Mortise & Tenon by Machine

With help from jigs and fences

by Ian Kirby

Woodworkers have devised endless methods for cutting mortise and tenon joints, relying upon hand tools, machine tools and various combinations of the two. Deciding which method to use depends primarily on the tools one has at one's disposal.

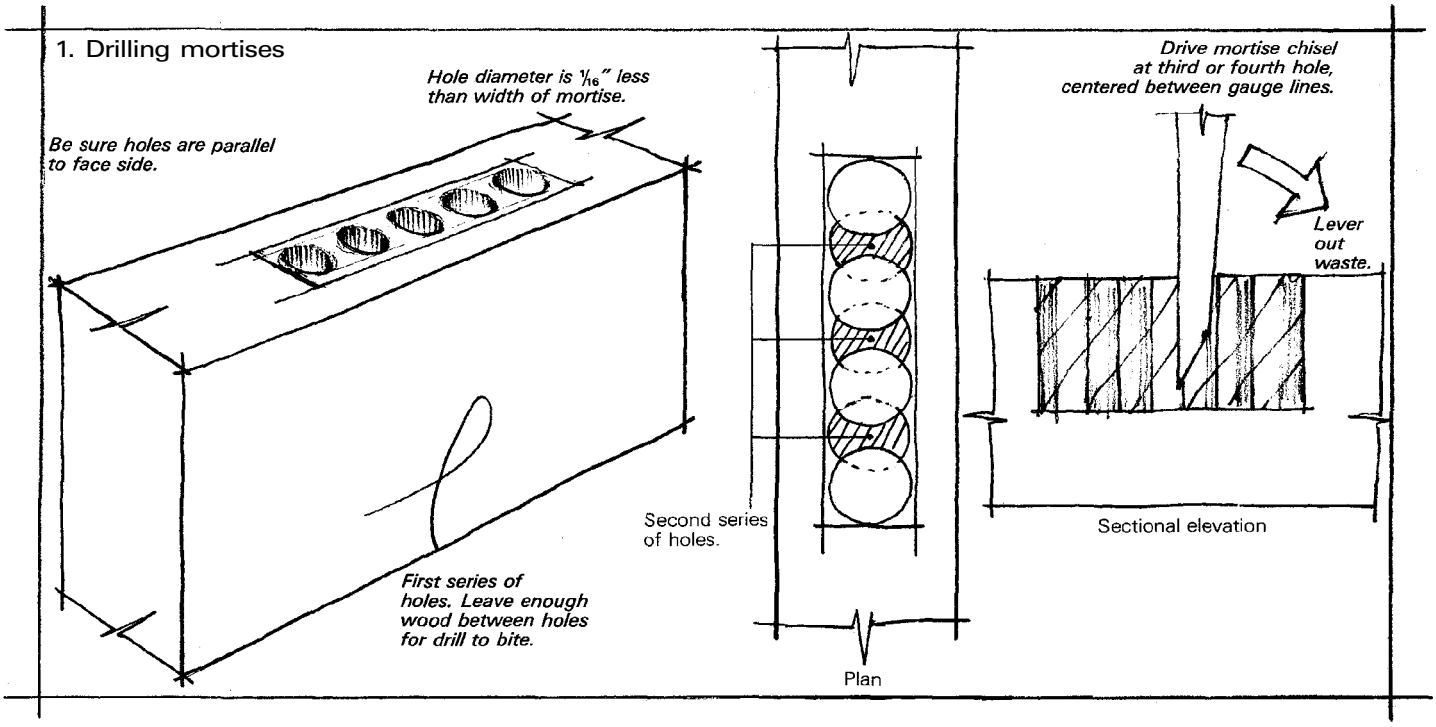
Up to now in this series of articles, I have concentrated on hand-tool methods, which have several virtues. The tools are not special. There is a logic to the process. It is reasonably quick. Once one has mastered the skill, one can achieve the desired result exactly. Having designed a joint, the workman need never compromise in its manufacture. However, the result is always at risk and one must concentrate to avoid spoiling it. It can become exceedingly tedious if one has a lot of joints to do.

