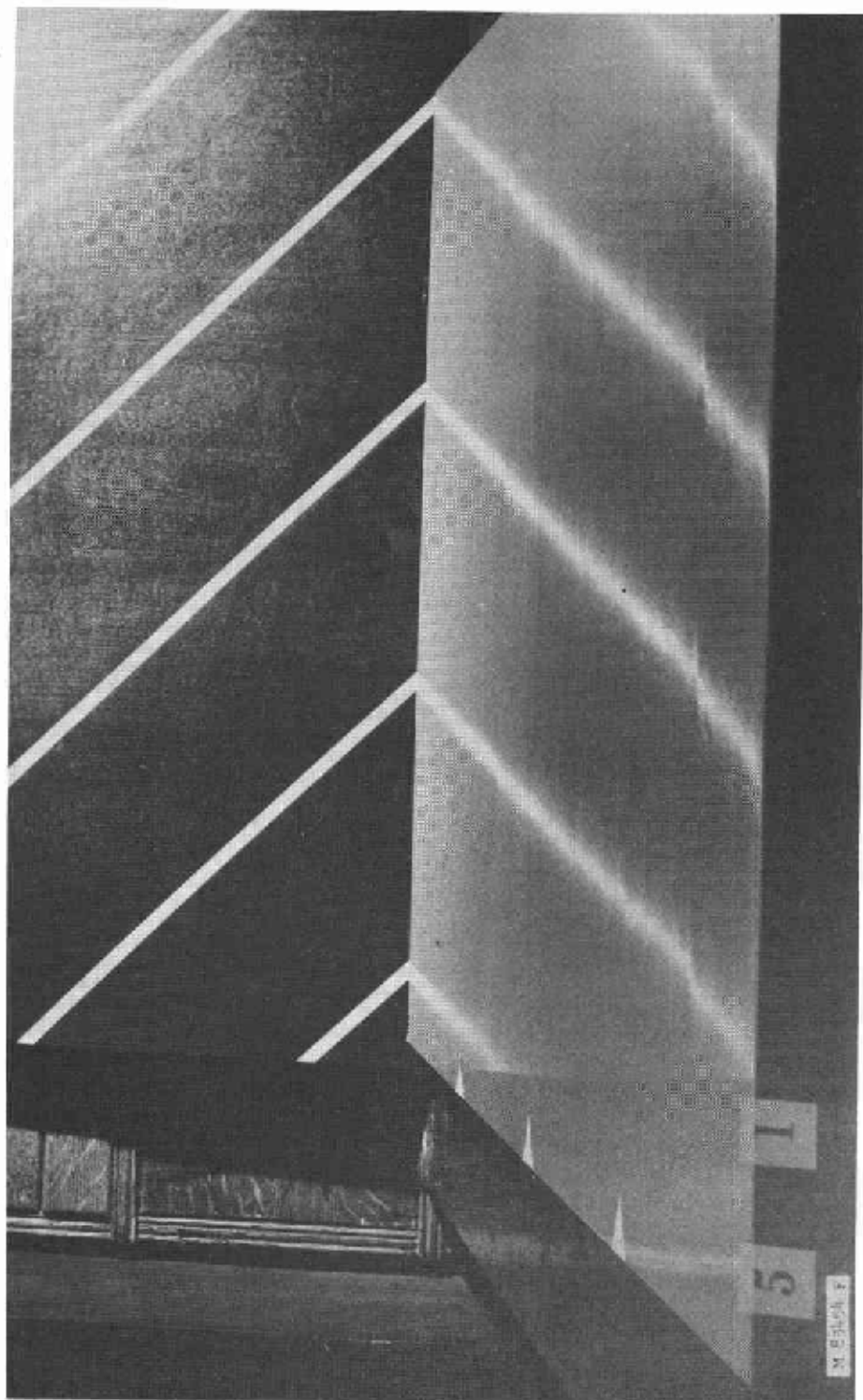


Figure 3.--Top face of panel with core of 4-inch-wide strips of vertical-grained all-heart redwood, photographed at a moisture content of about 10 percent. This is the same panel that is shown in figure 2. The two distinct grooves in figure 2 have changed to ridges.

