Raised Grain—Its Causes and Prevention

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THE term "raised grain" is used with at least three different meanings by lumbermen and woodworkers. These meanings are: (1) the condition of the surface of a board that has a corrugated feel and appearance after it has been planed (Fig. 8); (2) the loosening and raising of the tops and edges of the annual layers of growth on the surface of a board so as to form projecting slivers and to give the appearance of the annual layers of growth shelling off (Fig. 1); and (3) the loosening of individual fibers or groups of fibers at one of their ends, making them project from the surface like fuzz or fur (Fig. 2). Only the first of these meanings conforms to the accepted definition of raised grain given in American Lumber Standards. The second meaning conforms to the definition of loosened grain, while the third condition is not described in American Lumber Standards because it is not ordinarily recognized as a defect. All of these conditions, however, are objectionable, especially in woodwork that is to be given coatings of finish. Although an intensive study of the various types of raised grain has not been made. numerous observations have disclosed certain facts and suggested certain remedies that will be discussed here.

Corrugation of the Surface

The corrugated appearance of the surface of lumber, as here referred to, is due to the summerwood (the harder layer of each annual growth ring) projecting above or being depressed below the level of the softer springwood. It occurs particularly in woods with pronounced difference in structure between the summerwood and the springwood, especially among the softwoods, but has also been observed in wood **with** such relatively uniform structure as yellow poplar.

In flat-grain lumber, corrugation of the surface is due principally to the planer knives crushing the hard summerwood into the softer springwood beneath it and the summerwood subsequently being raised up as the springwood cells underneath gradually resume their original shape to some extent. Figure 3 represents a magnified cross section of a piece of white fir showing the crushed condition of the springwood cells near the surface.

It is well known that mechanically compressed wood swells more on absorbing moisture than normal wood. Hence if flat-grain lumber is planed while dry and later is allowed to absorb moisture the summerwood may rise considerably because the crushed springwood to a large degree returns to its original size. A study of raised grain made by E. M. Davis of the Forest Products Laboratory shows that, in general, the least corrugation took place in lumber in which no change in moisture content occurred after maching and that the most corrugation took place in lumber planed at a low moisture content and subsequently placed in damp air. Such rising of the grain evidently is a gradual process, since there was more of it at the end of two weeks than after one week, and more then than immediately after planing. Some rising of grain was found even in surfaced lumber that did not change in average moisture content.

The pounding of the summerwood into the springwood is evidently aggravated by dull planer knives, as might be expected.

*Maintained at Madison, Wis., in co-operation with the University of Wisconsin.

