MACHINING TESTS FOR PARTICLE BOARD; SOME FACTORS INVOLVED

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MACHINING TESTS FOR PARTICLE BOARD; SOME FACTORS INVOLVED[1]

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Summary

This report outlines some of the factors involved in machining particle board and describes practical tests for evaluating the machining properties of different boards. The prospective user of particle board can employ the same tests in his own shop to select a board suitable for his needs. The machining operations tested included sawing, planing, sanding, tenoning, shaping, routing, and drilling. Evaluation and comparison of the machining properties of the many particle boards on the market are outside the scope of this report.

Introduction

In the United States today there are about 50 plants that make some type of particle board. New plants are springing up almost monthly. Different brands of particle board often vary in such respects as size, shape, and orientation of the component particles, in the species of wood used, in the kind and amount of binder, and in density as affected by the degree of compression. It is only natural, therefore, that they should differ in such properties as machining.

Since particle boards are manmade, their properties are subject to a large degree of control. They can be, and are, engineered for properties (including machining) that are at least adequate for the proposed use. This explains why there is less spread in properties between the boards included in this report than between our best and poorest native hardwoods.

Particle boards, except for the few that have a special finish for decorative effect, are typically concealed in use. The broad surfaces may be veneered or covered with plastic laminate, while the edges may be banded

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[1]Presented at the annual meeting of the Forest Products Research Society at Buffalo, N. Y., on June 25, 1957.

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

with solid wood for cabinet use or finished with a metal molding for counter tops.

Because of this concealment, machining is a less important property than it is with finish lumber. Nevertheless, particle board is often planed, sanded, drilled, shaped, routed, and tenoned. Machining, therefore, is one of the factors with which the consumer is concerned when he selects a board for his special use. Because of their structure, however, most particle boards do not machine so smoothly as lumber, and for most uses different measures of evaluation would apply.

Materials Tested

The experimental work was done with seven commercial boards from 5/8 to 13/16 inch thick, representing the chief types on the market. Table 1 lists some characteristics of these boards. Except for boards Nos. 1, 6, and 7, they all weigh close to 40 pounds per cubic foot.

Figure 1 shows the surface appearance of these boards as they are sold. The board numbers used in figure 1 are used for the same samples in all figures. Boards Nos. 1, 2, 3, and 4, the flat-press boards, were all pre-sanded. No. 4 has a smooth decorative surface of especially prepared flakes. The extruded boards, Nos. 5, 6, and 7, have some surface glaze as well as some concentration of fines on the surface.

The material was conditioned to 30 percent relative humidity before test.

Particle Board Texture

Particle board texture depends largely on the size and shape of the particles and on the degree of compression. Many boards have numerous openings or voids between particles. These occur through the entire sheet. Particle board No. 2 is compared with oak in figure 2. Oak is about as coarse-textured as any of our common woods. Both samples were sanded with a coated abrasive of about the same fineness, and the scratches would not be visible without enlargement. The voids in the particle board are much wider and deeper than the pores in the oak. Because of voids it is often necessary to crossband particle board core stock before applying the finish veneer, in order to prevent "dimples" from "telegraphing" through and showing on the surface. Voids also explain why particle board cores are not used with exposed edges in good quality work.

Particle Board Grain

Particle board grain results from the way the particles are oriented to the broad surface of the board. Figure 3 illustrates typical grain in flat-press and extruded boards.

Samples 3B and 3C are cut from the same flat-press board, 3A, to show end views. Both reveal a general tendency for the particles to become oriented with their plane parallel to the broad surface of the board. They machine alike because they have similar orientation of particles.

Samples 7A, 7B, and 7C, represent an extruded board. In contrast to those of flat-press board, the particles in this board tend to become oriented with their plane perpendicular to the surface, as is clearly shown in samples 7A and 7B. Sample 7C, however, has a different particle arrangement, because of which adjacent edges in this board machine as differently as end grain and side grain in lumber.

Power Consumption and Tool Dulling

Different amounts of power are required to cut different particle boards, depending on density and other properties. The seven test boards were reduced to a uniform thickness of 5/8 inch before test. An 8-inch carbon-steel circular saw with combination-type teeth was used. Since the first keenness of freshly sharpened saws does not last long, the saw was first run through 200 lineal feet of particle board in order to dull it slightly and thereby get more typical test results. The saw was set to project 1/2 inch above the test material, which was mechanically fed at 16 feet per minute. Table 2 shows the results obtained with a recording wattmeter.

In spite of some slight inconsistencies, the expected trend is quite evident; the denser the board, the more power is required. Extruded boards, Nos. 5, 6, and 7, required more power in proportion to weight than the flat-press boards. Three times as much power was needed to cut the heaviest, No. 7, as to cut the lightest, No. 1.

Particle boards are commonly reported to dull cutting tools more rapidly than lumber does. Data of table 3 show that much may depend on the board under consideration. Table 3 compares No. 1, the lightest, and No. 7, the heaviest board -- both of which happen to be of Douglas-fir -- with a common core wood, sweetgum. Power readings were taken on a recording wattmeter at the start and after each 100 lineal feet of cut. A freshly sharpened saw was used for each material, and the increase in power consumption was taken as a measure of dulling.

