

INSTRUMENTS FOR RAPIDLY MEASURING SLOPE OF GRAIN IN LUMBER

Information Reviewed and Reaffirmed

April 1955

INFORMATION REVIEWED
AND REAFFIRMED
1960

LOAN COPY

Please return to:

Wood Engineering Research
Forest Products Laboratory
Madison, Wisconsin 53705



No. 1592

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
FOREST PRODUCTS LABORATORY
Madison 5, Wisconsin
In Cooperation with the University of Wisconsin

INSTRUMENTS FOR RAPIDLY MEASURING
SLOPE OF GRAIN IN LUMBER^{1, 2}

By

ERIC A. ANDERSON, Technologist
ARTHUR KOEHLER, Chief
Division of Silvicultural Relations
and
ROBERT H. KRONE, Engineer

A piece of lumber is said to have slope of grain when the fibers do not run parallel to its main axis. Excessive slope of grain reduces strength, makes surfacing more difficult, and may cause warping with change in moisture content.

Slope of grain is commonly referred to as cross grain. It includes spiral, diagonal, wavy, interlocked, and curly grain and any other deviation of the grain that may be present in a piece of wood.

Slope of grain on a tangential (plain-sawed or flat-grain) surface is usually referred to as spiral grain, and slope of grain on a radial (quarter-sawed or edge grain) surface, as indicated by the annual rings when they are distinct, is referred to as diagonal grain. When the grain slopes on both surfaces a combination of the two gives the true slope of grain within a piece. Similarly, a combination of the slope of grain on adjacent portions of any two surfaces at right angles to each other, even though they are not tangential and radial surfaces, gives the true slope of grain within a piece near both surfaces.

¹Results here reported were obtained during 1945.

²A more detailed discussion of methods of detecting and measuring slope of grain in lumber and veneer may be found in Forest Products Laboratory Report No. 1585, "Guide to Determining Slope of Grain in Lumber and Veneer," Sept. 1943.

Since many pieces of lumber do not have radial and tangential surfaces adjacent to and near each other, further references to spiral grain and diagonal grain will be omitted and reference will be made only to slope of grain on adjacent surfaces and their combination within the piece.

Determining Direction of Grain in Wood

One of the best ways of determining how the grain runs in a piece of wood is to split it, but since that mutilates the piece it will not be discussed further except to say that it usually is best to split the wood radially and tangentially since it splits best in those planes, although wood with interlocked grain cannot be split satisfactorily in the radial direction.

The direction the grain takes on any surface may be determined by a scribe, free flowing ink, magnification, or in some woods, by observation of resin ducts and large pores, and on tangential and on radial surfaces by observation of the direction of seasoning checks and annual rings, respectively.

In using a scribe of the type illustrated in figure 1, light pressure must be applied so that the point will enter the wood slightly while it is pulled in the direction in which the grain appears to run. It is desirable to make a trial run followed by a check run in which the scribe is pulled in the direction of the mark made during the trial run, unless it obviously did not follow the grain the first time.

In woods in which summerwood is much harder than springwood, the scribe may follow the springwood rather than follow the direction of the grain. It then becomes necessary to make a series of short lines in the springwood. In that case the slope of grain must be measured parallel to the individual lines and not parallel to a general line connecting them.

A free flowing ink, such as fountain pen ink, applied by drawing a rather broad pen point or an eye dropper across the grain, will show the direction in which the grain runs by fine ink lines extending from both sides of the ink mark. A little alcohol mixed with the ink helps it to spread more rapidly. A straightedge may then be placed parallel with these fine ink lines and the slope determined.

A hand lens having a magnifying power of about 7 to 15 diameters offers a means of observing the fibers and placing a straightedge parallel with them so that their slope may be measured. Resin ducts, present in some softwoods, and pores in those hardwoods in which they can be seen as fine grooves on longitudinal surfaces, indicate direction of grain on the surface without requiring magnification. These features are particularly

useful for inspecting finished parts on which the use of a scribe or ink is not permissible.

Seasoning checks indicate the true direction of grain only on surfaces that are tangential, and the annual rings indicate the true direction of grain only on surfaces that are radial.

It is frequently confusing to the inspector to note that a line representing the direction of the grain (fibers) on a surface may cross the annual rings as indicated on the top surface in figure 2. This effect is to be expected whenever spiral or diagonal grain or both are present in pieces whose surfaces are not radial or tangential.

Measuring Slope of Grain

Slope of grain is usually expressed as the relation between the unit deviation and the length of a base line from which the deviation occurs. Frequently a longitudinal corner is used for the measurement of the length but any line that is parallel to the long axis may be used. For example, if in figure 2, the line indicating the slope of grain on the face, namely, bo, departs 1 inch, as ab, in 12 inches from a longitudinal corner, as ao, the slope of grain on that face is 1 in 12.

Also, in the same figure, if a line representing the slope of grain on the edge, as co, departs 1/2 inch, as ac, for every 12 inches from the same longitudinal corner, the slope of grain on the edge is 1/2 in 12, which is equivalent to 1 in 24. The line do, represents the combined, or true, slope of grain within the piece because it is at the intersection of a vertical and a horizontal plane, both of which are parallel to the grain on the surfaces and cut the corner at the same point, o. The ratio of the line ad to ao is a measure of the combined, or true, slope of grain.

To obtain a numerical value for the combined slope of grain, the two slopes, 1 in 12 and 1 in 24, are then referred to table 1 where the desired value may be obtained by reading downward under the column headed 1 in 12 and to the right on the line marked 1 in 24 until these two intersect. At this intersection, the combined slope of grain is shown as 1 in 10.7.