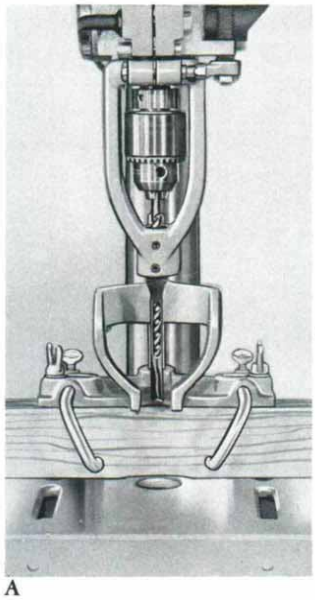
Special-purpose machines designed for mortising are one alternative. I'll discuss some of them later; they are generally fast and accurate, but expensive and beyond the needs of most shops. The middle ground is to use a machine not specifically designed to cut a given joint, such as the table saw, radial saw, drill press or router. These machines, with the assistance of suitable jigs, can remove the bulk of the waste accurately and efficiently. Some hand-finishing can then produce the desired result. The notion that there is only one way to achieve a result is simply wrong, for every workman develops his own techniques, and this article thus cannot be exhaustive. But regardless of methods, every workman should arrive at the same result in the end. The available tools do not determine the size or proportions of the joint, nor excuse inaccuracy in its manufacture.

The mortise — To deal with the mortise first, and ignoring such details as sloping haunches, twin joints and dimensioning, the main consideration is that the two inside faces be parallel to each other and to the face side or edge of the stock.

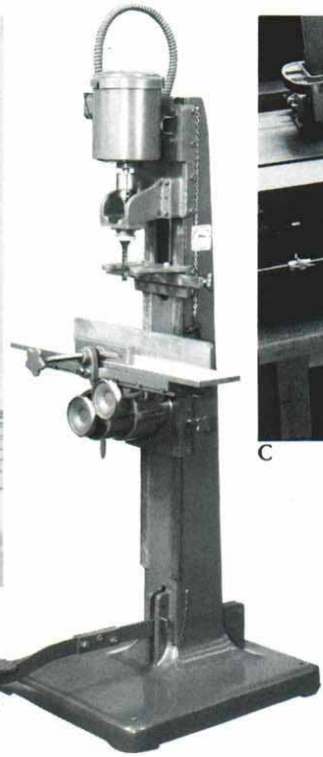
A frequent question is, "Can I drill out most of the waste and then pare down the cheeks with a wide chisel?" The answer is "yes" to the drilling, and "no—or only with great difficulty" to the chiseling. To keep the mortise square and parallel when using a wide chisel really requires a jig. Sighting the chisel while paring across the grain is too hit-or-miss. And a jig would probably be too complex because of the nature of the operation. An acceptable result can be achieved, however, by drilling a row of overlapping but undersized holes to remove the bulk of the waste, and squaring up to the line with a mortise chisel. The joint still has to be marked out with the mortise gauge, to assist at the chiseling stage.

In any machine operation, one must think of the cutting tool itself in close association with the fences and guides related to it. Usually there is no marking out for a joint made entirely by machine. Layout marks tell where to cut a joint—with a jigged system one wants to be forced to cut where the jig directs. When using a drill press (not a portable drill) to remove the waste, the machine's depth stop establishes the mortise depth. A fence fixed to the table so the face side or

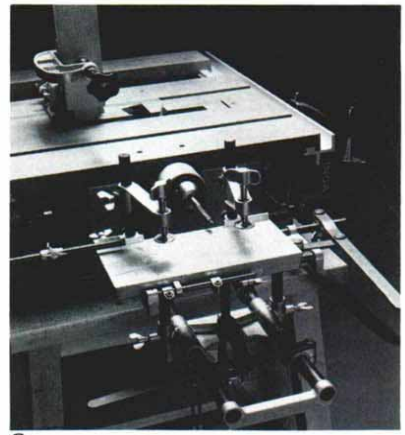




A

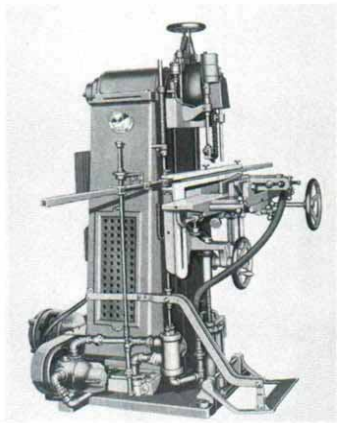


B

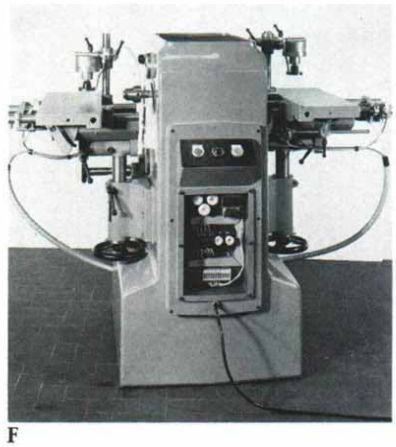


C

D



E



F

A. *Hollow-chisel mortising attachment for drill press (Rockwell model 15-840). Y-shaped yoke at top attaches hollow chisel to quill; lower yoke is part of fence arrangement clamped to drill table.*