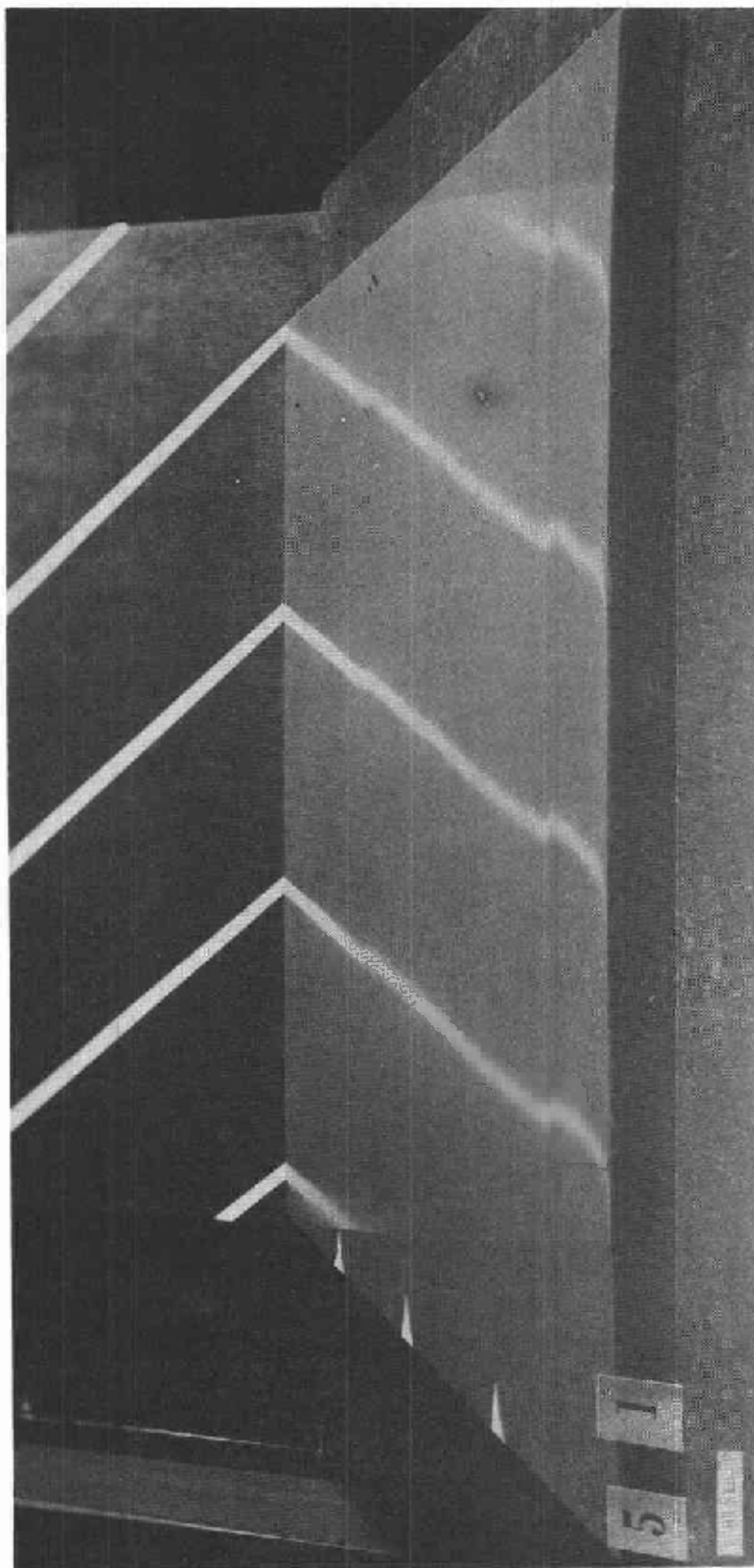


Figure 4.--Top face of panel with core of 4-inch-wide strips of vertical-grained heartwood and sapwood redwood, photographed at moisture content of about 6 percent. Note moderate ridges and grooves.

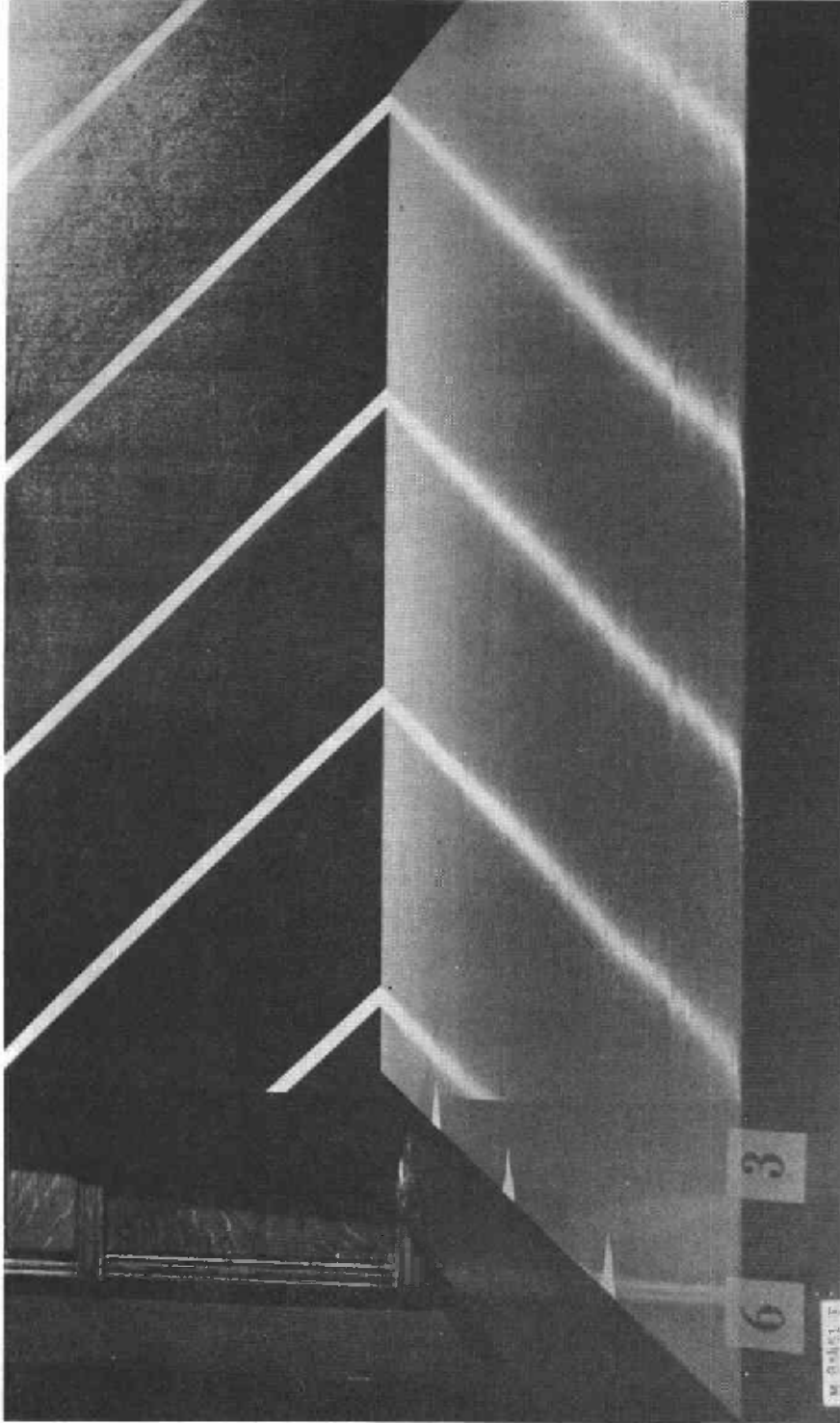


Figure 5.--Top face of panel with core of 4-inch-wide strips of vertical-grained heartwood and sapwood redwood, photographed at a moisture content of about 10 percent. Note that the ridges and grooves shown in figure 4 have become diminished.