Lines representing grain slopes on the two faces need not be determined from exactly the same point on the longitudinal corner, nor need they extend to the ends of the piece. For example, in figure 2, the ratio of a'b' to a'o also represents the slope of grain on the face. However, since the direction of grain may vary a great deal along the length of a

board, or across its width, it is necessary that the two values obtained as a basis for combined slope of grain be taken closely enough together to avoid errors due to these variations. The resultant value for combined slope then applies to the portion in which the measurements were made.

Instruments for Measuring Slope of Grain

The slope of grain may be measured with a number of different instruments. For quick determination and direct reading of slope of grain the Forest Products Laboratory has devised several pieces of equipment. One consists of a plate of clear glass, on which lines representing one or several slopes are placed to the right and left of a central line at right angles to one edge of the plate. With the aid of a square, this plate can be alined with its center line parallel to the edge of the board, and the slope of the grain, which preferably is first indicated with a pencil line, can be determined by paralleling it with the appropriate sloping line on the plate. (See fig. 3).

Another instrument for measuring slope of grain is shown in figure 4. It consists of a straightedge, a, pivoted on the end of a flat bar, b. On the bar is a slide, c, arranged so that the bar itself may be squared with the edge of a board and slid back or forth across the board. The whole instrument can, of course, be moved along the edge of the board so that the straightedge can be alined with the grain anywhere on the surface to be inspected. An indicating arm, d, is fastened rigidly at right angles to the straightedge, and the slope of grain is read directly on a scale fastened to the end of the bar, b.

The slope of grain also can be measured directly by means of adjustable parallel bars about 20 inches long of which one bar is flat and graduated in inches and has a T-head extending for 1 inch at right angles to the bar on each side, as shown in figure 5. The other bar is L-shaped in cross section. By fitting the L-shaped bar along an edge of a board and bringing one end of the T-head on the other bar to a line indicating the direction of grain, as bo, the distance in which the grain deviates 1 inch from parallelism with an edge of the board can be read directly from the graduations on the bar, as 9.6 inches in figure 5. If the grain slopes in the other direction, the other end of the T-head must be used. The slope of grain can be measured over shorter distances by using a 1/2-inch graduation on the T-head and doubling the reading on the graduated bar.