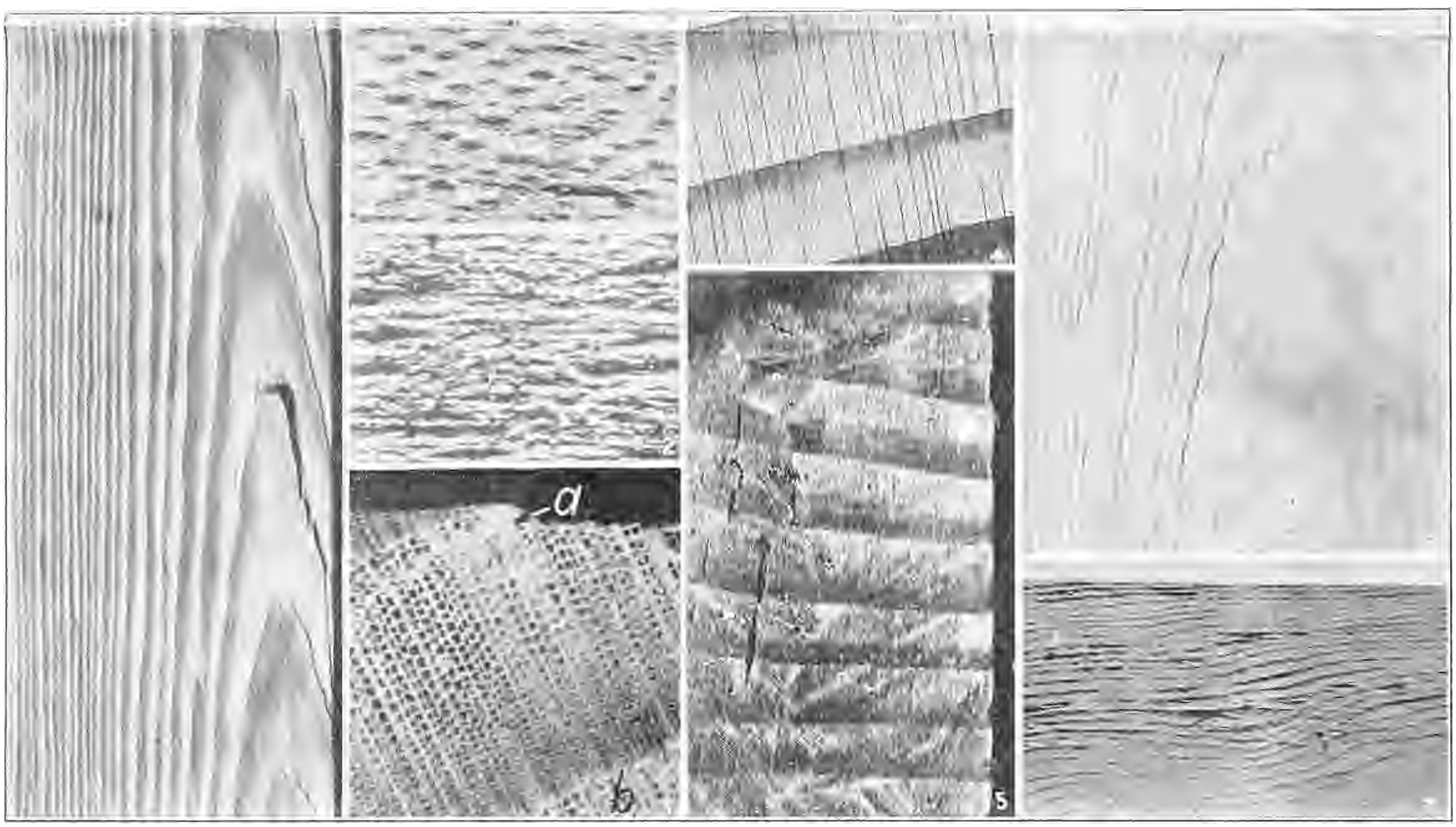

Fig. 1—Loosened grain on the pith side of Southern yellow pine flooring. All pattern stock should be dressed with the face on the bark side unless serious defects predominate on that side. Fig. 2—A. The planed surface of a mahogany board showing very little fuzz. B. The sanded surface of the same board showing numerous projecting fibers. Fig. 3—The crushed condition (a) o fthe springwood under the summerwood, near the surface, in an enlarged cross section of corrugated white fir. Note that the springwood cells (b) in the annual ring below are not crushed. Fig. 4—An enlarged view of a thin cross section of Douglas fir. The inner and softer part of a band of summerwood runs out into a thin edge on the bark side at the top. The outer and harder part of another summerwood band runs out into a thin edge on the pith side, with an abrupt change to the soft springwood contiguous to it. Fig. 5—The corrugated edge of an enlarged cross section of Douglas fir, caused by dressing an edge-grain face when it was wet, with subsequent drying. Noe the shrinkage of the summerwood. Fig. 6—The pattern of the grain showing through a coating of paint on a Southern yellow pine board. This condition can be reduced and sometimes even avoided by proper attention to the lumber and the planers. Fig. 7—Painted drop siding showing loosening of the grain along the edges of the summerwood where it comes to the surface. If the siding had been machined so that the face were on the reverse side this loosening would not have happened.

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In some boards planed with a sharp planer at the Forest Products Laboratory there was no evidence under the microscope of crushing of the springwood. Other machine conditions, such as the bevel of the knife edge, the heel on the knives, the knife speed, and the feed of the work may also affect the rising of grain but no study was made of this subject by the writer. Wood planed by hand is said to show very little corrugation afterward.

The corrugation of flat-grain lumber was found by Davis to be more common and more pronounced on the pith side of a board than on the bark side, as is shown in Figure 8. (The terms "pith side" and "bark side" are here used to designate respectively the sides toward and away from the center of the tree.) This difference in the behavior of the two sides can be attributed to the more or less gradual transition of springwood into summerwood, as follows:

On the pith side of a flat-grain board there is a sudden transition from the outermost and hardest part of the summerwood of an annual ring to the innermost and softest portion of the springwood of the contiguous annual ring underneath it; see the lower side of the board in Figure 4. This hard portion of the summerwood, where it comes to the surface in thin edges, offers the maximum resistance to cutting and the soft springwood underneath offers the least resistance to indentation; hence a maximum crushing of summerwood into springwood occurs at that point. On the bark side of the board it is the inner and softer portion of the summerwood that diminishes to an edge where the summerwood band intersects the surface, and this comparatively soft portion of the summerwood is underlain by the harder portion of the springwood band of the same annual ring; see the upper side of the board in Figure 4. Consequently, the summerwood at that point does not offer as much resistance to cutting and the springwood offers more resistance to indentation immediately below the surface. Farther to the left along the top surface of Figure 4, where the summerwood is both harder and thicker, the stresses caused by the pounding of the planer knives are partly absorbed and more evenly distributed before they reach the softest portion of the springwood beneath so that, as a rule, crushing does not take place on the bark side of the board.