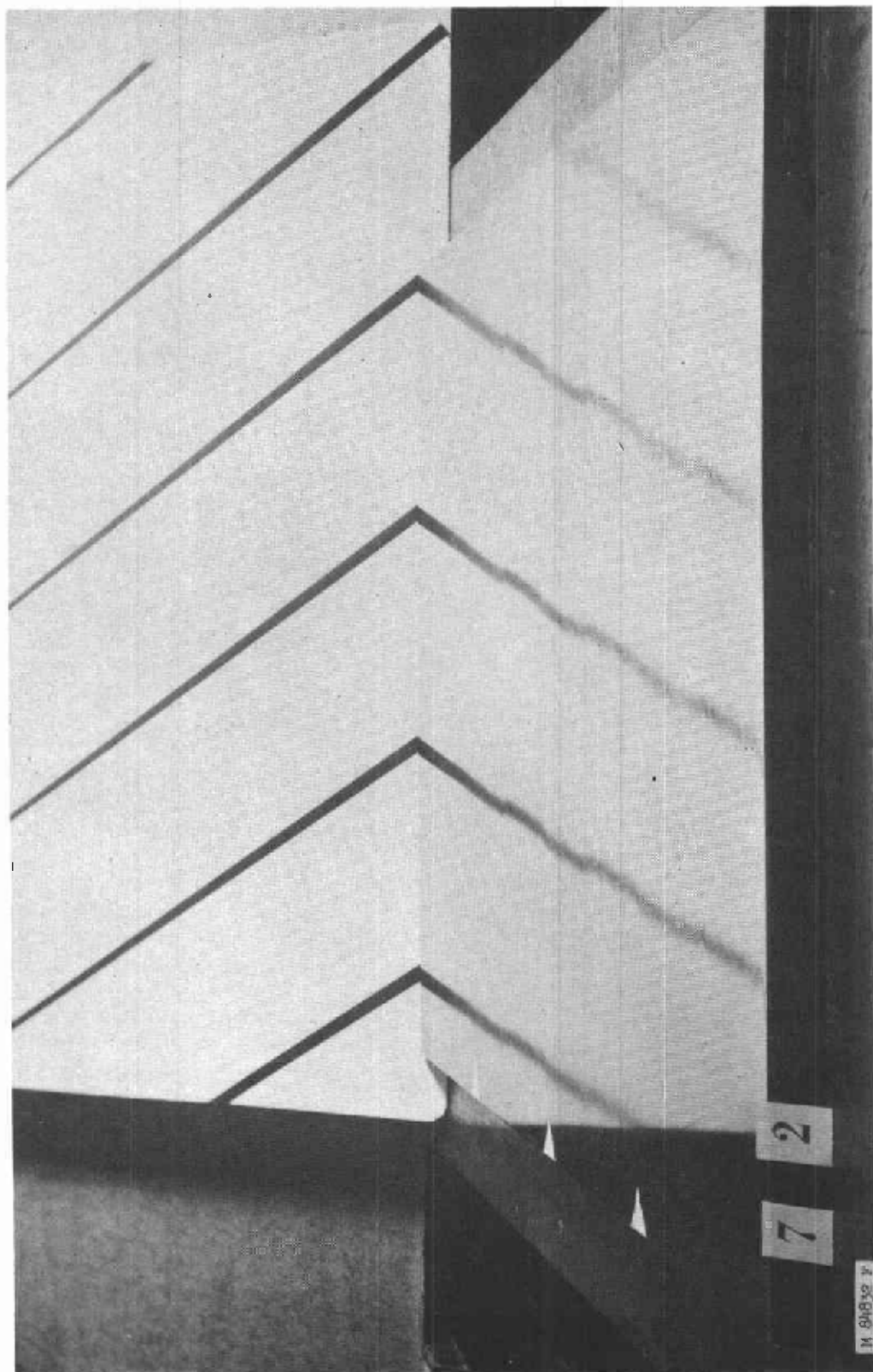


Figure 6.--Top face of panel with core of 4-inch-wide strips of flat-grained all-heart redwood, photographed at a moisture content of about 6 percent. Note the numerous moderate to severe ridges and grooves.