For the 400 lineal feet of cut tested, at least, more power was required to saw the sweetgum lumber than the lighter board, No. 1, but less than the heavier board, No. 7. The rate of dulling, however, was more rapid for both particle boards than for the sweetgum. The power required to saw board No. 1, for instance, was 1.8 times greater after the saw had gone 400 lineal feet than it was at the start. The power required to saw board No. 7 was 2.17 times greater after the saw had gone 400 feet but only 1.44 times greater for the sweetgum. Because of the more rapid dulling produced by the particle boards, their power consumption might well be much higher after an hour's sawing.

Although board No. 1 required less power to saw than the sweetgum, it was lighter than most particle boards and may have been an exception to the rule. Any board that exceeds 30 pounds per cubic foot in weight (and this includes the great majority) is somewhat heavier than sweetgum and substantially heavier than yellow-poplar, which are probably the two favorite core woods. The additional power required to saw particle boards is, therefore, due in part to their greater density. Another factor, of course, is the binder used to make particle boards, usually about 8 percent by weight.

Machining Tests

Sewing

The chief problem met with in sawing particle board is rapid saw dulling. In plants of any size, carbide-tipped saws are usually used to avoid it.

Because of its texture, particle board cannot be expected to saw as smoothly as lumber, but this is relatively inconsequential because the sawed edges are normally concealed in use. Where it is desirable to minimize the chipping out of particles on the corners of sawed edges, the following steps will help considerably: keep saws sharp, reduce the feed rate, and keep the saw slot as narrow as practical. On the other hand, if it is desired to compare several different boards, the combination of a dull saw, a fast feed rate, and a wide saw slot will increase the chipping and accentuate any differences that may exist between the different boards.

With extruded boards, sharper corners will generally be produced by first sawing perpendicular to the grain and then parallel to the grain.

With respect to edge chipping, the seven boards fell into two groups: the better group consisted of boards Nos. 3, 4, 6, and 7, which were about equal. These in the second group, Nos. 1, 2, and 5, were also about equal but at a slightly lower level.

Planing

Before applying veneer, particle boards are sometimes planed to the required thickness. Other things being equal, a smooth planed surface is preferable for veneer application. As in other machining operations, the results vary not only between different brands but with any given brand under different machining conditions.

Figure 4 shows the results obtained with a cabinet planer at 3,600 revolutions per minute and a feed of 36 feet per minute with a 1/16-inch cut. These were not necessarily the best machining conditions. The object, however, was to show differences in the behavior of different boards when treated alike under typical shop conditions. Direction of feed had little effect on quality of surface in the flat-press boards, Nos. 1, 2, 3, and 4. These four do, however, differ noticeably in the openness of the planed surface because of differences in manufacture, such as kind of wood, size of particles, and amount of compression used. With the extruded boards, Nos. 5, 6, and 7, direction of feed was a significant factor. These three boards were fed both at right angles to the chip direction and parallel to it. As shown in figure 4, the results were consistently better in boards fed parallel to the chip direction. Fortunately, the machine operator usually has an option as to the direction of feed. Cuts were made at 1/32, 2/32, and 3/32 inch, but cut depth appeared less important than it is with lumber, although the shallower cuts gave somewhat better results. Roughening of the surface in planing results in part from the voids that are found to some extent in all particle boards, and in part from chip tearouts. In general, chip tearout can be reduced by adjusting the feed and speed rates to increase the number of knife cuts per inch.

Sanding

A sheet of particle board as it comes from the press often varies in thickness at different points by as much as 1/16 inch or more. This variation is too great for core stock, and sanding is commonly done to size all sheets to a uniform thickness. Six- and eight-drum sanders are generally used for this job. A thickness tolerance of ± 0.005 inch is common commercial practice, and this can sometimes be bettered under favorable conditions. In addition to sizing, sanding removes any surface glaze that may be present in extruded boards.

Sanding creates a smoother surface than planing, mainly because it does not produce the chip tearout that may result from planing, as well as eliminating minor surface irregularities. Once boards are sanded differences in their surface smoothness depend chiefly on the size and number of the voids. Significant differences in this respect can be detected by careful visual examination and comparison. Since the voids are distributed throughout the thickness of the board, sanding beyond a certain point does not improve the results.

Tenoning

Particle board cores are typically edge banded with narrow hardwood strips to which they are joined with a tongue and groove. The groove is cut on the strips, and the tongue is cut on the particle board. Frequently the tongue is cut on a double-end tenoner, and the process is referred to as tenoning. In this test the tongue was cut on a spindle shaper at 5,400 revolutions per minute.

The results differed quite noticeably in different boards. Board No. 4 produced the smoothest cut, Nos. 1 and 5 the roughest, and the remaining four boards produced intermediate cuts. With the four flat-press boards, Nos. 1 to 4, there was no noticeable difference in the tenoning of adjacent edges. With the three extruded boards, however, cutting parallel to the grain gave noticeably smoother work than cutting across it.

Banding extruded boards for core stock is an operation that is necessarily performed on all four edges, including the two that are more difficult to machine.

Shaping

Although corners and edges of particle board are not customarily exposed in use, they are sometimes shaped to receive metal fittings or for other reasons.