B. *Hollow-chisel mortiser, Oliver No. 194. Table includes hand wheel for clamping work against fence, with hold-down mounted on vertical column. Wheels below table control sideways travel, tilt and height. Foot pedal moves chisel and motor assembly into the work.*

C. *Inca horizontal-boring and mortising option on 10-in. table saw uses three-jaw chuck attached to saw arbor. It includes work clamps and adjustable stops. Hand wheel at bottom raises and lowers table, and levers control infeed and cross feed.*

D. *Griggio slot mortiser, from Italy, takes end-mill cutter in stationary horizontal chuck. Hand wheel raises table, clamp holds work, levers move table and work in and out, back and forth. Sold by H. Weigand Corp., Claremont, N.H., and Carpenters Machinery Co., Philadelphia.*

E. *Chain-saw mortiser has hydraulic clamp and feed—operator loads the stock, taps the foot pedal, and unloads it. Photo: Northfield Foundry & Machine Co., Northfield, Minn.*

F. *Bacci oscillating chisel mortiser, also from Italy, has double-ended cutter shaft and two tables for production work. Cutter rotates at 8,750* RPM *and also swings back and forth 200 times per minute. Pneumatic tables move synchronously in all three planes. Thus the size and shape of the mortise is virtually unlimited. Photo: Richard T. Byrnes Co., West Chester, Pa.*

edge of the wood can be placed against it establishes the distance to the center of the drilled holes. Two end stops determine the left-to-right travel of the workpiece, and if the wood is squarely placed within these fences, the correct side uppermost and the right way around, then the series of holes can be drilled only within the defined parameters.

The diameter of the drill, however, should be at least 1/16 in. less than the width of the mortise chisel that is to be used to clean out the remainder of the waste. The pattern of holes depends in part on the type of drill bit. Best is a bit with two scribing lips, like a Russell-Jennings. A Forstner bit also gives good results. An engineer's bit for drilling metal is not so effective; a spade bit gives variable results depending on the type of wood and on the feed and speed.

Drill the end holes first, then drill along leaving up to 1/4 in. between holes (figure 1). Drill out the remainder by positioning the spur on the webs of wood left between the holes. The edges of a drill may overhang, as long as the center is cutting into solid material. The drill drifts when the center is not cutting firmly into wood. Drive the mortise chisel straight down into one of the middle holes, about half-way to full depth, and carefully lever out the small amount of tissue remaining on the walls of the mortise with the chisel's bevel downward. Don't try to go to the bottom in one cut—you'll quickly get the feel and realize that the operation can be fast and simple. Finish the ends by knifing the line and driving the chisel straight down, just as when doing it all by hand.

Mortising machines — The hollow-chisel mortiser is free-standing, with built-in table, fences, clamps and stops. In small shops it is usually an attachment for the drill press—a square chisel with a hole in the center through which an auger-type drill fits (figure 2, p. 86). A yoke fastens the chisel to the drill-press quill, so the chisel and drill will move together into the work, but only the bit rotates. As the bit removes most of the waste, the chisel, sharpened on the inside to form four cutting edges, follows to shear out the remaining wood and force it into the auger. The chisel shaft has at least one window through which chips can escape.