Another method for measuring directly the deviation of grain from a longitudinal corner or a line parallel to the corner is to use a divider or machinist's caliper about 8 inches long, preferably of the hermaphrodite type

type, with wide flat legs of equal length and with the curved leg sharpened to a dull chisel point. The inner edges of both legs should be beveled toward each other like the blades of a pair of shears. If the same length of base line is always used, various slopes of grain corresponding to certain openings of the caliper can be indexed on the flat side of a leg (see figs. 6 and 7), to go with the particular length of base line used. Slopes for one length of base line, as 6 inches, may be marked on one leg and slopes for a base line of a different length, as 12 inches, may be marked on the other leg. For accurate calibration and subsequent reading, the calipers should be held to the light in order to determine the exact position of the apex of the V formed by the legs. Such a caliper can be used on any portion of the face of a board away from the edge if a base line parallel to the edge is drawn at a suitable place near where the grain is to be measured, as in figure 6.

A major advantage in using the caliper is evident when the combined slope is to be determined, for it can be measured directly across a corner (fig. 7) without making calculations or referring to table 1. This follows from the fact that the diagonal distance from b to c in the rectangle abdc in figure 2 is equal to the diagonal ad, which, as previously stated, indicates the deviation in slope of grain within the piece with respect to the line ao. It is not even necessary that the same portion of the base line be used (the same length of base line corresponding to the calibrations on the caliper must be used, however) since one or the other deviation can be extended parallel to the corner to the point where the measurement is to be made, as in figure 7.

Table 1.--Combined slope of grain¹

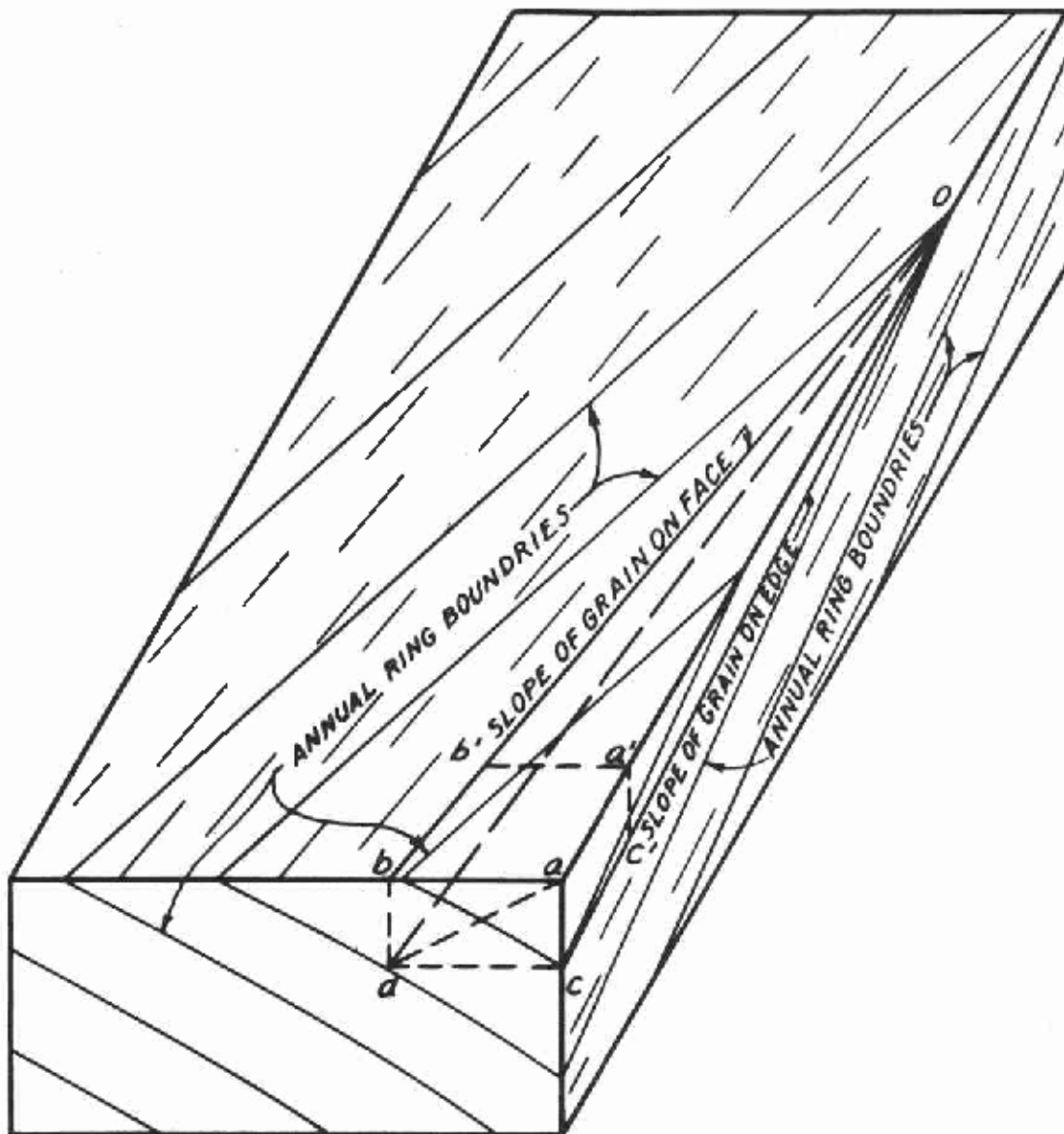
To determine the combined slope find the column marked by the steeper of the two slopes and in this column locate the figure in line with the less steep of the two slopes as given in the left-hand column. This figure represents the length in inches (or other units) in which the grain deviates 1 inch (or other unit) with respect to the longitudinal axis of the board. For example, if the slope on the face is 1 in 15 and that on the edge is 1 in 20, the combined slope is 1 in 12.0.