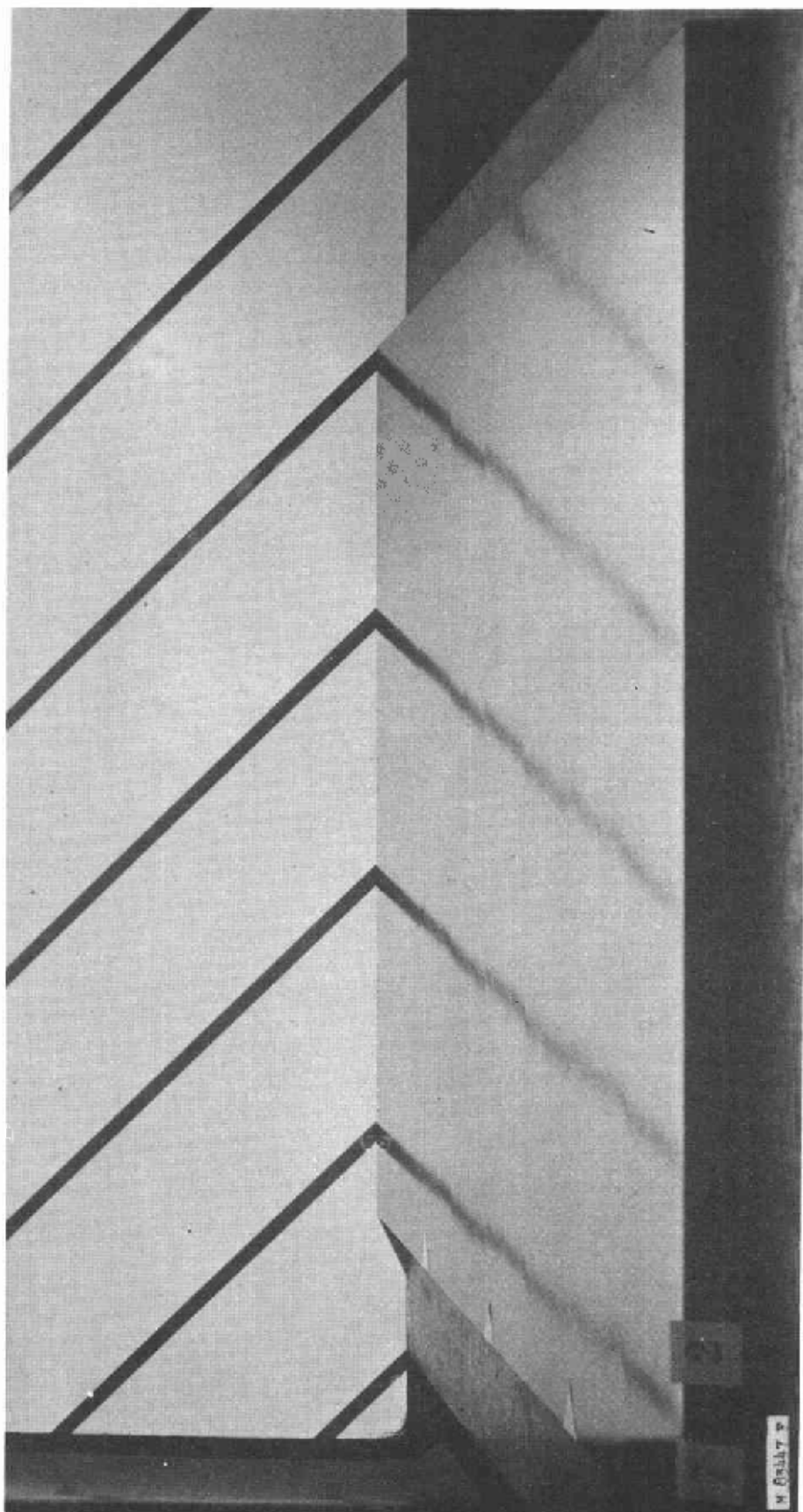


Figure 7.--Top face of panel with core of 4-inch-wide strips of flat-grained all-heart redwood, photographed at a moisture content of about 10 percent. The surface condition is comparable to that shown in figure 6, but there has been an interchange of ridges and grooves.