Figure 5 shows the results obtained when a cove was cut on one corner of the boards with a spindle shaper at 5,400 revolutions per minute. Board No. 4 gave the smoothest cut. Boards Nos. 2, 3, and 7 were about equal, but not quite so good. Boards Nos. 1, 5, and 6 were also about equal but again at a slightly lower level. In the extruded boards, the cuts parallel to the grain were smoother than cuts made at right angles.

Routing

Particle board panels must sometimes be grooved for insertion of shelves and dividers. In this test, grooves 3/8 inch wide by 3/8 inch deep were cut 1/4 inch from the edge to show more plainly any tendencies for chips or particles to break out that might be present in some boards. Cuts varied in smoothness (fig. 6), as in preceding tests, and in general the order of quality remained about the same among the different boards. The extruded boards all exhibited pronounced break-out tendencies when machined across the grain. The cuts shown in figure 6 were made with a high-speed router at 18,000 revolutions per minute. A second series of grooves, cut with a dado head, gave much better results -- too good, in fact to show any significant differences in break-outs.

Drilling

Where particle board is doweled, drilling quality will be important. Two factors are to be considered: smoothness of cut and trueness of hole size. A serious deficiency in either will reduce the strength of the doweled joint. A series of holes 1 inch deep were drilled with a 3/8-inch wood bit in adjacent edges of samples of the seven boards tested. Although it is by no means precise, significant differences in trueness of hole size can be detected with an accurately sized dowel. Boards Nos. 2, 3, and 7, provided the best fit. The test samples were then resawed to show the walls of the drilled holes. A considerable variation in smoothness of cut is apparent from figure 7. Since the four flat-pressed boards, Nos. 1, 2, 3, and 4, had no grain direction, they drilled the same in both edges, and only one sample of each is shown. For the three extruded boards, Nos. 5, 6, and 7, results on two adjacent edges are shown in figure 7 to illustrate effects of grain direction.

It has been shown[3] that the strongest dowel joints are obtained when the holes are 1/64 t0 2/64 inch larger than the dowel.

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[3]Nearn, W. T., Norton, N. A., and Murphey, W. K. Strength of Dowel Joint as Affected by Hole Size and Type of Dowel. Journal of the Forest Products Research Society 3(4):14, Nov. 1953.

Conclusions

Particle boards of the core type differ from finish lumber in several respects:

1. They differ from lumber in structure, because they are composed of wood particles that are resin-bonded together under heat and pressure.

2. Because of this different structure they differ from lumber in machining and other properties.

3. Requirements for particle boards of the core type differ from those for finish lumber because they are typically concealed in use.

4. Although the same machining operations can be performed on both particle boards and wood, particle boards do not machine so smoothly, but because they are typically concealed, a lower quality of machine work is adequate.

5. Different particle boards differ in machining properties. Since they are manmade products, they are engineered to have adequate machining properties, and there is less variability than between some species of lumber.

6. Visual examination is sufficient to reveal significant differences in the machining properties of different particle boards.

7. Most particle boards require more power to saw than do the common core woods, and particle board dulls saws faster than does lumber.

Table 1.--Characteristics of particle boards tested for machining properties

Board No.	Process	Species used	Approximate weight
			Pounds per cubic foot
1	Flat press	Douglas-fir	31
2	....do.....	.........do.....................	39
3	....do.....	White pine, including some bark	42
4	....do.....	Douglas-fir, including some bark	38
5	Extrusion	Eastern redcedar, yellow poplar, sweetgum, maple, elm	38
6	....do.....	Maple, birch, aspen, cherry	45
7	....do.....	Douglas-fir	48

Table 2.--Power consumed in sawing different particle boards

Board No.	Process	Approximate weight	Power required to saw
		Pounds per cubic foot	Watts
1	Flat press	31	240
2	.....do......	39	320
3	.....do......	42	320
4	.....do......	38	360
5	Extruded	38	560
6	.....do......	45	720
7	.....do......	48	720

Table 3.--Comparative dulling rates when sawing particle boards of Douglas-fir with sweetgum cores

Amount sawed	Power consumed		
	Board No. 1	Board No. 7	Sweetgum lumber
Lineal feet	Watts	Watts	Watts
0	200	480	360
100	240	600	400
200	280	880	440
300	320	920	520
400	360	1,040	520