Slope on face or edge, whichever is steeper

1-10:	1-11:	1-12:	1-13:	1-14:	1-15:	1-16:	1-17:	1-18:	1-19:	1-20:	1-21:	1-22:	1-23:	1-24:	1-25:	1-26:	1-27:	1-28:	1-29:
7.1	7.8	8.5	9.2	9.9	10.6	11.3	12.0	12.7	13.4	14.1	14.9	15.6	16.3	17.0	17.7	18.4	19.1	19.8	20.5
7.4	8.1	8.8	9.5	10.2	10.9	11.6	12.3	13.0	13.7	14.4	15.1	15.8	16.5	17.2	17.9	18.6	19.3	20.0	20.7
7.7	8.4	9.1	9.8	10.5	11.2	11.9	12.6	13.3	14.0	14.7	15.4	16.1	16.8	17.5	18.2	18.9	19.6	20.3	21.0
8.0	8.7	9.4	10.1	10.8	11.5	12.2	12.9	13.6	14.3	15.0	15.7	16.4	17.1	17.8	18.5	19.2	19.9	20.6	21.3
8.3	9.0	9.7	10.4	11.1	11.8	12.5	13.2	13.9	14.6	15.3	16.0	16.7	17.4	18.1	18.8	19.5	20.2	20.9	21.6
8.6	9.3	10.0	10.7	11.4	12.1	12.8	13.5	14.2	14.9	15.6	16.3	17.0	17.7	18.4	19.1	19.8	20.5	21.2	21.9
8.9	9.6	10.3	11.0	11.7	12.4	13.1	13.8	14.5	15.2	15.9	16.6	17.3	18.0	18.7	19.4	20.1	20.8	21.5	22.2
9.2	9.9	10.6	11.3	12.0	12.7	13.4	14.1	14.8	15.5	16.2	16.9	17.6	18.3	19.0	19.7	20.4	21.1	21.8	22.5
9.5	10.2	10.9	11.6	12.3	13.0	13.7	14.4	15.1	15.8	16.5	17.2	17.9	18.6	19.3	20.0	20.7	21.4	22.1	22.8
9.8	10.5	11.2	11.9	12.6	13.3	14.0	14.7	15.4	16.1	16.8	17.5	18.2	18.9	19.6	20.3	21.0	21.7	22.4	23.1
10.1	10.8	11.5	12.2	12.9	13.6	14.3	15.0	15.7	16.4	17.1	17.8	18.5	19.2	19.9	20.6	21.3	22.0	22.7	23.4
10.4	11.1	11.8	12.5	13.2	13.9	14.6	15.3	16.0	16.7	17.4	18.1	18.8	19.5	20.2	20.9	21.6	22.3	23.0	23.7
10.7	11.4	12.1	12.8	13.5	14.2	14.9	15.6	16.3	17.0	17.7	18.4	19.1	19.8	20.5	21.2	21.9	22.6	23.3	24.0
11.0	11.7	12.4	13.1	13.8	14.5	15.2	15.9	16.6	17.3	18.0	18.7	19.4	20.1	20.8	21.5	22.2	22.9	23.6	24.3
11.3	12.0	12.7	13.4	14.1	14.8	15.5	16.2	16.9	17.6	18.3	19.0	19.7	20.4	21.1	21.8	22.5	23.2	23.9	24.6
11.6	12.3	13.0	13.7	14.4	15.1	15.8	16.5	17.2	17.9	18.6	19.3	20.0	20.7	21.4	22.1	22.8	23.5	24.2	24.9
11.9	12.6	13.3	14.0	14.7	15.4	16.1	16.8	17.5	18.2	18.9	19.6	20.3	21.0	21.7	22.4	23.1	23.8	24.5	25.2
12.2	12.9	13.6	14.3	15.0	15.7	16.4	17.1	17.8	18.5	19.2	19.9	20.6	21.3	22.0	22.7	23.4	24.1	24.8	25.5
12.5	13.2	13.9	14.6	15.3	16.0	16.7	17.4	18.1	18.8	19.5	20.2	20.9	21.6	22.3	23.0	23.7	24.4	25.1	25.8
12.8	13.5	14.2	14.9	15.6	16.3	17.0	17.7	18.4	19.1	19.8	20.5	21.2	21.9	22.6	23.3	24.0	24.7	25.4	26.1
13.1	13.8	14.5	15.2	15.9	16.6	17.3	18.0	18.7	19.4	20.1	20.8	21.5	22.2	22.9	23.6	24.3	25.0	25.7	26.4
13.4	14.1	14.8	15.5	16.2	16.9	17.6	18.3	19.0	19.7	20.4	21.1	21.8	22.5	23.2	23.9	24.6	25.3	26.0	26.7
13.7	14.4	15.1	15.8	16.5	17.2	17.9	18.6	19.3	20.0	20.7	21.4	22.1	22.8	23.5	24.2	24.9	25.6	26.3	27.0
14.0	14.7	15.4	16.1	16.8	17.5	18.2	18.9	19.6	20.3	21.0	21.7	22.4	23.1	23.8	24.5	25.2	25.9	26.6	27.3
14.3	15.0	15.7	16.4	17.1	17.8	18.5	19.2	19.9	20.6	21.3	22.0	22.7	23.4	24.1	24.8	25.5	26.2	26.9	27.6
14.6	15.3	16.0	16.7	17.4	18.1	18.8	19.5	20.2	20.9	21.6	22.3	23.0	23.7	24.4	25.1	25.8	26.5	27.2	27.9
14.9	15.6	16.3	17.0	17.7	18.4	19.1	19.8	20.5	21.2	21.9	22.6	23.3	24.0	24.7	25.4	26.1	26.8	27.5	28.2
15.2	15.9	16.6	17.3	18.0	18.7	19.4	20.1	20.8	21.5	22.2	22.9	23.6	24.3	25.0	25.7	26.4	27.1	27.8	28.5
15.5	16.2	16.9	17.6	18.3	19.0	19.7	20.4	21.1	21.8	22.5	23.2	23.9	24.6	25.3	26.0	26.7	27.4	28.1	28.8
15.8	16.5	17.2	17.9	18.6	19.3	20.0	20.7	21.4	22.1	22.8	23.5	24.2	24.9	25.6	26.3	27.0	27.7	28.4	29.1
16.1	16.8	17.5	18.2	18.9	19.6	20.3	21.0	21.7	22.4	23.1	23.8	24.5	25.2	25.9	26.6	27.3	28.0	28.7	29.4
16.4	17.1	17.8	18.5	19.2	19.9	20.6	21.3	22.0	22.7	23.4	24.1	24.8	25.5	26.2	26.9	27.6	28.3	29.0	29.7
