The Cutting Action of Plane Blades

In this appendix we will take a closer look at what happens when a plane is used, and the events that occur at the cutting edge as the iron does its job. This may be more detail than you care to have, and is not essential to the classification aspect of this work. However, it does serve to clarify the reasons for certain details of plane structure, and may be of help to those of you who are learning to use these tools. I am indebted to Prof. R. Bruce Hoadley (1980) for his lucid exposition of cutting mechanics.

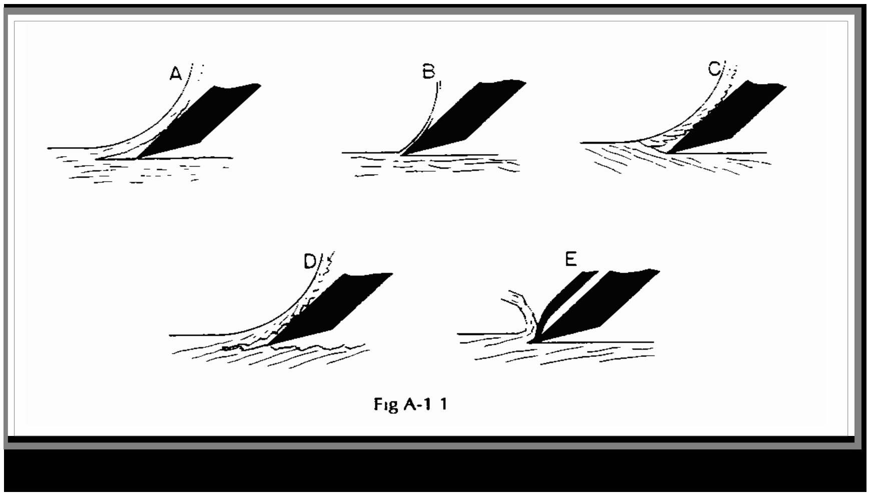

Fig.A-1:1

A blade cutting wood must move wood aside to make room for its passage. The shaving must be bent and levered out of the way as it slides up the face of the blade. If the cut is deep, the force needed to bend the shaving is greater than that required to separate wood fibers, and a split appears in front of the blade (A in Fig.A-l:l). If the shaving is thin, it bends away to let the blade move forward with very little splitting, and a smoother cut results (B).

An early woodworker was immediately aware of grain direction in any piece of wood he picked up, and almost unconsciously placed it in the proper orientation before planing it. If the fibers of the wood are not exactly parallel to the surface, the piece is oriented with the fibers sloping up in the direction of plane motion. By so doing, "planing with the grain", any split that does develop moves up into the wood that will be removed as a shaving (C). The shaving is weakened and less able to force another split. The planed surface is cut, not split, and is smooth. In cutting against the grain, on the other hand, the split enters the surface you are making. The shaving is stronger and better able to widen the split (D) and a rough surface, or "torn grain" results (if, indeed, the plane does not come to a wrist-wrenching halt). Of course, no one does this deliberately, but wood grain does reverse direction more often than one would wish.

The plane body helps to avoid this in two ways. Beside preventing the blade from digging in, the sole of the plane immediately in front of the blade presses down on the wood and tends to restrain splitting. Obviously, the closer to the blade this section of the sole is (the narrower the mouth of the plane) the more effective it is, but the thinner the shaving must be if it is not to choke the plane. Means of adjusting the mouth opening are found in most metal planes and in some wooden smoothing planes, to permit an optimum setting for the purpose at hand. The effectiveness of this factor is lost if the front of the mouth, due to wear or another reason, does not press on the workpiece. This is a major reason for maintaining sole flatness. The Japanese, in fact, remove "a hair of light" from their plane·soles between nose and mouth, and perhaps between mouth and heel, to ensure that the front of the mouth exerts maximum pressure.

