cutter-head. It is obvious that the distance from shaft **m** to cutter **j** must be equal to the sum of the distances **m l** and **j l**, or **j m**.

Another way of determining the distance of circle **l** is to run the cutter-head into a board, which is left in the planer when that machine is stopped with the knives in the cut. Take measurements from shaft **m** to the edge of the curve in the plank. Add to this distance, as shown by the calipers, the distance it is desired that the bead-cutter projects, and set that cutter the distance from the shaft as found in the manner described. If carefully done, this is a most excellent way of setting supplementary cutters as shown by Figs. 1 and 2.

An inspection of Fig. 2 will reveal some things to which the planer man should pay very close attention. Among these little things is the manner in which the planer-knife is ground as shown at **n**. It will be noted that there is very little clearance between the heel of the knife and the circle in which the cutting edge revolves. After the knife has been whet or filed a number of times, the heel will be drawn closer toward the cutting circle, and, particularly if the knife is ground a little too "stunt" to begin with, the heel of the knife may strike the wood, and then there will be the mischief to pay. The cutter-head will rattle and jump; the surface of a board cannot be planed smooth, no matter how sharp may be the knives or slow the feed per minute.

Another and similar trouble which is frequently met with is the use of a bolt at **d**, one which was too thick a head and touches the wood back of the cutters. This sometimes causes a great deal of trouble before it is detected. It is often caused by stretching of the knife bolts. These bolts stretch under the strain of planing and of the wedging of chips under the cutter-knife. The stretched bolt touches the bottom of the hole, and to make that bolt screw up tight, the planer man sometimes puts a washer or two under the bolt head. This raises the head so far that it strikes the wood the same as the heel of the knife struck, and with the same results—poor planing, and little of it at that.

Still another trouble—and an exasperating one, too—that of a new cutter-knife which proves so wide that the back edge strikes the cutting circle. Sometimes this can be cured by setting the knife out a trifle more than is otherwise really desirable beyond the chip-breakers. The cut will not be quite as smooth on cross-grained lumber, but as the knife speedily wears narrower, it will not be long before the knife can be set in its proper place again.

The planer man should beware of imperfect bolts in the cutter-head. Many a good planer-knife has been ruined by being thrown out of the machine when the bolts break. The amount of centrifugal force developed by a high-speed cutter-knife is very great. When the bolts are unduly strained by tightening up with a large wrench, there is liable to be trouble when the knives strike a heavy cut. Do not tighten the knife bolts too much. A ten-inch wrench is plenty large enough for tightening planer-knife bolts instead of the fourteen-inch wrench often used for that purpose.

Planer-knife bolts should be made of very soft mild steel or Norway iron. The latter is preferable, but hard to get. In fact, there is very little iron manufactured at the present time. About all the so-called "iron" which the dealer sells or the blacksmith uses is Bessemer steel instead of wrought iron.

Planer-knife bolt should never be made of tool steel. At first sight, that material would seem to be just the thing for the purpose because bolts made from that metal would never give trouble by stretching. But, although that trouble is effectively cured, another and worse defect soon becomes manifest to the user of tool steel planer-knife bolts; they will break short off under a heavy strain instead of stretching a little and then holding fast under the strain.

Tool steel will not stand up under strain when it carries any sharp corners or angles, and, as the presence of threads makes angles and corners a necessity, "snap" goes the bolt under strain, and it is found to be worse and more dangerous than the softest iron bolts that soon stretch all out of shape.

Just compute the strain put upon a ½-inch planer bolt when a man pulls 100 pounds on a 14-inch wrench placed upon the head of the bolt, which has twelve threads to the inch. A man turning a nut or a bolt with a 14-inch wrench will probably apply his power about twelve inches from the centre of the bolt, the remaining two inches of the wrench being used for obtaining a proper hold. This makes the power applied, 100 pounds, move in a circle 24 inches in diameter. As the power moves around the circumference of a 24-inch circle, its travel will be 75,138 inches; while the weight or load on the screw is advancing 1-12 inch. Thus the leverage is 7.38 to 1-12, or 904.6 to 1. When 100 pounds pull is applied to the leverage, the power exerted to screw up the bolt is 904.6 × 100, or 90,460 pounds. Allowing one-half of this amount to be used up in friction of the screw, there remains the very tidy sum of 45,300 pounds pull on that bolt-head. This is more than enough to break any ½-inch bolts ever put into a planer head.

Bolt Strength.

The strength of any bolt may be easily calculated. A ½-inch bolt has a diameter at the bottom of the thread of about ⅜ inch, and the cross section of the metal at the bottom of the thread is ⅜ × ⅜ × .7854, or about .1104 square inch of metal. Iron breaks under about 45,000 pounds pull to the square inch. Soft steel breaks at about 60,000 pounds. For planer bolts there should be allowed a factor of safety of five, thus bringing the safe strain down between 9,000 pounds for iron bolts and 12,000 pounds strain for steel to each square inch of cross section.

As there can be but .1104 square inch of iron in the bolt, it can, of course, be expected to carry only .1104 × 9,000, or .1104 × 12,000, amounting to between 9,936 and 13,248 pounds, according to the material from which the bolt is made. Allowing an equal amount of "would-be pressure" to be expended in friction of the bolt and its head in the thread and on the planer-knife, and calculating the larger strain of the soft steel only, it is found that the power exerted by the screw should equal about 26,496 pounds. Dividing this amount by 12, the length of the short arm of the screw lever (multiplying by 1-12), it is found that the quotient is 2,208, which represents the product of the power applied and the long arm of the lever. As the power supposed to be exerted is 100 pounds, the long arm of the lever, the distance through which the power travels, must be 22.08 inches. This represents the circumference of a circle of about 7 inches in diameter. Therefore, the necessary power can be applied only 3½ inches from the centre of the bolt and the necessary pressure given with 100 pounds pull. This means that a 6-inch wrench is ample for tightening ½-inch planer bolts. Imagine the damage done when a big man pulls for all he is worth on the end of a 14-inch wrench when tightening planer-knife bolts. Is it any wonder that these bolts break as often as they do, or is it not to be wondered at that planer-bolts stand the trouble as long as they do?