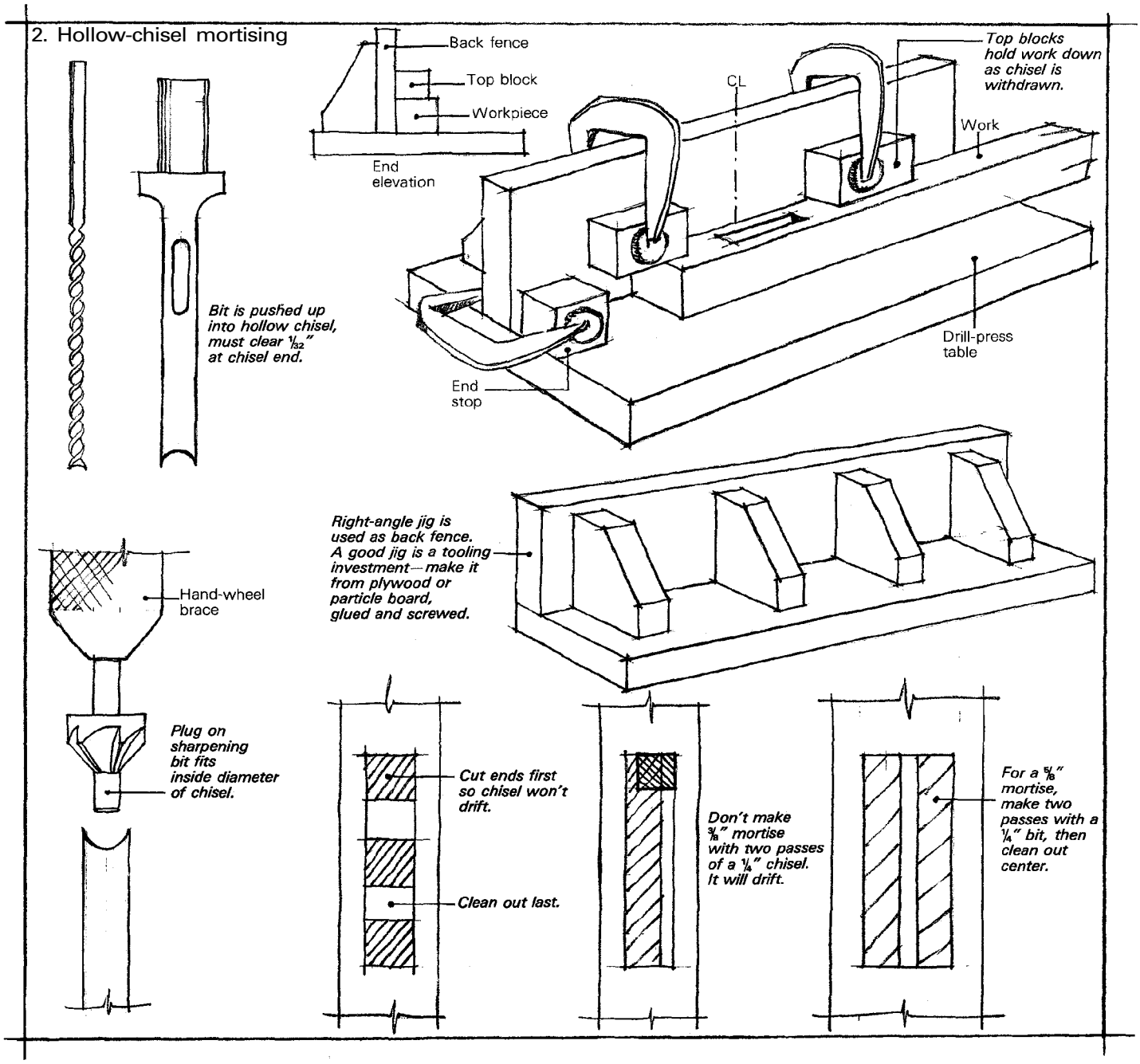
The quality of a hollow-chisel attachment is closely related