The wear, or the front wall of the throat, slopes backward but does not match the slope of the bed (to make it so would increase the frequency of choking, or jamming with shavings). As the sole of the plane wears, it is periodically returned to flatness by use of another plane. Because of the difference in slopes, the mouth widens as a result of this, and the cut deteriorates. After too many such treatments, the plane is either relegated to roughing work, or is repaired by inlaying a hardwood patch in the sole in front of the mouth to restore the correct opening.

Another major improvement in performance was introduced early in the 18th century, with the discovery of the benefit of the cap or breaker iron. A shaving riding up the surface of a single iron gains some leverage helping it to initiate a split in front of the cutting edge. The cap iron serves to break or to fold the shaving before it has gained too much leverage (E). With this help, a sharp, well tuned and finely set plane can cope with difficult grain.

It is apparent that the transition from a cutting to a splitting action would be delayed if the pitch were lowered, as the shaving would need less bending to get out of the way. However, the lower pitch requires a smaller angle between the face of the blade and the back. There is less steel in back of the edge to support it, and it would lose its keenness rapidly. Another factor is heat removal. A surprising amount of heat is generated by friction at the edge, and unless this is conducted away the temper is at risk. A small sharpening angle doesn't provide for good heat removal: a razor blade would not hold up well in a plane. The usual compromise puts the pitch angle at about 45 degrees.

In the idealized drawings of Fig.Appendixl:l, we see that the wood touches only the front of the blade. It doesn't appear to touch the back bevel.

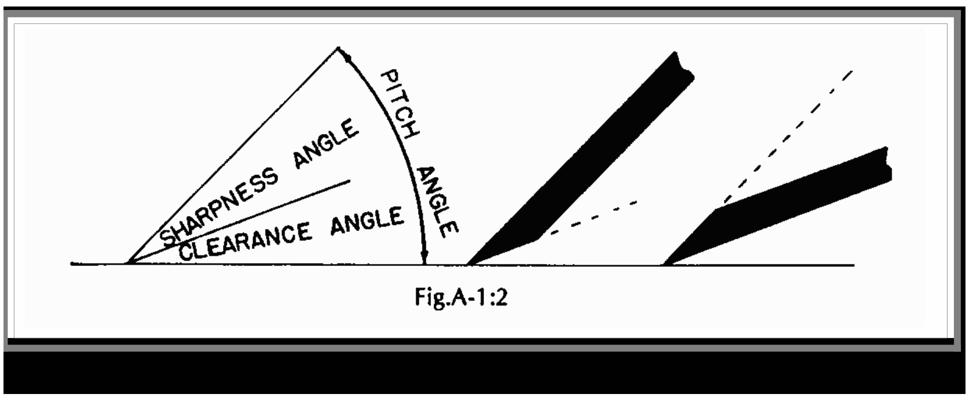

Fig.A-1:2

How, then, does it know whether the sharpening angle is 45º or 20º, and why then the fuss about different angles for hard or soft wood?

The clearance angle is the angle between the bevel on the back of the blade and the wood surface. It is the angle by which the blade clears the freshly cut surface (Fig.A-l:2). This clearance is required, for the following reason. The thrust as the blade moves forward distorts the wood a small amount, until the wood yields to the cutting action. Part of this distortion is a downward compression. As the blade moves on, the freshly cut wood springs back and would tend to lift the plane blade if it had no clearance. Greater downward pressure would be required for a smooth cut, and friction would increase.

The sharpness angle is the angle between the front of the blade and the bevel on its back. (Pitch is the sum of the sharpness angle and clearance angle). The actual angle of the cutting edge is greater than the grinding angle since it is increased by honing (few tradesman honed exactly at the grinding angle as much more steel would have to be removed in doing so, which is a time-consuming process). Thus the sharpness angle is at risk of increasing with successive honings, with consequent reduction of the clearance angle. If the clearance angle becomes negative, the cutting edge of the iron does not touch the wood, and the plane is of little use until the blade is reground.