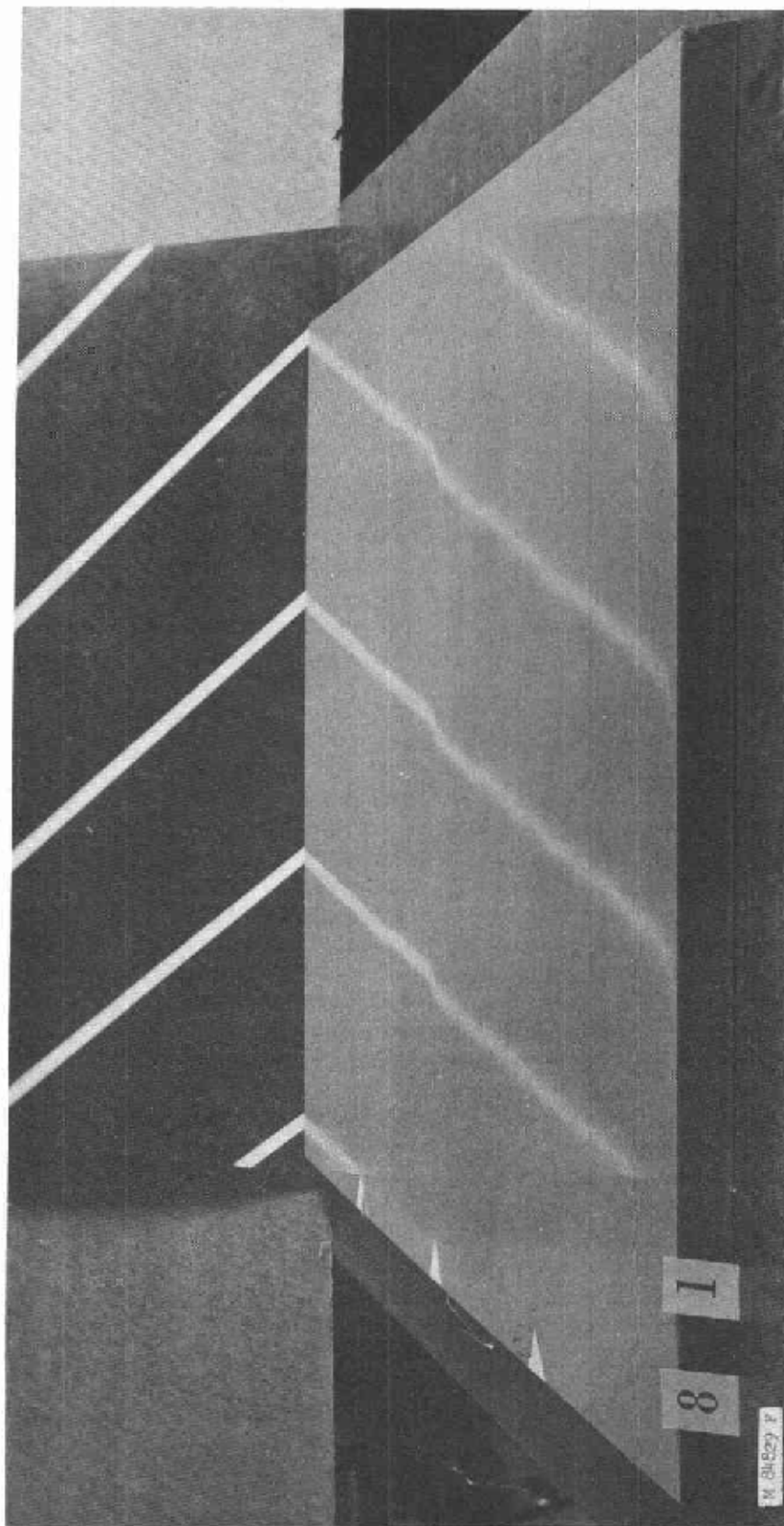


Figure 8.---Top face of panel with core of 4-inch-wide strips of flat-grained heartwood and sapwood redwood, photographed at a moisture content of about 6 percent.
Note the severe ridge near the center of the panel.

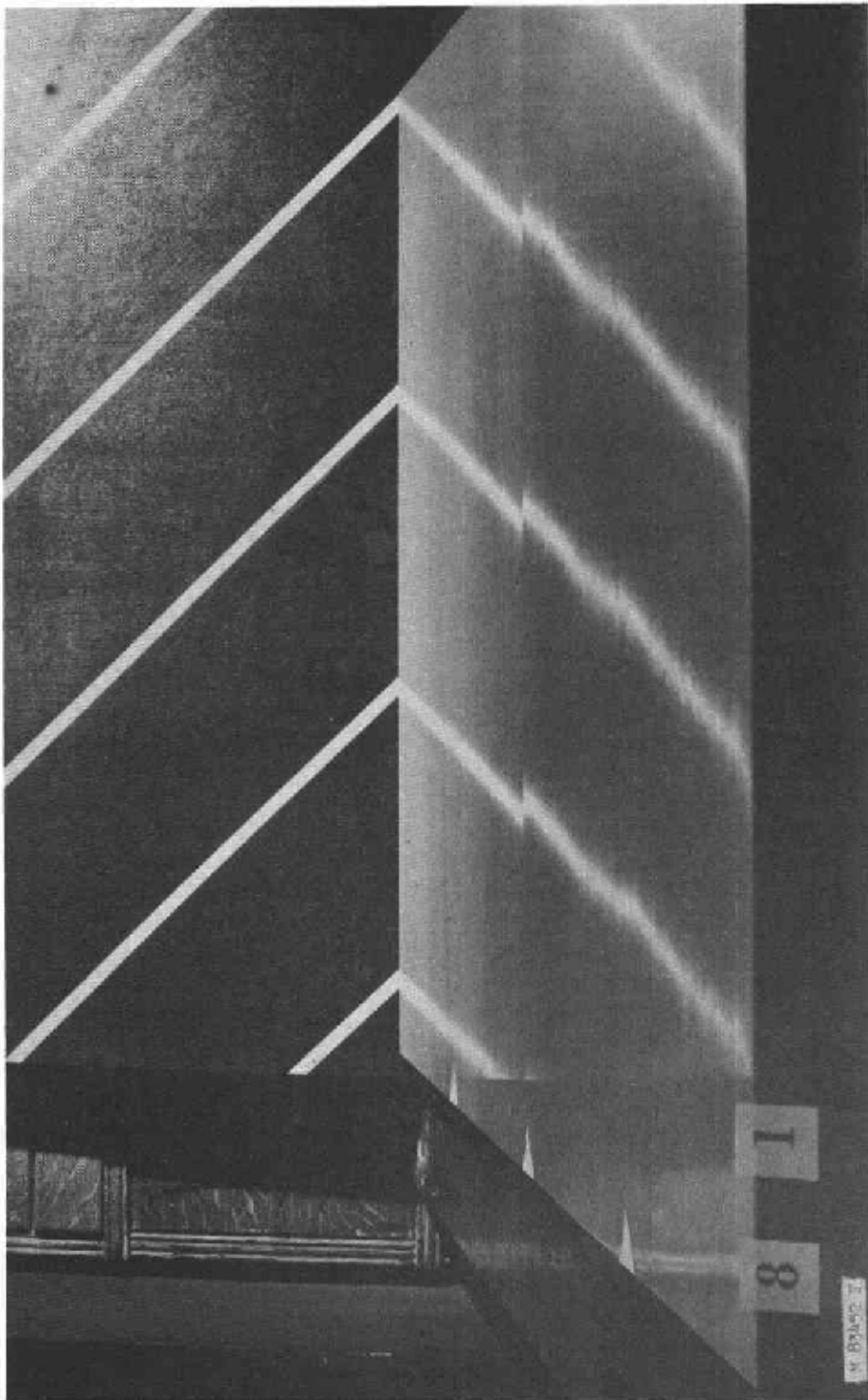


Figure 9.--Top face of panel with core of 4-inch-wide strips of flat-grained heartwood and sapwood redwood, photographed at a moisture content of about 10 percent. Note that the severe ridge shown in figure 8 has become a severe groove.