Specific gravity and width of annual ring appear to have no effect on the degree to which the surface becomes corrugated. Davis examined numerous boards of six softwood species and found no consistent difference in this respect either between heavy and light boards or between slow and fast growth. In general, the least amount of corrugated surface is found in species having little contrast between springwood and summerwood, such as white pine and cedar.

In edge-grain lumber a different situation holds with respect to the cause for corrugated surfaces; here it is a difference in shrinkabe between springwood and summerwood. Summerwood shrinks more across across the grain than springwood. Hence, if edge-grain lumber is dressed when it is at a relatively high moisture content the summerwood bands will recede below the level of the springwood bands as the lumber dries, giving the surface a "washboard" appearance. (Fig. 5.) If dry edge-grain lumber is surfaced and later allowed to absorb moisture, the summerwood will stand out above the springwood, with a washboard appearance again resulting. The continuity of the summerwood bands inward from the surface of edge-grain lumber is responsible for considerable shrinkage stress and deformation. In flat-grain lumber, on the other hand, each summerwood band extends inward only a very small distance before it alternates with a springwood band of less shrinkage potential and therefore purely shrinkage differences do not produce such pronounced differences in springwood and summerwood levels as in edge-grain lumber. Furthermore, the fact that the tangential shrinkage is comparatively high, in some species more than twice that of the radial, augments the shrinkage effect on edge-grain faces.

Both edge-grain and flat-grain lumber may, also become corrugated in machining through dull planer knives tearing out more of the soft springwood than of the harder summerwood, and in service by the springwood becoming worn away more rapidly through mechanical abrasion, erosion (shingles are an example), and weathering. In the so-called "sugi" finish in cypress and in other species used for decorative panels the soft springwood is brushed or sand blasted down so that the summerwood projects coonsiderably.

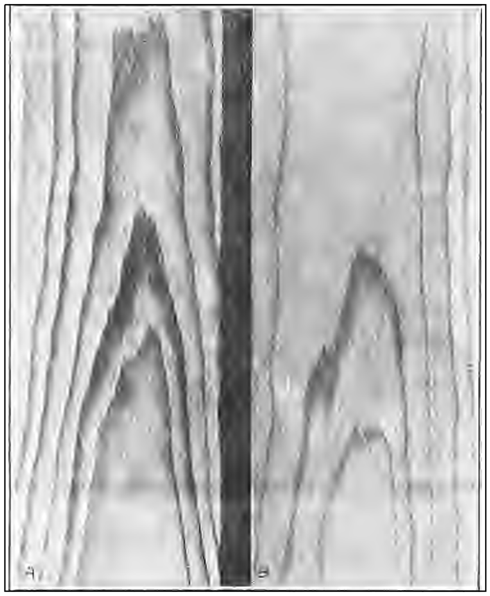

Fig. 8—A. Raised grain on the pith side of a white spruce board. B. The bark side of the same board, without raised grain.

Reduction in the amount of the type of raised grain that is characterized by a corrugated condition of the surface of the lumber evidently can be attained by sharpening planer knives properly and then keeping them sharp and, further, in not allowing the surface of the lumber to change appreciably in moisture content. For outside work, the second suggestion, of course, will not apply, since wood exposed to the weather will change in moisture content even when painted. It has been demonstrated by F. L. Browne of the Forest Products Laboratory that rising of the summerwood may occur under paint films, thereby not only causing the pattern of the grain to show through (Fig. 6) but also loosening up the paint film and thus necessitating early repainting.

Loosening of Tips and Edges of Growth Layers

The type of raised grain that is characterized by loosening of the tips and edges of the annual rings on the surface of flat-grain lumber is also due primarily to dull or improperly sharpened planer knives and to changes in moisture content, although the two causes act here in a somewhat different manner than they act in producing corrugated surfaces.

The pounding action of the planer knives may be severe enough to break down the springwood immediatey below the first layer of summerwood so that little or no subsequent shrinkage stress is required to separate the annual rings near the surface. (The stresses again are dissipated farther beneath the surface.) That pounding wood on its flat-grain face will separate the annual rings was known to the Indians and early settlers, who used the method to separate black ash bolts into splints for basket weaving.