16.7	17.4	18.1	18.8	19.5	20.2	20.9	21.6	22.3	23.0	23.7	24.4	25.1	25.8	26.5	27.2	27.9	28.6	29.3	30.0
17.0	17.7	18.4	19.1	19.8	20.5	21.2	21.9	22.6	23.3	24.0	24.7	25.4	26.1	26.8	27.5	28.2	28.9	29.6	30.3
17.3	18.0	18.7	19.4	20.1	20.8	21.5	22.2	22.9	23.6	24.3	25.0	25.7	26.4	27.1	27.8	28.5	29.2	29.9	30.6
17.6	18.3	19.0	19.7	20.4	21.1	21.8	22.5	23.2	23.9	24.6	25.3	26.0	26.7	27.4	28.1	28.8	29.5	30.2	30.9
17.9	18.6	19.3	20.0	20.7	21.4	22.1	22.8	23.5	24.2	24.9	25.6	26.3	27.0	27.7	28.4	29.1	29.8	30.5	31.2
18.2	18.9	19.6	20.3	21.0	21.7	22.4	23.1	23.8	24.5	25.2	25.9	26.6	27.3	28.0	28.7	29.4	30.1	30.8	31.5
18.5	19.2	19.9	20.6	21.3	22.0	22.7	23.4	24.1	24.8	25.5	26.2	26.9	27.6	28.3	29.0	29.7	30.4	31.1	31.8
18.8	19.5	20.2	20.9	21.6	22.3	23.0	23.7	24.4	25.1	25.8	26.5	27.2	27.9	28.6	29.3	30.0	30.7	31.4	32.1
19.1	19.8	20.5	21.2	21.9	22.6	23.3	24.0	24.7	25.4	26.1	26.8	27.5	28.2	28.9	29.6	30.3	31.0	31.7	32.4
19.4	20.1	20.8	21.5	22.2	22.9	23.6	24.3	25.0	25.7	26.4	27.1	27.8	28.5	29.2	29.9	30.6	31.3	32.0	32.7
19.7	20.4	21.1	21.8	22.5	23.2	23.9	24.6	25.3	26.0	26.7	27.4	28.1	28.8	29.5	30.2	30.9	31.6	32.3	33.0
20.0	20.7	21.4	22.1	22.8	23.5	24.2	24.9	25.6	26.3	27.0	27.7	28.4	29.1	29.8	30.5	31.2	31.9	32.6	33.3
20.3	21.0	21.7	22.4	23.1	23.8	24.5	25.2	25.9	26.6	27.3	28.0	28.7	29.4	30.1	30.8	31.5	32.2	32.9	33.6
20.6	21.3	22.0	22.7	23.4	24.1	24.8	25.5	26.2	26.9	27.6	28.3	29.0	29.7	30.4	31.1	31.8	32.5	33.2	33.9
20.9	21.6	22.3	23.0	23.7	24.4	25.1	25.8	26.5	27.2	27.9	28.6	29.3	30.0	30.7	31.4	32.1	32.8	33.5	34.2
21.2	21.9	22.6	23.3	24.0	24.7	25.4	26.1	26.8	27.5	28.2	28.9	29.6	30.3	31.0	31.7	32.4	33.1	33.8	34.5
21.5	22.2	22.9	23.6	24.3	25.0	25.7	26.4	27.1	27.8	28.5	29.2	29.9	30.6	31.3	32.0	32.7	33.4	34.1	34.8
21.8	22.5	23.2	23.9	24.6	25.3	26.0	26.7	27.4	28.1	28.8	29.5	30.2	30.9	31.6	32.3	33.0	33.7	34.4	35.1
22.1	22.8	23.5	24.2	24.9	25.6	26.3	27.0	27.7	28.4	29.1	29.8	30.5	31.2	31.9	32.6	33.3	34.0	34.7	35.4
22.4	23.1	23.8	24.5	25.2	25.9	26.6	27.3	28.0	28.7	29.4	30.1	30.8	31.5	32.2	32.9	33.6	34.3	35.0	35.7
22.7	23.4	24.1	24.8	25.5	26.2	26.9	27.6	28.3	29.0	29.7	30.4	31.1	31.8	32.5	33.2	33.9	34.6	35.3	36.0
23.0	23.7	24.4	25.1	25.8	26.5	27.2	27.9	28.6	29.3	30.0	30.7	31.4	32.1	32.8	33.5	34.2	34.9	35.6	36.3
23.3	24.0	24.7	25.4	26.1	26.8	27.5	28.2	28.9	29.6	30.3	31.0	31.7	32.4	33.1	33.8	34.5	35.2	35.9	36.6
23.6	24.3	25.0	25.7	26.4	27.1	27.8	28.5	29.2	29.9	30.6	31.3	32.0	32.7	33.4	34.1	34.8	35.5	36.2	36.9
23.9	24.6	25.3	26.0	26.7	27.4	28.1	28.8	29.5	30.2	30.9	31.6	32.3	33.0	33.7	34.4	35.1	35.8	36.5	37.2
24.2	24.9	25.6	26.3	27.0	27.7	28.4	29.1	29.8	30.5	31.2	31.9	32.6	33.3	34.0	34.7	35.4	36.1	36.8	37.5
24.5	25.2	25.9	26.6	27.3	28.0	28.7	29.4	30.1	30.8	31.5	32.2	32.9	33.6	34.3	35.0	35.7	36.4	37.1	37.8
24.8	25.5	26.2	26.9	27.6	28.3	29.0	29.7	30.4	31.1	31.8	32.5	33.2	33.9	34.6	35.3	36.0	36.7	37.4	38.1
25.1	25.8	26.5	27.2	27.9	28.6	29.3	30.0	30.7	31.4	32.1	32.8	33.5	34.2	34.9	35.6	36.3	37.0	37.7	38.4
25.4	26.1	26.8	27.5	28.2	28.9	29.6	30.3	31.0	31.7	32.4	33.1	33.8	34.5	35.2	35.9	36.6	37.3	38.0	38.7
25.7	26.4	27.1	27.8	28.5	29.2	29.9	30.6	31.3	32.0	32.7	33.4	34.1	34.8	35.5	36.2	36.9	37.6	38.3	39.0
26.0	26.7	27.4	28.1	28.8	29.5	30.2	30.9	31.6	32.3	33.0	33.7	34.4	35.1	35.8	36.5	37.2	37.9	38.6	39.3
26.3	27.0	27.7	28.4	29.1	29.8	30.5	31.2	31.9	32.6	33.3	34.0	34.7	35.4	36.1	36.8				