Figure 10.---Photograph of cross section of core of panel shown in figures 8 and 9. Note the angles made by the annual rings with the glue line which lies beneath the ridge and groove shown in figures 8 and 9. The condition shown here is illustrated by figure 1 of the main body of the report.

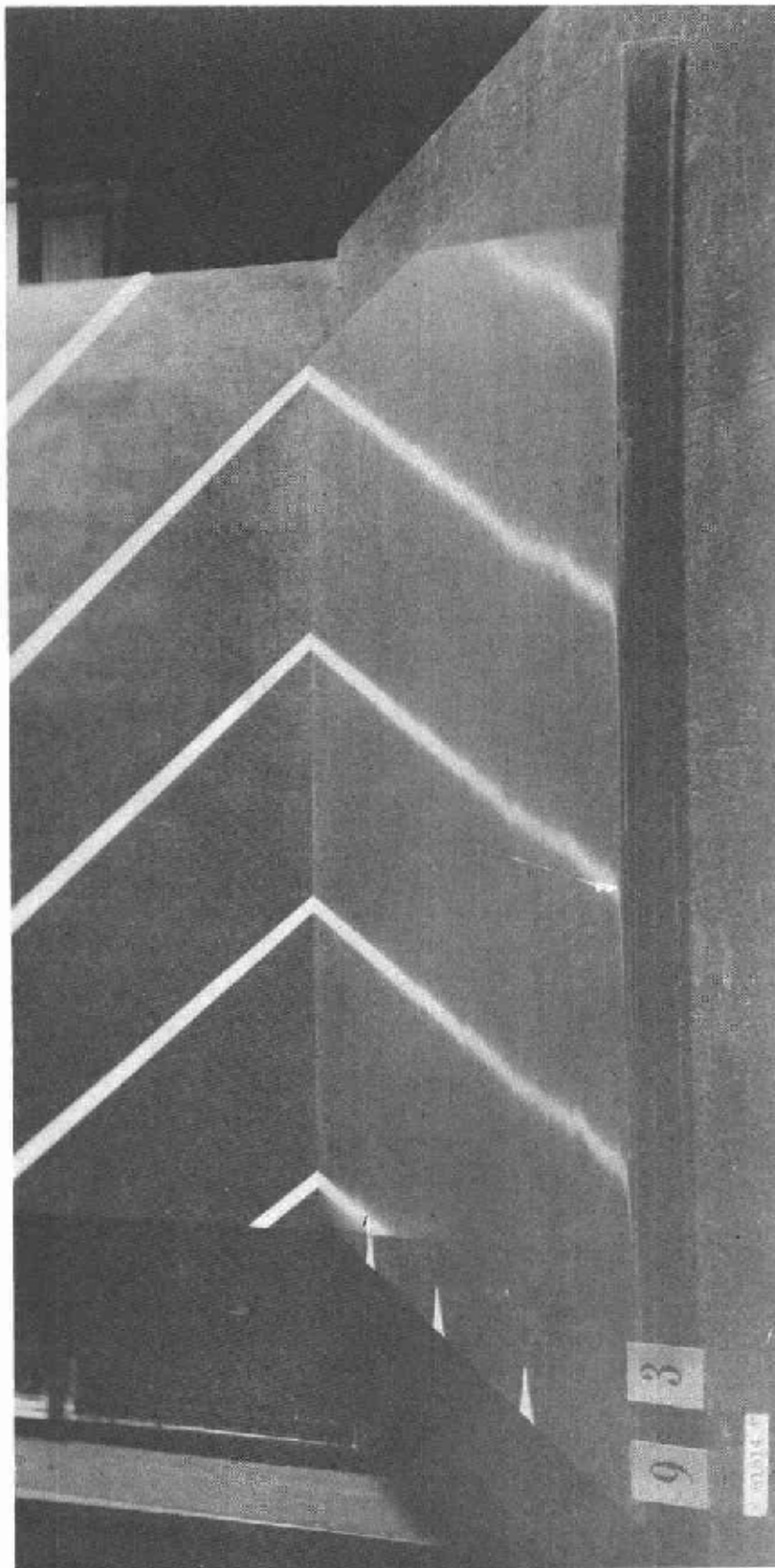


Figure 11.--Top face of panel with core of 4-inch-wide strips of flat-grained heartwood and sapwood yellow-poplar photographed at a moisture content of about 6 percent. Several moderate to severe ridges and grooves are indicated.