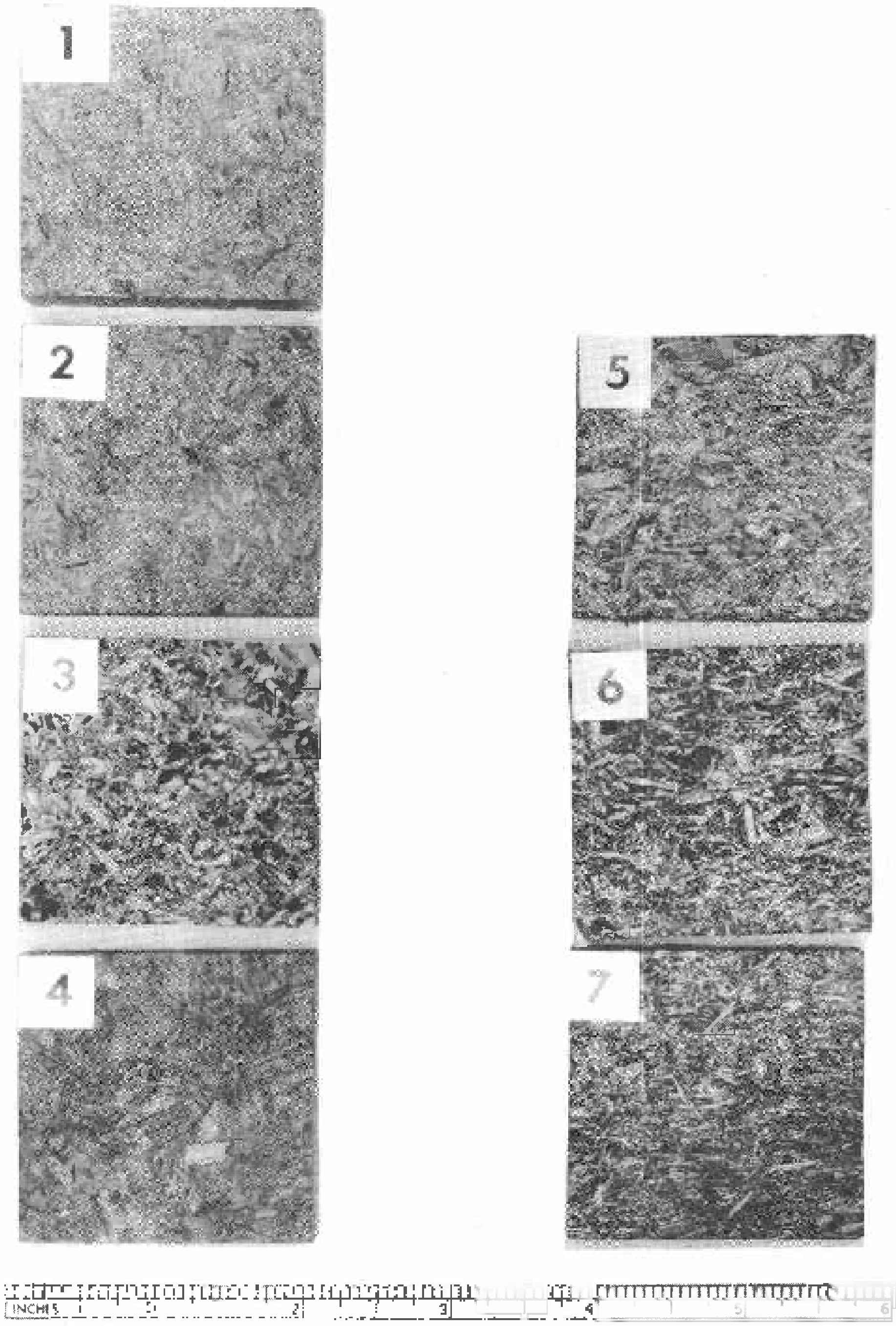

Figure 1. --Surface appearance of the seven particle boards used in machining tests.

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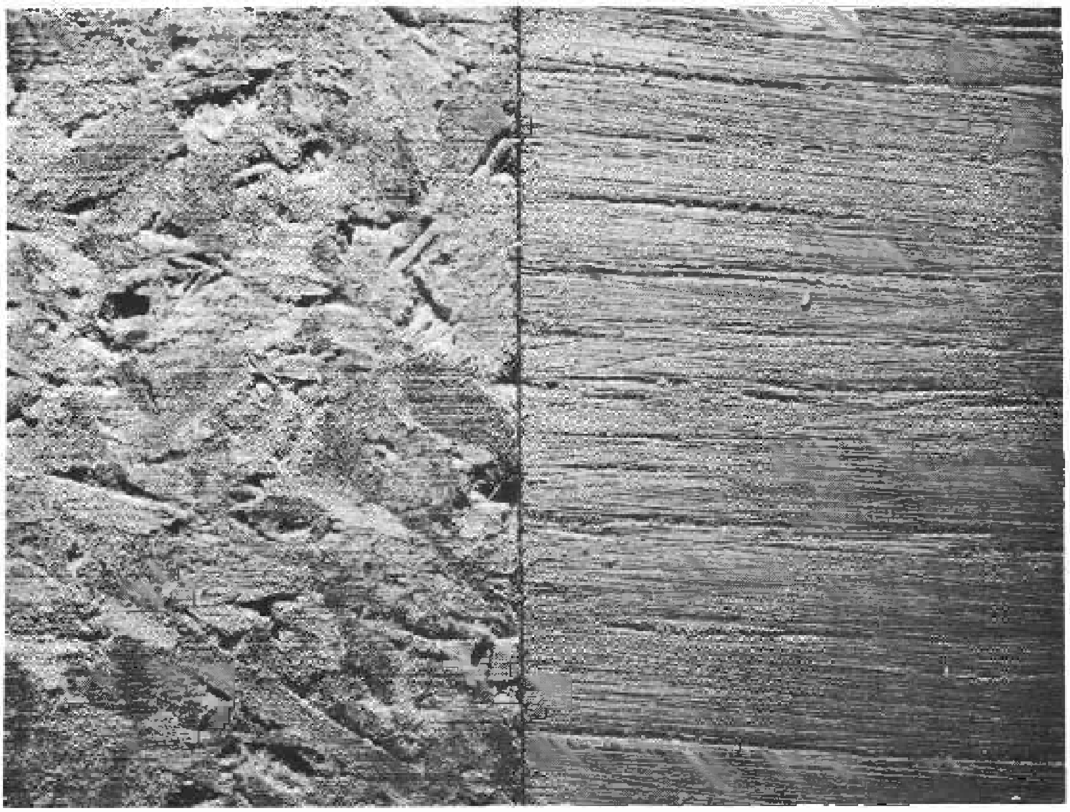