Figure 1.--Scribe for determining slope of grain. The needle is a phonograph needle or a moisture-meter prong. The length of the bar from the handle to the needle is about 5 inches. The needle is inclined about 15 degrees to the axis of the handle.



M 60821 F

Figure 2.--A board, with neither radial nor tangential surfaces, showing slope of grain on the face, as bo, on the edge, as co, and the combined slope within, as do.

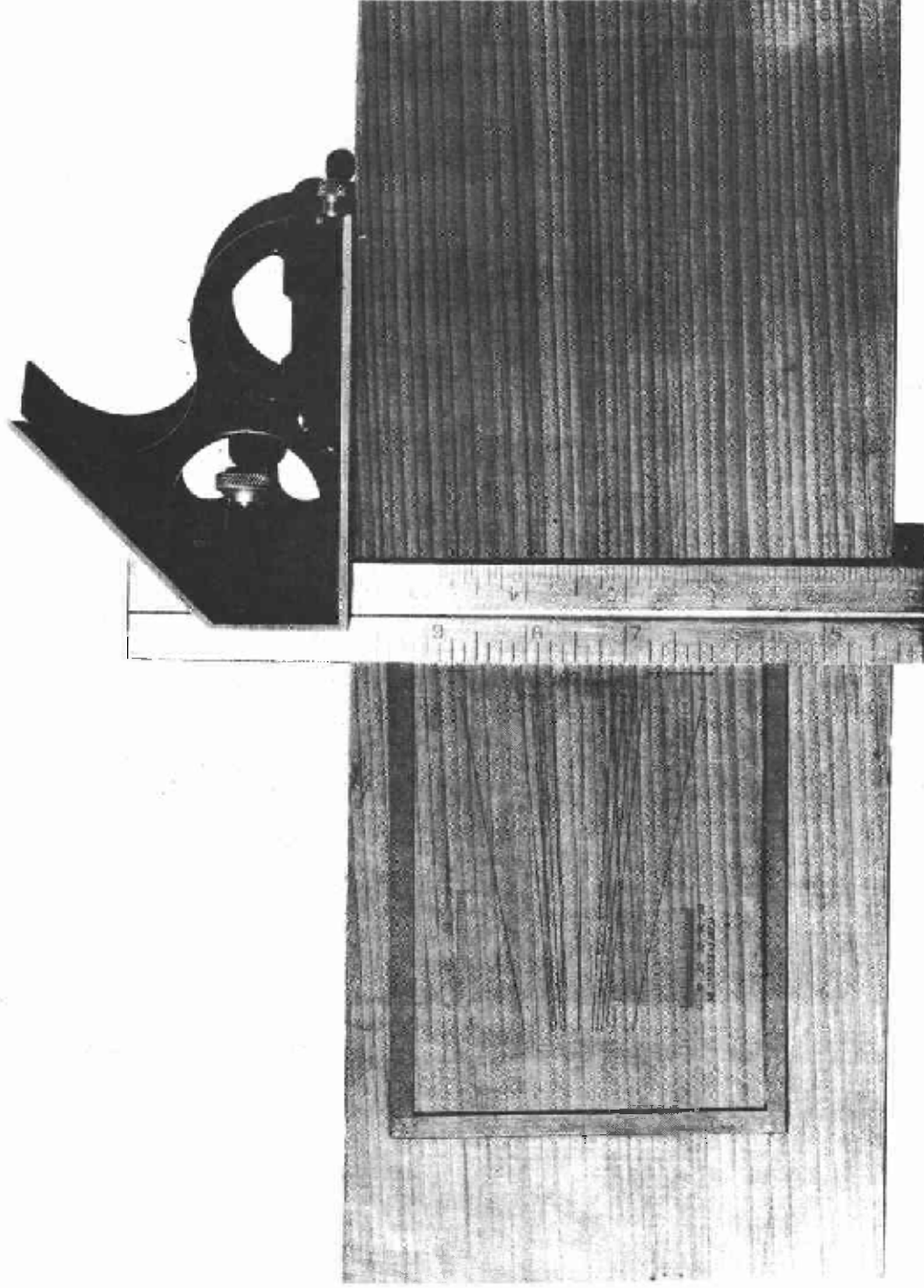


Figure 3.--Photographic glass plate, on which various slopes of grain from straight to 1 in 5 have been photographed, aligned with a square on a board for measuring slope of grain. The middle line, which represents zero slope, is at right angles to the edge next to the square. To protect the emulsion on the plate varnish may be used.