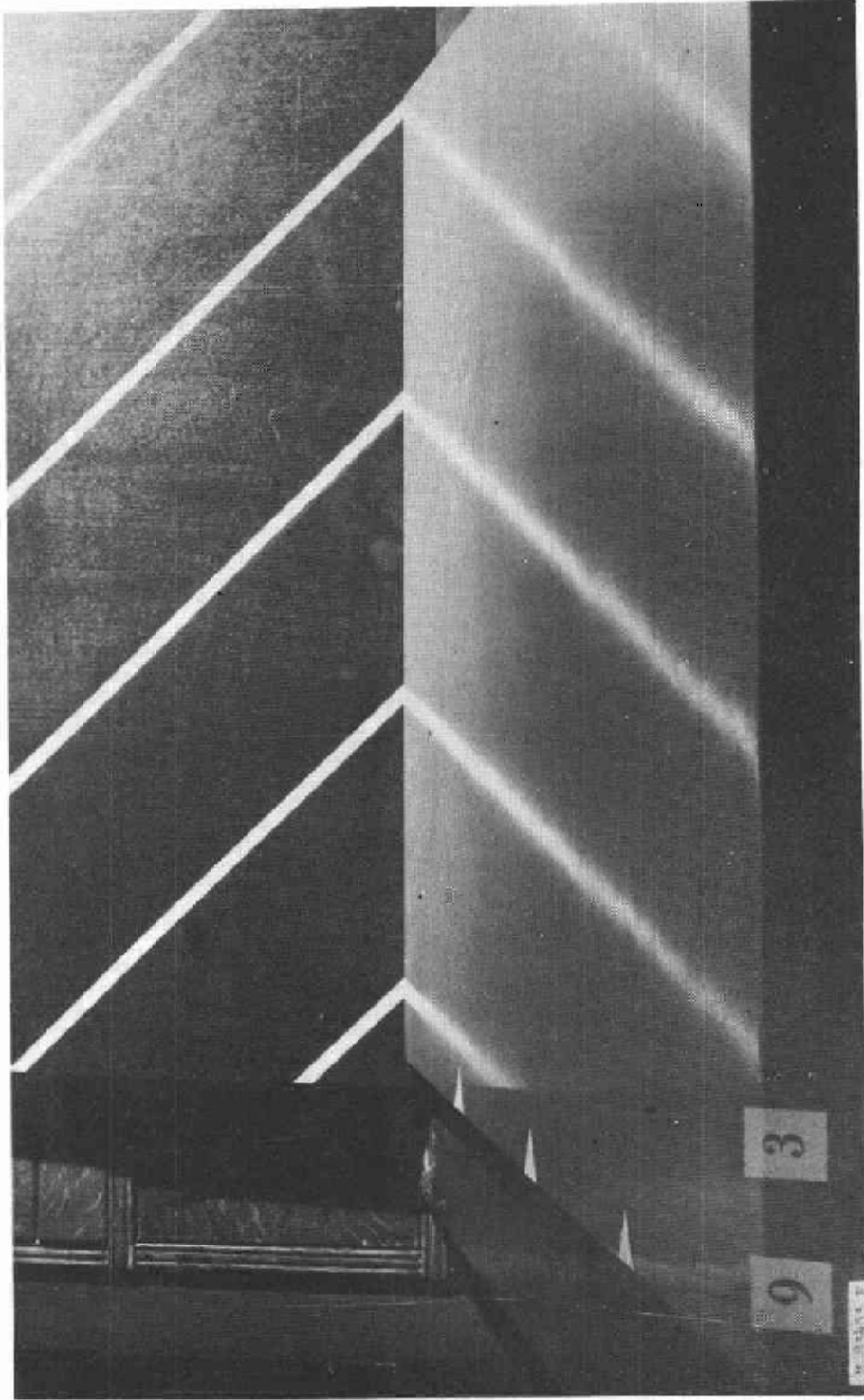


Figure 12.--Top face of panel with core of 4-inch-wide strips of flat-grained heartwood and sapwood yellow-poplar, photographed at a moisture content of about 10 percent. Note the marked improvement in the condition of the surface over that shown in figure 11.