Figure 2. --Comparison of surface appearance (enlarged) of particle board No. 1 with white oak after being sanded.

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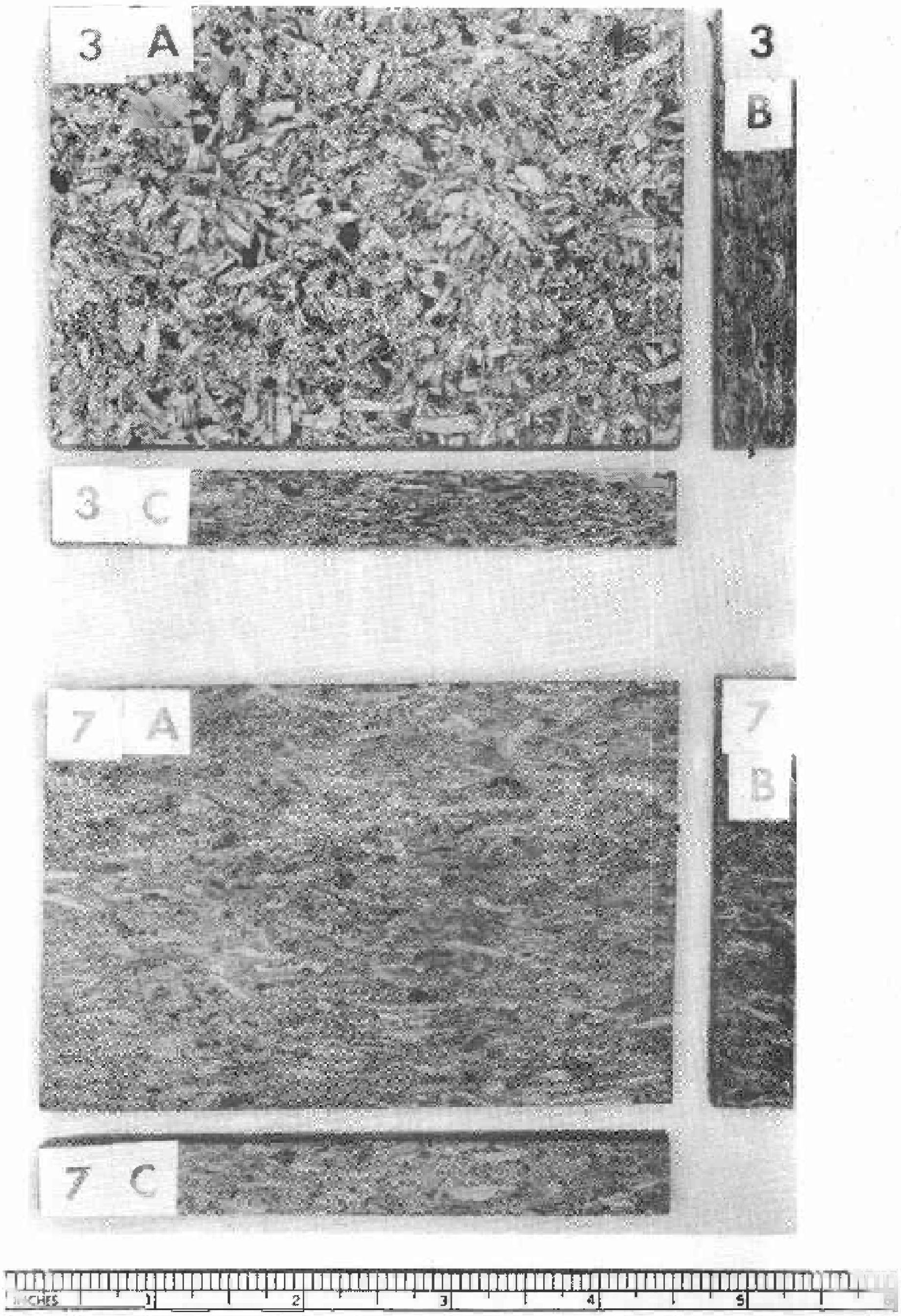

Figure 3. --Formation of "grain" due to chip orientation in a flat-pressed board, No. 3, and an extruded board, No. 7.