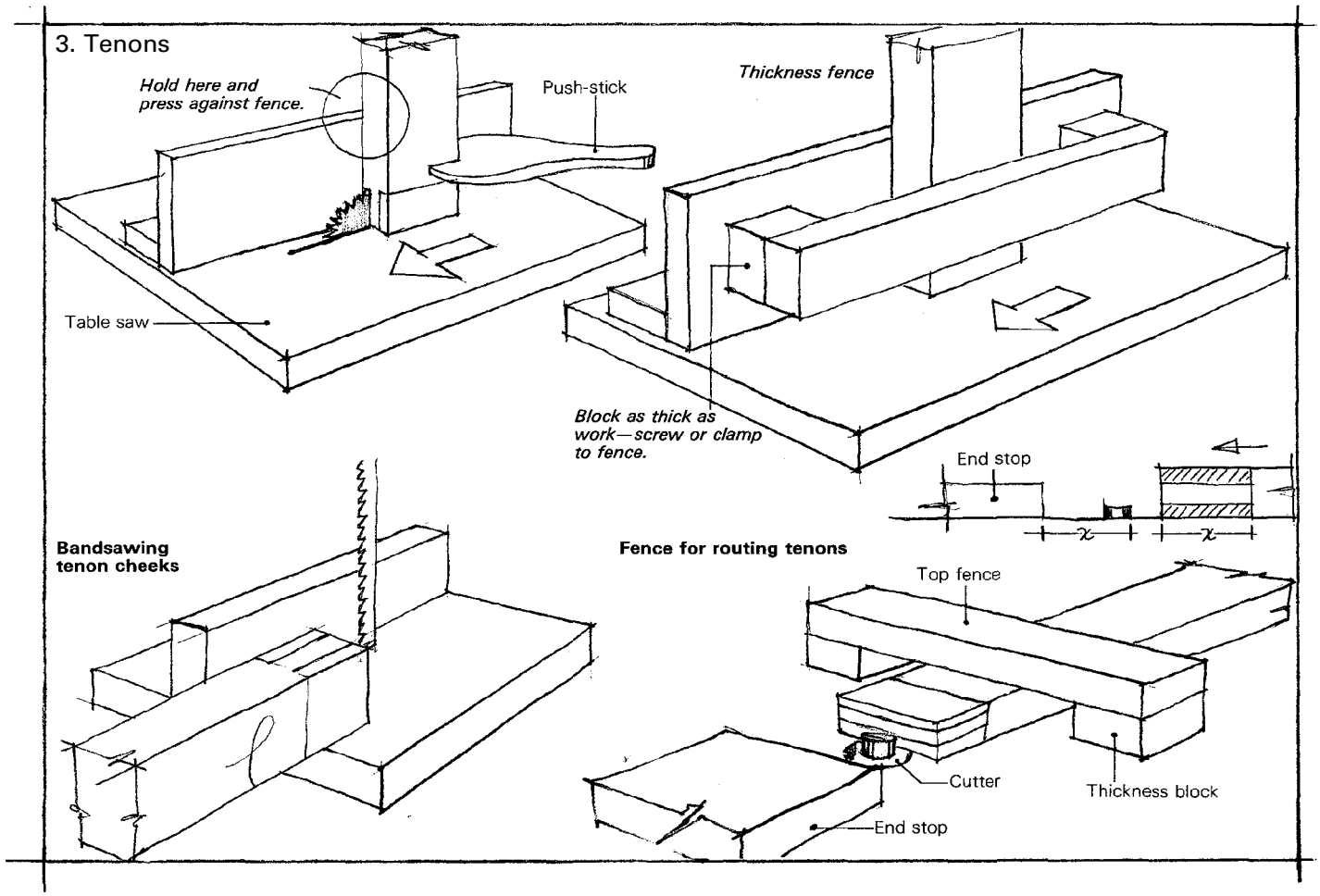
to its price—a good set for ¼-in., ⅜-in. and ½-in. mortises will cost about $200. Before ordering any attachment, be sure it is compatible with your drill press. You don't have to worry about whether the drill press can stand the work load—it will.

When mounting the tool, make sure the plane of the table is at right angles to the bit. Also make sure that the square chisel has its inside face parallel to the fence. Adjust the bit so it does not touch the sharpened end of the chisel, otherwise both will overheat. Aim for a gap of 1/32 in., enough to loosely fit a business card. It's usually possible to jig the hollow-chisel mortiser so that you don't need any marking out on the wood (figure 2). For short runs, it's probably easier to square pencil lines across the wood and omit the end stops.

It is normal to cut the end holes first, then to cut intermediate holes with wood left between them, and finally to clean out with another pass along the work. This is because the hollow chisel tends to drift if it is not cutting on all four edges, or on two opposite edges. Each worker will find a pattern that suits him. The square chisel is reluctant to withdraw from some woods. The remedy is to polish the outside of the chisel to reduce friction, and to reach full depth by ¾-in. bites. Withdraw the bit, clear the waste, and take a second ¾ in. in the same place. This characteristic of the machine makes it imperative to hold the wood firmly down on the bed, by clamping one or more blocks onto the back fence. The fence shown in figure 2 is simple and sturdy, and worth making well since good jigs are a tooling investment.

A small but important point is to keep the whole of the fence rig clear of chips, so they don't get between the workpiece and fence. In industry, a squirt of compressed air does it. Next best is to keep a brush at the machine and sweep off the bed and jig after each cutting. Many people minimize the





problem by cutting grooves and reliefs along the inside corners of jigs and fences, but the brush is still necessary.