Although softwoods permit a smaller sharpening angle, they also yield more before being cut and thus require a larger clearance angle. Pitch (clearance plus sharpness) requirement changes little. The verdict of history as well as of recent experiments (e.g., James Krenov) is that a pitch of 45º or slightly more is best for bench planes. The historic name for the 45º bed angle is common pitch. A bit higher (50º, called "York pitch") is used in some bench planes for hardwood and is usual for rabbet or grooving planes. Middle pitch (55º) and half pitch or cabinet pitch (60º) are frequent in molding planes for soft and hardwood respectively. Angles of less than 45º are referred to as low angle or extra pitch, and are seen in some types of planes for softwood and for cutting end grain. It is preferred by the Japanese, who use a rather different planing style.

The bed angle of metal miter planes or low-angle block planes is much lower. However, the actual pitch is in the same range as above because the blade in such planes is mounted bevel up. Thus an iron with a sharpness angle of 25º mounted at a bed angle of 20º with the bevel up gives the same effective pitch as if mounted at common pitch in a smooth plane with the bevel down (Fig. Appendix 1:2). An increase in effective pitch is gained only at the expense of the clearance or sharpness angle. Other reasons exist for the lower bed angle, the principal one being that the blade is supported by the bed almost up to the cutting edge, and chatter is reduced. With bevel down mounting, bed support ends at the top of the bevel.

In cutting moldings (where the final surface is as left by the plane and further refining by scraping or sanding is not normally done), it was particularly important to have stock of straight and consistent grain. Where grain reversal was inherent in the nature of the work, as in cutting moldings for curved surfaces, the molding planes were used in pairs, one cutting in each direction. Even in straight work a pair of molders can be useful, although these are quite rare -- presumably because matching the profiles is quite difficult. As we have seen, side bead planes are the only type commonly found paired, usually cut in one stock as the double side bead.

In furniture hardwoods, grain reversal is much more common than in sofwood; indeed, some of the attractive grain patterns are a result of this. Some even have "roey" grain -- in which the grain direction changes repeatedly across the width of the board, even within the width of the plane blade.

In dealing with this, final finish is done with a hand scraper or a scraper plane, with a nearly vertical blade. Why is this effective? A vertical blade has little tendency to cause splitting or fiber separation ahead of the edge. The action is not to lift the shaving, but to crush the wood cells, decrease their strength, and scrape them away in very thin shavings. Much more work must be done to remove a given quantity of wood, but a smoother surface is gained.

Molding planes do not have narrow mouths over all sections of their profile, and normally are without cap irons to help with awkward grain. In coping with furniture woods, the last resort is to increase the pitch. As pitch is increased, the action of the edge changes from the cutting type toward the scraping type. At cabinet or half pitch (60º the shaving tends to yield by a combination of fiber separation and cell crushing. The shavings are weaker and less likely to generate micro-splits. Higher pitch improves finish but also makes the plane much harder to push. Finding the right compromise for specific jobs accounts for the variety of pitches found in the molders.

In cutting across the grain direction, a different type of problem arises. Splitting in front of the blade is no longer the difficulty, as the splits propagate off the sides of the cutting edge. This is not objectionable in roughing, where a diagonal cut is common, but is highly objectionable in cutting a dado (a rectangular trench across the grain). Using a rabbet plane across grain would leave a dado with very ragged sides. The dado plane solves this by placing a nicker blade in front of the main cutter. This acts as a pair of knives which sever the wood;fibers at the points where the edges of the main cutter will meet them. The main blade is normally skewed, for reasons to be given below.

Finally, there is end-grain planing, for smoothing the ends of a board or fitting miters. Here the blade must sever the wood fibers rather than separate them one from another. If the cutting edge is not sharp, the fibers will be pushed forward before they yield. Separation from their neighbors will occur and small splits will appear perpendicular to the surface (or at an angle, in the case of miters). Small mouth openings and cap irons do not help in this case, but sharp edges, low pitch, and skew cutting do.