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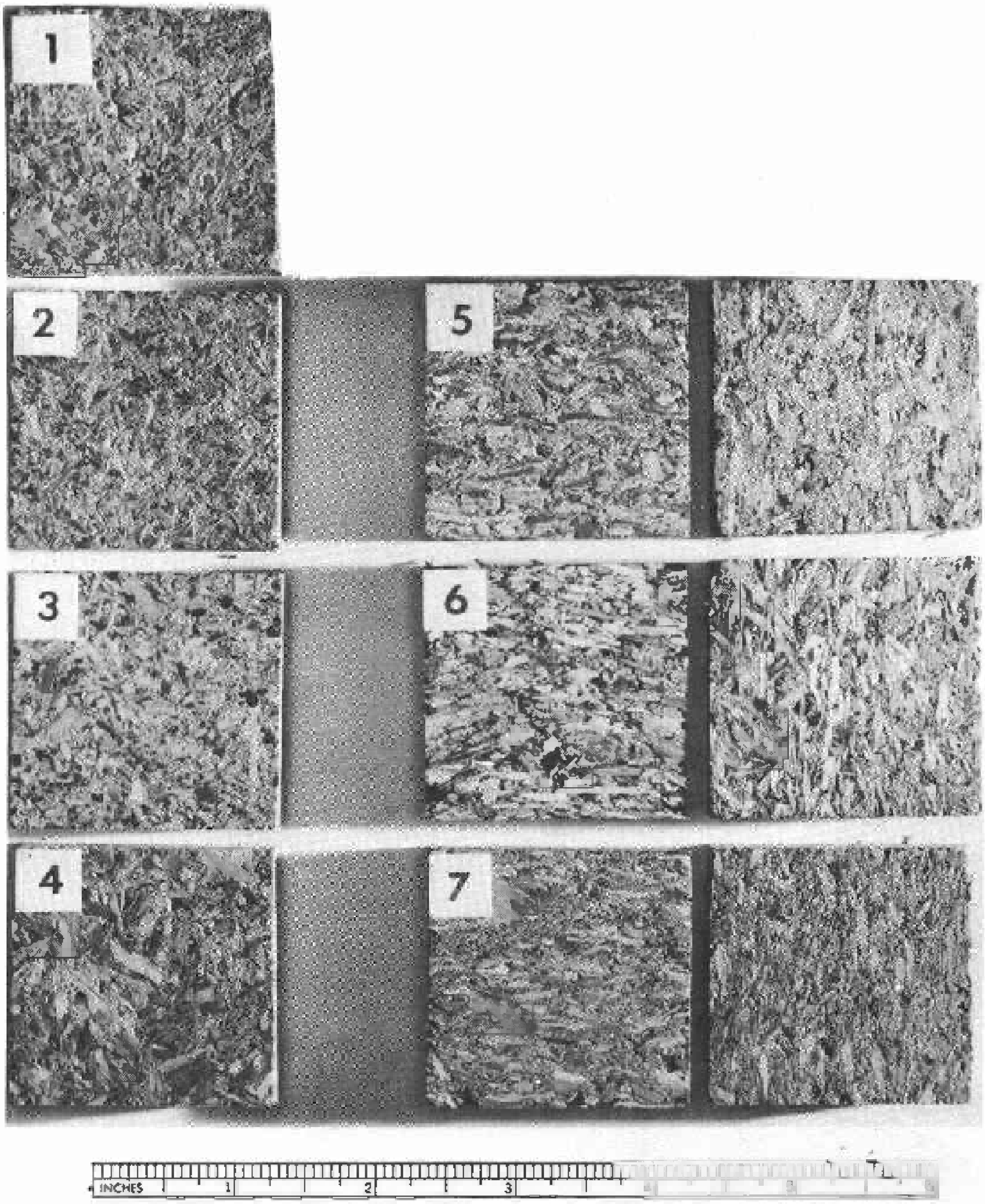

Figure 4. --Planing quality of the seven particle boards.