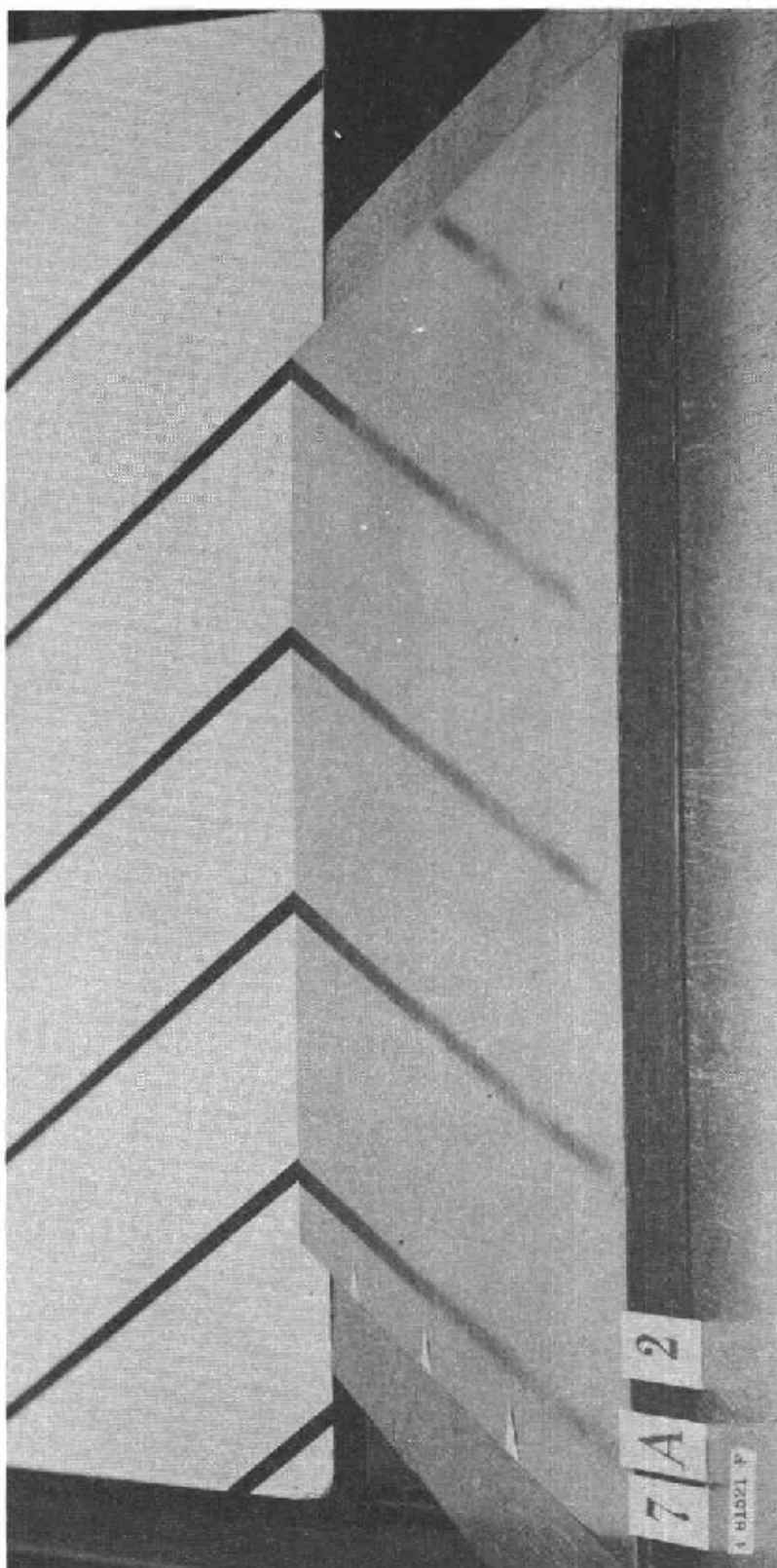


Figure 13.--Top face of panel with core of 4-inch-wide strips of flat-grained all-heart redwood, with cross bands and veneers glued with a cold-setting glue, photographed at a moisture content of about 6 percent. Note that the surface is free of appreciable ridges or depressions.

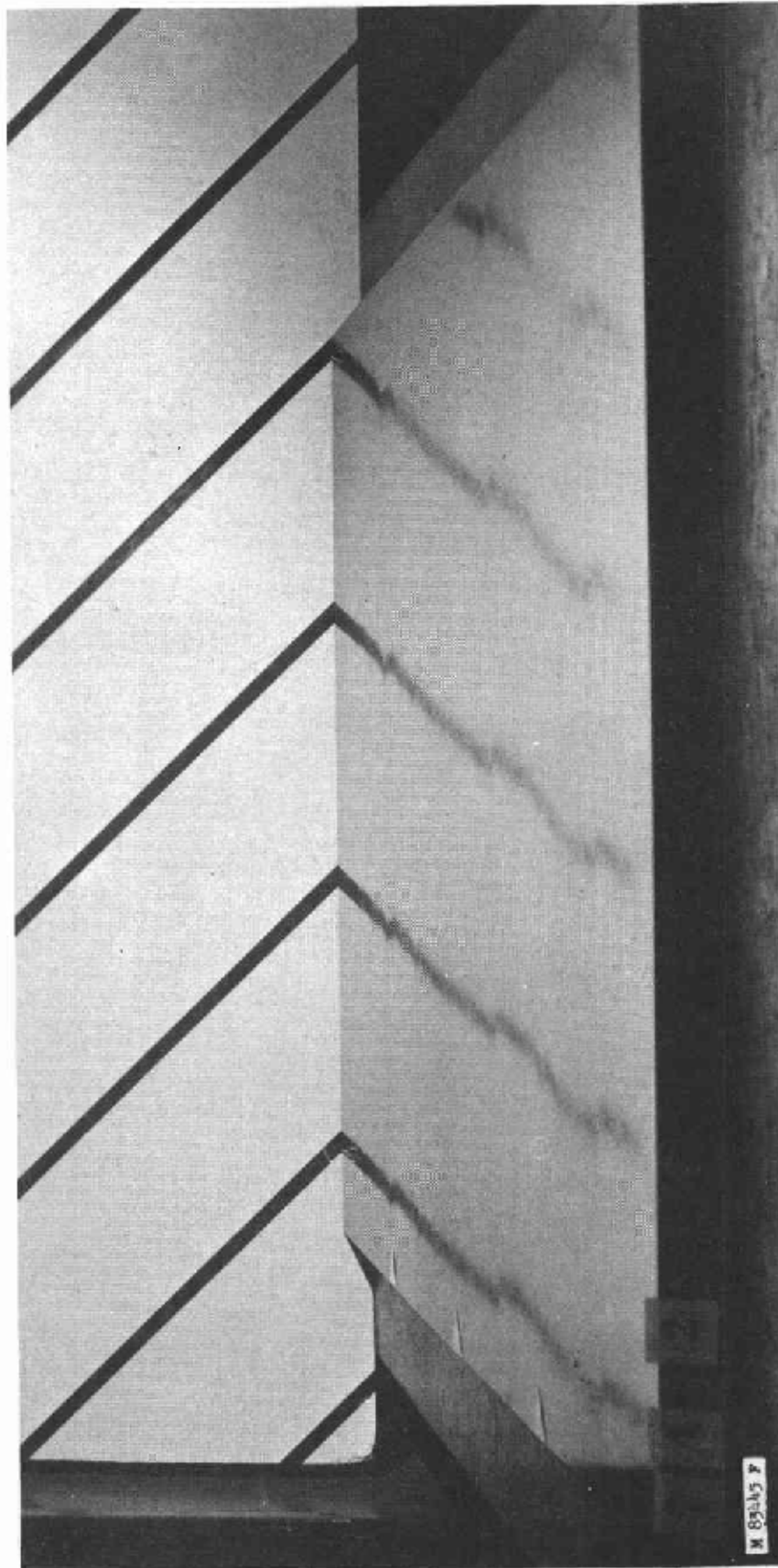


Figure 14.--Top face of panel with core of 4-inch-wide strips of flat-grained all-heart redwood, with cross bands and veneers glued with a cold-setting glue, photographed at a moisture content of about 10 percent. Note the several severe ridges and grooves that developed with an increase in moisture content from 6 to 10 percent.