It is not good practice to make a ⅜-in. wide mortise with two passes of a ¼-in. bit. The bit will be cutting on only three sides during the second pass, and it will probably drift. The ¼-in. bit will make a ⅜-in. mortise, via two passes on each side and a third down the center.

A hollow chisel is sharpened with a bit that looks like a rose countersink with a cylindrical plug on the end. The outside diameter of the plug is a hair smaller than the inside diameter of the chisel. Set the chisel upright in a vise, load the bit into a wheel brace, and place the plug into the chisel's bore. The reamer flutes are very effective and only a few turns of the drill with light pressure will remove enough metal. Don't use an electric drill for sharpening—it goes too fast and you can't feel the action. Sharpen the drill bit in the usual way, from the inside of the auger so its diameter doesn't change.

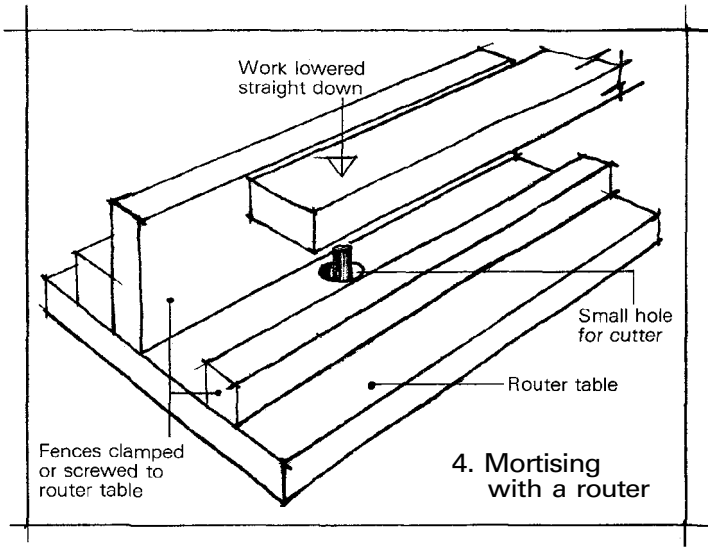
Among the more specific machines for mortising is the horizontal slot mortiser or long-hole borer. Like the router, it leaves a round end. Fundamentally, it consists of an end-mill style cutter, with a sharpened end and sharp flutes, revolving horizontally over a traveling bed much like the cross-slide of a metal lathe. The bed moves the work into the cutter to full depth, then traverses to make a mortise. The same machine can also make tenons, forming one cheek and shoulder with each horizontal traverse. Some versions of this machine hold the work stationary and move the cutter into it.

A chain mortiser is akin to a chain saw, with its bar held vertically and set into a slide device. The system is not used much in the furniture industry, being better for long and deep mortises in large-sectioned material such as fence posts.

Probably the most sophisticated mortising machines use a swinging and orbiting cutter, driven by a cam system and a little like a sewing machine writ large. These machines can cut an absolutely accurate mortise through any kind of wood, even plywood, without regard for knots or end grain.

Tenons — Generally, making tenons with a nonspecific machine is not as difficult as mortising—although there are probably as many variations on the theme. The most common tool for cutting the cheeks is the table saw, with the work held vertically by a fence and passed over the blade. A carbide-tipped blade gives best results. If the tenon is centered, both cheeks can be cut at the one setting. You can build or buy a suitable fence that rides in the crosscutting slots. A stationary fence must have enough overhang before and after the sawblade to support the full width of any piece being tenoned, and it is probably best to make it the full width of the table. Using the simple fence shown (figure 3), the left hand (assuming you are right-handed) holds the top of the workpiece against the fence, while the right traps the work and pushes it with the aid of a push-stick. If you feel at risk using this method, then arrange a thickness fence as well. A home-built version of the traveling jig sold by most manufacturers was shown in Methods of Work, Sept. '79.

The simplest way to cut the shoulder, of course, is to saw it



4. Mortising with a router

with a transverse fence. Whether you cut the shoulder first or the cheek first is a matter of personal style and there are arguments both ways. I prefer to cut the cheek first in order to have the largest bearing surface while the work stands on end. Also, if the shoulder has already been cut, the small block of scrap often wants to get back on the saw teeth and then fly around the room in an unsettling way. If one has a dimension saw—that is, one with a traveling table—the same fence system can be mounted right on it. The workpiece can then be clamped onto the vertical fence, and both hands can be employed pushing the bed and workpiece past the blade.