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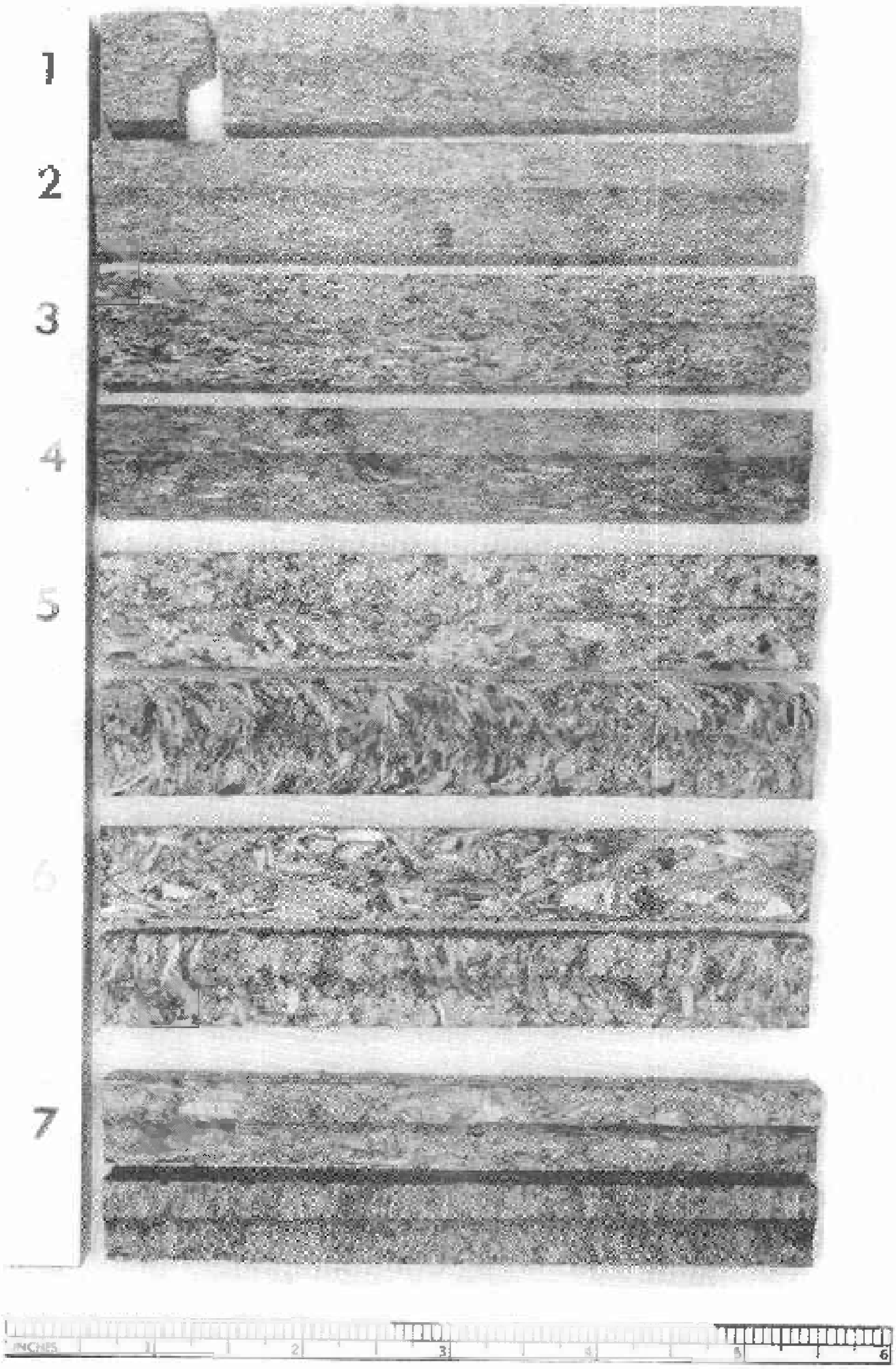

Figure 5. --Shaping quality of the seven particle boards.

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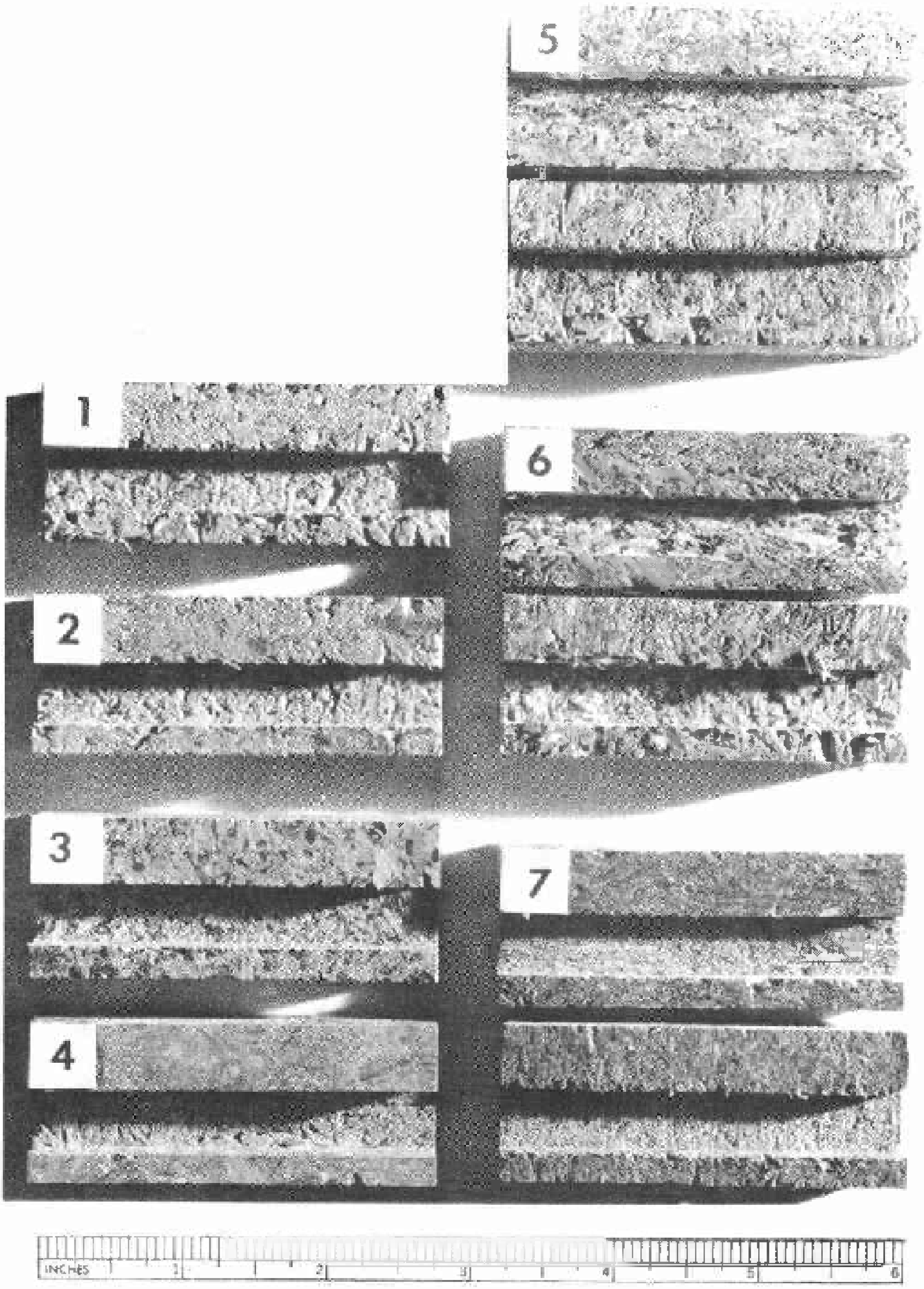