Z M 63764 F

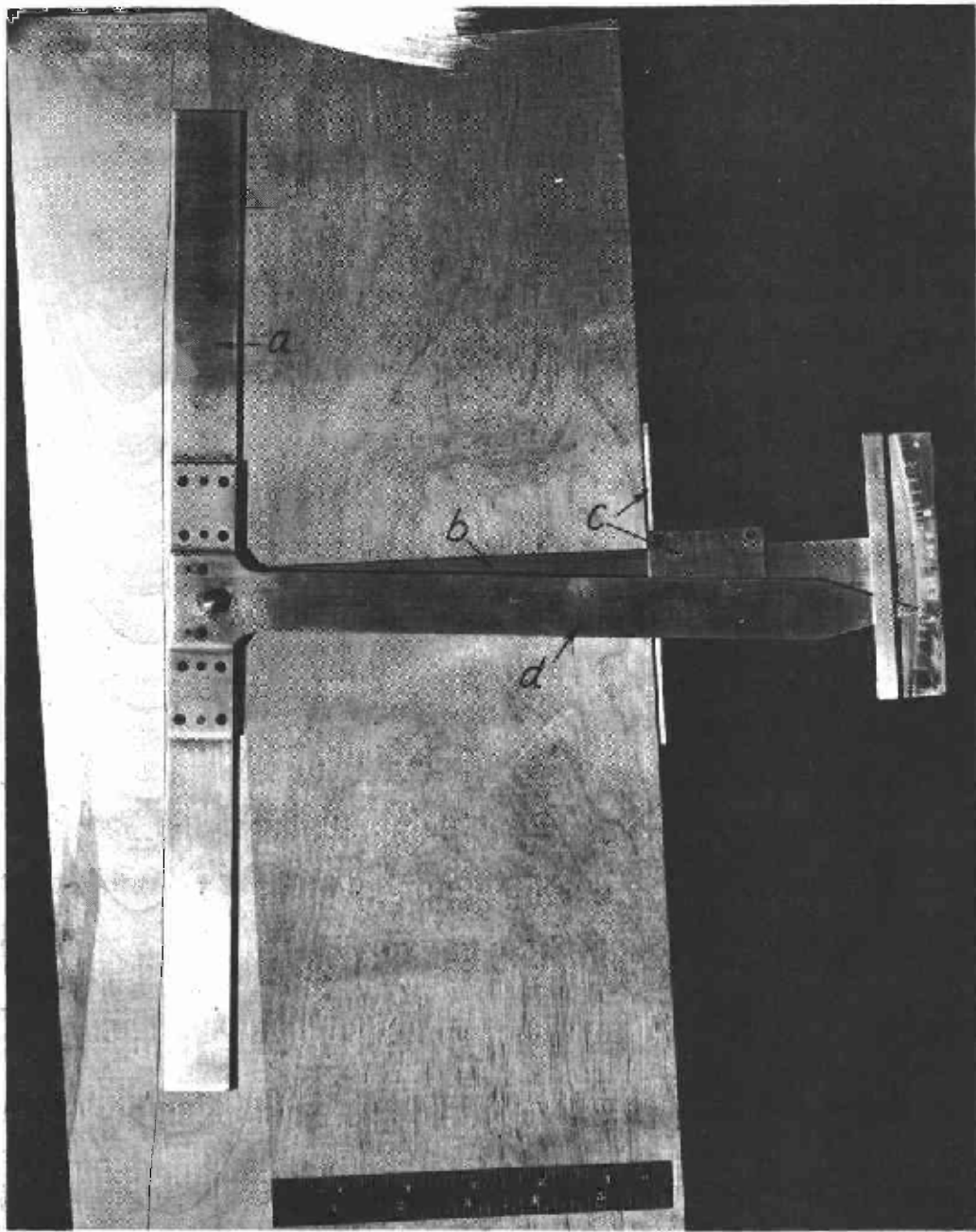


Figure 4.--Instrument for measuring slope of grain on the surface of a board on which the direction of the fibers has been previously ascertained and indicated with a line. A straightedge a pivots on the end of a flat bar b. Slide c squares the bar to the edge and allows it to be shifted back and forth across the board. Indicating arm d shows the slope of grain on the scale.

Z N 63765 F

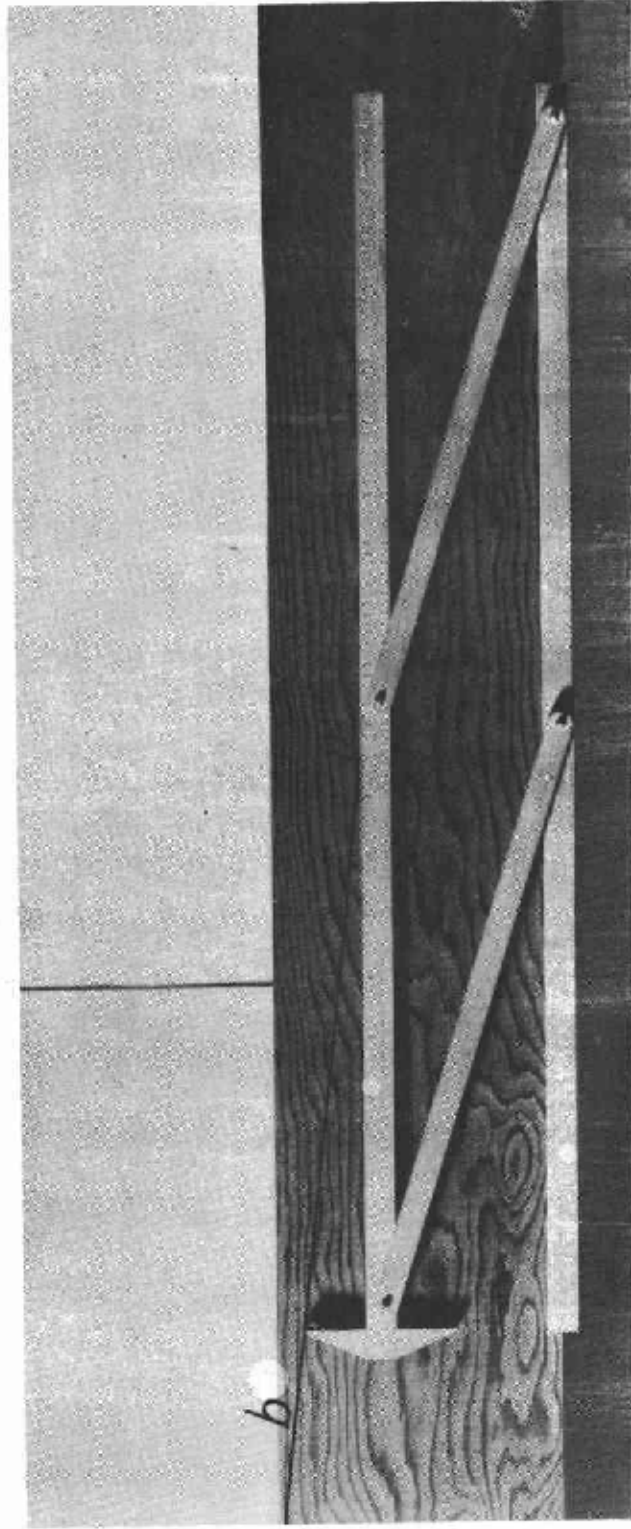


Figure 5.--Adjustable parallel bars with T-head on one bar for measuring slope of grain on any portion of the face of a board. The line b shows direction of grain as determined by a scribe.