The slowest method is to set the saw for the shoulder cut and move the work along one-kerf thickness at a time. It may be the handiest method with a radial arm saw, however, and the operation speeds up considerably when one substitutes a dado head. Most radial arm saws can be rotated through 90° and locked parallel to the table surface, whereupon the wood can be laid flat on the table and the saw pulled through the cheek. The work requires a platform and fence, plus room to clamp each piece in place, as the amount of outward thrust can be considerable. The method is efficient for quantities of identical parts.

When used to cut tenons, the band saw could be considered an automated backsaw, since it is easy to use freehand. The wood must be truly square and the blade running perpendicular to the table, otherwise the tenon will come out at some odd angle. This is workmanship of risk, and the decisions about where to cut and where to stop are no different than when working by hand. It is feasible to use a fence with the band saw, although the blade has to be sharp and tensioned just right, else it will wander. Some band saws just do not seem to have the capacity to saw a straight line when using a fence, no matter what one does to try. Feed speed and the hardness of the wood are contributing factors (see p. 96), and generally a slow feed gives the best results.

Because the waste being removed is shallow, a router can mill a good tenon. In most cases it is best to cut the shoulder lines with the radial arm or table saw first. Then lay the work flat on the router table and pass it over a straight cutter or any end-mill style cutter. Fences are as necessary here as with any other method, although the cut is easy and it is tempting to wing it. Please don't take the chance.

There are also a wide variety of industrial tenoning machines, many of them using shaper-style cutterheads mounted in pairs to mill both faces of the tenon at once. Such machines are very efficient and suitable only for high-volume work.

The router — The electric router, combined with a careful system of jigs and fences, is a useful mortiser. When making a wide mortise—anything over ½ in.—it's better to make two slots ¼ in. wide at each side, and then to remove the waste from the middle. When making a deep mortise, go to the depth in two or more bites.

Don't try to drop the router into the work. Use a table with the router hung underneath, the bit projecting through its surface (March '79). The minimum number offences is two, one along each side of the work. End stops are always a help, but their use is often limited by the size of the router table. The common method is to rest one end of the work on the table and lower the other end onto the cutter. This is not the best way, since the work comes down in an arc. Instead, hold the work parallel to the table against the fence (figure 4), and lower it straight down with both hands, keeping the hands well away from the cutter. The dimensions of the work will dictate the dimensions of the fences, but the aim is to arrange the system so you can keep a tight hold on the workpiece. We usually make fences long-grained in the direction of travel, and if the workpiece projects well above the fences, control is not hard to achieve. But if the workpiece is small in cross section, make the fences by simply clamping wide boards, cut off square, flat on the table.

Most problems in routing mortises arise because of the small size or make-do nature of the router table. It's worth investing in a piece of coreboard or good-quality plywood and making a proper large table, once and for all. Rout a recess underneath so you don't lose the table thickness from the depth of cut, and keep the cutter hole small so the table will support the wood right up to the cut. The larger the hole, the harder it is to measure and to visually assess cutter height, and the easier it is for fingers to get into the hole.

It also pays either to devise adjustable fences for the table, or else to screw the fences down. It may seem odd to go to some trouble to get a clean, often expensive working surface only to mar it with screw holes, but the life of the surface will be longer than you imagine. If you keep the fences with screw holes already drilled in them, the system is easy to use and quickly set up. It's usually safer and more accurate than clamping down whatever comes out of the short-ends box.

A routed mortise has round ends. One can shape the tenon to match, or one can finish the mortise square with the conventional chisel. There are points on both sides. When the mortise goes through, round ends make a most acceptable design detail. It takes some skill to round the tenons, but it's worth the effort. An alternative is to leave the mortise round and the tenon square, and to force the two together. This procedure is not unusual in production. The width of the tenon is made so that its corners will bite into the semicircular ends of the mortise. The crushed corners create a tight friction fit, enabling the assembly to be taken from the clamps after a very short pressure time. □

Ian Kirby operates Hoosuck Design and Woodworking in North Adams, Mass. This completes his series of articles on the mortise and tenon joint; previous installments appeared in March '79, May '79, and Sept. '79. Readers are welcome to contribute their own variations; another appears on p. 95.