Figure 6. --Routing quality of the seven particle boards.

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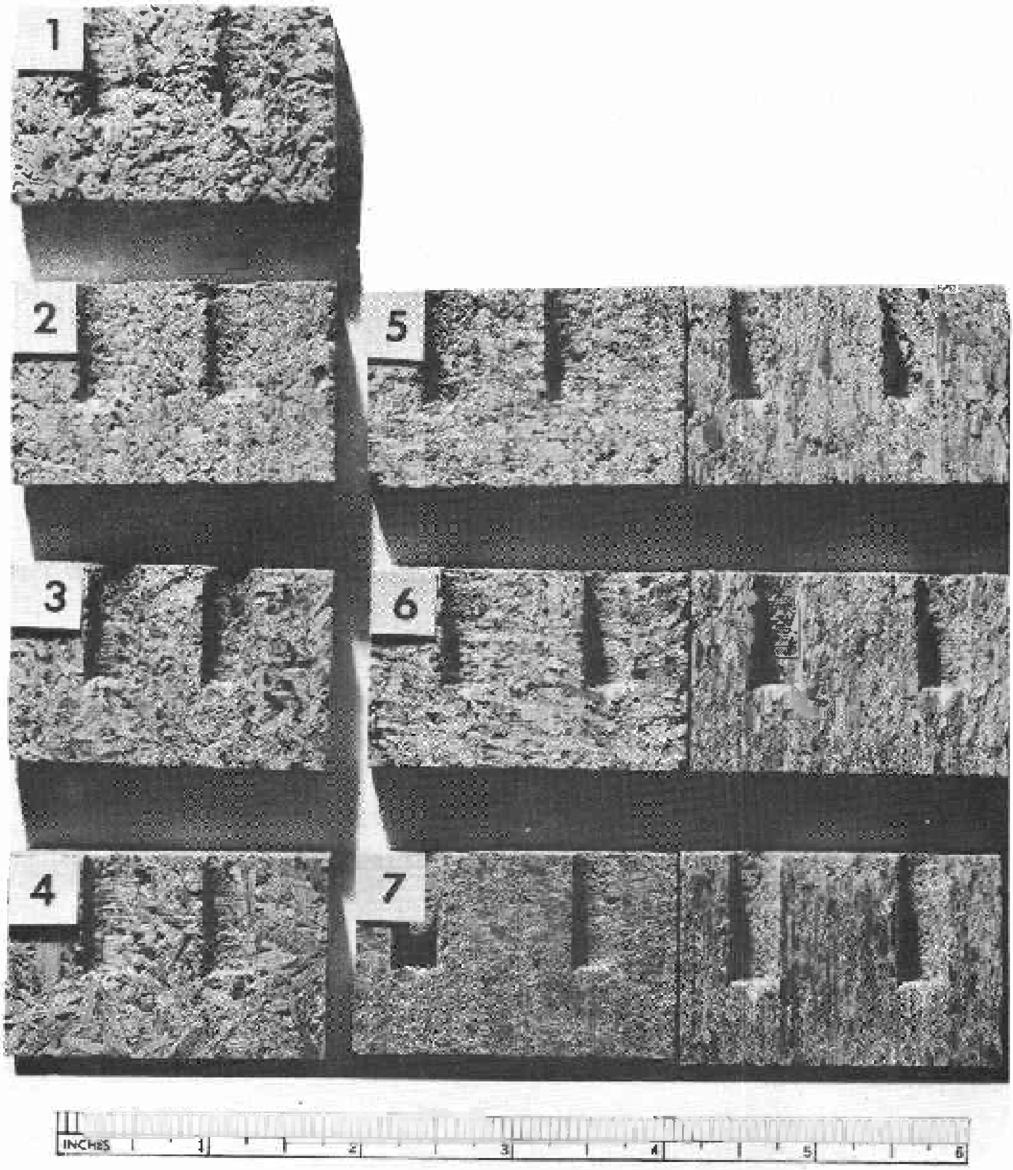

Figure 7. --Drilling quality of the seven particle boards.

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