Pronounced shrinkage stresses are developed where springwood adjoins summerwood because the springwood tends to shrink less transversely, as already stated, but more longitudinally than the contiguous summerwood. The stress resulting from this difference in shrinkage is more localized at the boundary of contiguous annual rings, where the transition between springwood and summerwood is very abrupt, than between springwood and summerwood in the same annual ring, when the transition is more gradual. With the crushing of the springwood and the shrinkage stresses working together to separate the annual rings it is surprising that more shelling of annual rings does not occur on the surface of planed lumber. It is at the tips of the annual rings that the largest and most uniform flat expanses of springwood and summerwood occur near the surface and hence these portions can develop the greatest differential shrinkage stresses caused by surface change in moisture content. Therefore, separation usually takes place first at the tips of the summerwood bands, and then later it takes place along the edges, where the summerwood comes to the surface.

The shelling of the annual rings is more pronounced by far on the pith side than on the bark side of flat-grain lumber. This difference comes from three main causes. On the pith side of a board the tips of the annual layers of growth run out and therefore are more easily loosened than on the bark side where they run in and are covered up by subsequent layers. On the pith side the tips and edges of the summerwood present a more abrupt transition in hardness from the springwood beneath, as already explained, and therefore the springwood is subjected to more severe crushing and breaking down than on the other side where the transition is more gradual. The greater longitudinal shrinkage of springwood tends to pull the summerwood of the same annual ring loose and away from the surface on the pith side as in Figure 1. In addition, the curvature of the annual rings makes it easier to bend an annual layer of growth away from the surface on the pith side, just as it is easier to bend a quill point inward than outward.

The objections to shelling of the annual layers of growth are plain. The projecting slivers make handling, working, and painting difficult and dangerous. In flooring such slivers are particularly objectionable in mopping and dusting. And when the wood layers loosen up along their edges in service they not only spoil the effectiveness of the paint film by breaking it but also make repainting difficult. (Fig. 7.)

To reduce to a minimum the shelling of the growth layers, which occurs especially in softwoods, the same precautions as those suggested for reducing the corrugation of the surface recommend themselves, namely, keeping the planer knives in good condition and drying the wood before planing and storing it afterward so that it will not change a great deal in moisture content after planing. Again, as with corrugation, for outside work keeping the moisture content of the surface nearly constant is not so effective as maintaining the planer properly.

In addition, whenever pattern lumber is worked, the bark side should be made the face side unless there are prepondering defects on that side, since the layers of growth do not loosen up nearly so much on the bark side as on the pith side. This fact seems to be overlooked frequently in the manufacture of pattern lumber. Some mills pay no attention to it, Davis found in a survey of many mills in the South and West.

Loosening of Fibers

That type of raised grain in which the fibers fuzz up is the bane of wood finishers because the projecting fibers make it difficult to secure a smooth finish; Figure 3 shows projecting fibers on the surface of a sanded piece of wood. Some species of wood fuzz up more than others and, in general, the hardwoods are more refractory in this respect than the softwoods. Even in the same species of wood there is considerable variation in the smoothness of surface that may be obtained under identical working conditions. With increasing moisture content the tendency for the fibers to fuzz up becomes more pronounced.

Sanding is responsible for more fuzzing than planing because the grains of sand tear up parts of fibers, whereas the planer more frequently cuts through the fibers and consequently leaves fewer loose ends sticking up. However, under certain conditions, especially a high moisture content, some types of wood fuzz up badly under the planer knives. Fuzzing can sometimes be reduced in planing by feeding the board through the machine so that the knives cut with the grain on the face instead of against it.

Wood finishers commonly sponge the surface of a piece of wood with water and resand it after it has again become dry. The application of water causes the loose ends of fibers to swell and twist and erect themselves more or less. On redrying they do not resume their original position but remain projecting a certain amount from the surface. On resanding the dry surface with fine sandpaper many of the particles of fuzz can be torn off without producing an equal amount of new fuzz. Sometimes a coat of thin shellac sizing is used to stick down the loose fiber ends before applying the regular finish.

Probably less is known about the cause and prevention of fuzziness in wood than of the other types of raised grain here discussed. Why some woods fuzz up more easily than others and how fuzzing can be prevented in any wood are problems for further investigation. It is already evident, however, that proper drying of lumber and proper types of cutting edges and abrasives are important requirements in overcoming the fuzzing up of fibers.

Summary

Certain apparent causes and some remedies are suggested for three types of raised grain. It is pointed out that improper seasoning and storage methods and improper conditions of woodworking machinery have much to do with the extent to which raised grain develops. The fact that the pith sides of a board gives more trouble in corrugation of the surface and loosening of the annual layers of growth than the bark side does not seem to be fully recognized by manufacturers of pattern stock. More research in wood surfacing is necessary, however, before further recommendations can be made as to the conditions of the lumber and machinery under which these objectionable features can be reduced to a minimum.