Z M 63765 F

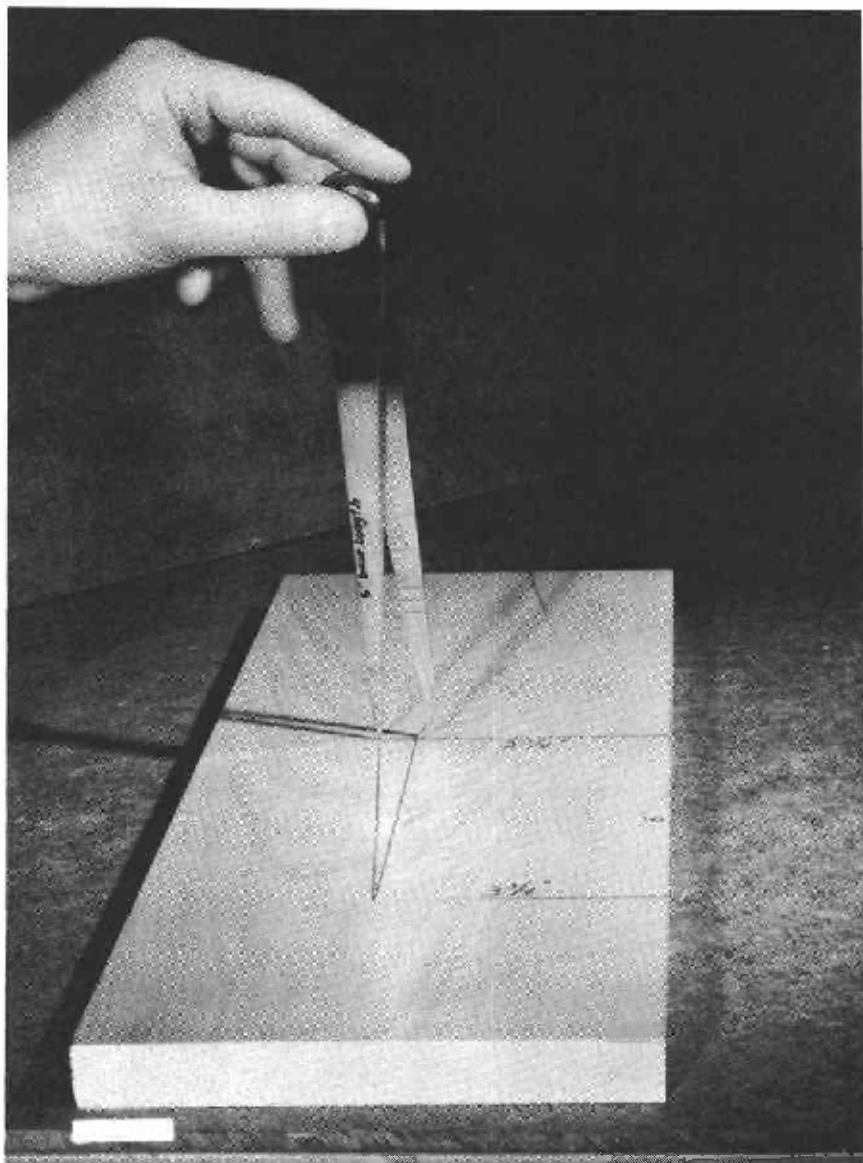


Figure 6.--Direct measurement of slope of grain in the middle of a board by means of a graduated caliper.

Z M 63766 F

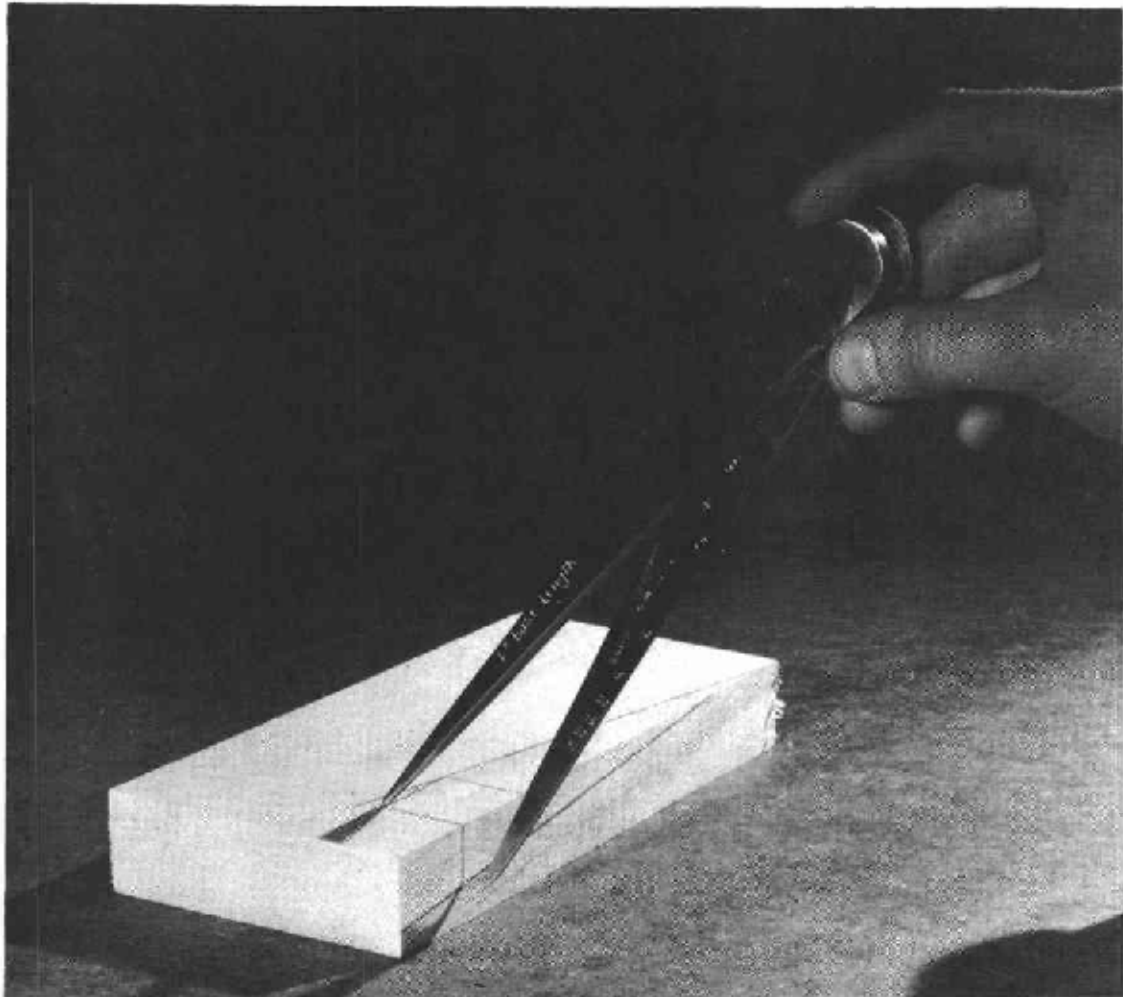


Figure 7.--Direct measurement of combined slope of grain by means of a graduated caliper using different base lines of the same length.

Z M 63767 F