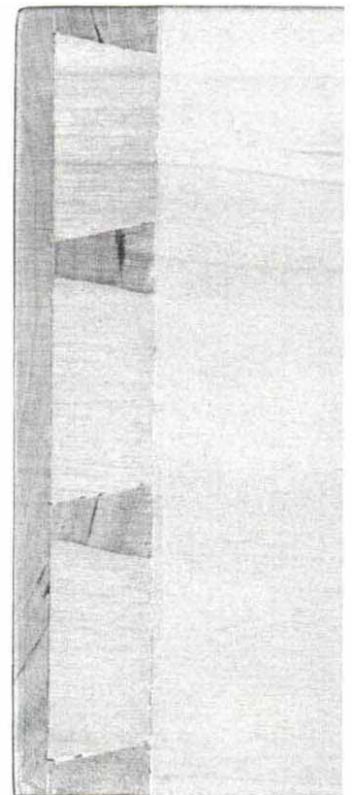




The small, conventional drawer and five shallow trays in Frid's compact, knockdown drawing table provide plenty of storage, and illustrate the basic drawer-making techniques that you can apply to any kind of furniture.

How to Make Drawers

Design for drawing table illustrates the principles

by Tage Frid

About twenty years ago, when I first started teaching at the Rhode Island School of Design, I was commissioned to make drawing tables for the school dormitories. The tables were to be plain and inexpensive, yet sturdy and able to withstand abuse. Because dormitory rooms are small, each table had to be space-efficient. This last requirement made the tables a good exercise in an important cabinetmaking skill—designing and building drawers.

When I design a piece with drawers, I first consider what will be put in them. This helps determine how I will build both the carcass (the body of the cabinet into which the drawers go) and the drawers, and of what materials. The overall size of the drawing table described in this article (see plans, p. 38), which is an improved version of the one I made twenty years ago, is based on standard sizes of drafting paper and parallel rulers. For storing big sheets of paper and finished drawings, I wanted an open compartment below the

adjustable drawing surface. For odds and ends, I added a drawer to the right of the space where your knees go. For instruments, pencils and pens, I also included some shallow trays that slide in grooves milled inside the carcass.

Once I had decided on the drawer and trays, I worked out the construction details for the carcass. There are three basic ways to make a carcass that will contain drawers: with glued-up solid wood, or with a frame-and-panel system, or with cabinet-grade plywood. I used plywood for my drawing table because it's good for knockdown joinery, and because it's simple and fast to work with. Lately, though, I've been using more and more solid wood for my furniture because I can do more with it, such as shaping, carving and bending. Of course, solid wood shrinks and swells with the seasons, so you must account for this in your drawer-hanging. A frame-and-panel carcass, with a solid or plywood panel, isolates most of the wood movement, but it limits your shaping choices, and

complicates the joinery and drawer-hanging.

There are several ways to hang a drawer. When I was an apprentice in Denmark, I learned the method shown in figure 1, which is the one I used for the top drawer of my drawing table and in all of my best furniture. The drawer slides in and out of the carcass on two horizontal members called runners, which fit into grooves milled in the sides of the carcass. At the front of the carcass, the drawer rests on a stretcher or a rail, which also ties together the front edges of the carcass and provides a surface to which drawer stops can be glued. For a drawer to work correctly, it must have some sort of guide to keep it from tilting down when it is pulled out. This guide, which bears against the top edges of the drawer sides, is usually called a kicker. In a chest of drawers, the bottom edge of the runner above acts as a kicker. The top drawer usually kicks against the inside of the carcass top, but in some cases (my drawing table is one) you have to install a separate kicker because the carcass doesn't have a top, or because the top is too far above the drawer to act as a kicker.

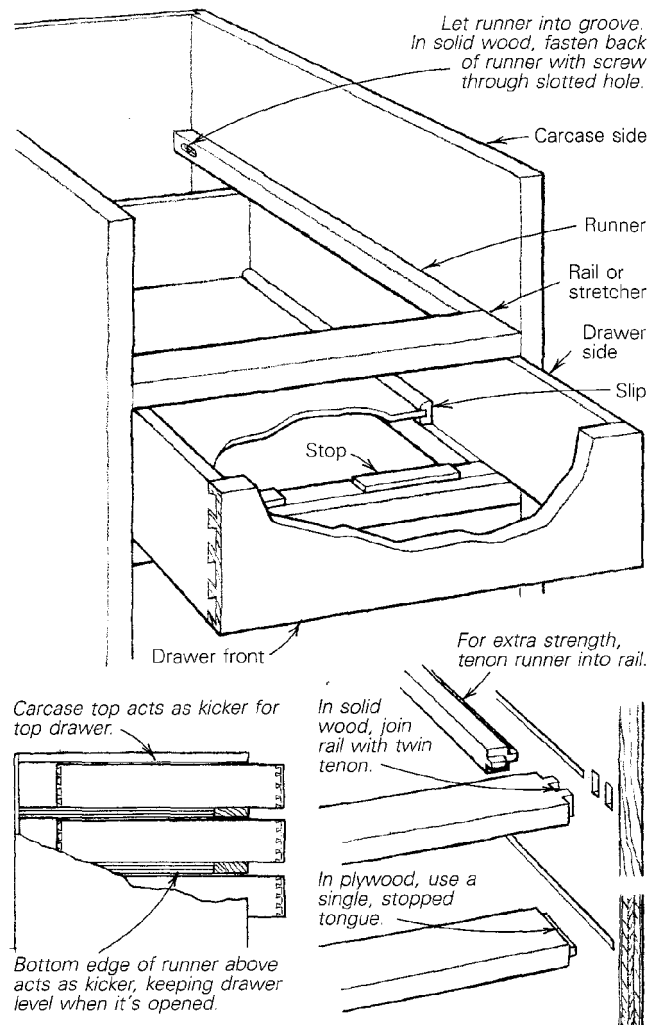
This method, called bottom-hanging (figure 1A), is good for almost any kind of furniture, whether plywood or solid. The runners are very strong and will carry the weight of a drawer filled with heavy objects. If lubricated with paraffin and made of a hardwood, such as oak or maple, the runners (and drawer sides) will last a long time. The big disadvantage is that to work right, a bottom-hung drawer must fit snugly, making it liable to stick in humid weather.

A drawer can also slide on runners that ride in grooves in the drawer sides, as in figure 1B. You don't need stretchers and kickers for each drawer, but you do need to tie a big carcass together with at least one front rail in the middle to keep the sides from bowing outward. Side-hanging is best for small, light drawers, such as in writing desks and jewelry boxes. I wouldn't use it in a chest of drawers or a kitchen cabinet, though, because the sliding surfaces are small and they would wear out pretty fast.

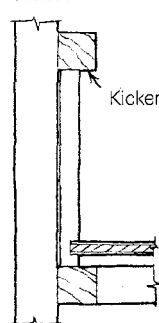
Some people think that metal runners (figure 1C) are used only in cheap factory furniture, but for heavy drawers, such as a desk file drawer or a kitchen-cabinet flour bin, I prefer them. Good-quality metal ball-bearing runners will support a heavier drawer than wood will, and some kinds allow the drawer to be fully extended so you can get what's in the back without removing the drawer. These runners last forever, and they never stick, no matter what the weather. Always buy your runners—or any hardware, for that matter—before you make the piece. Some types of runners require a drawer that is 1 in. narrower than the carcass opening; others need 1½-in. clearance. Nothing is more frustrating than to build a piece, only to find that the hardware you want to use won't work.

Getting started—If you want drawers that fit well, you have to take your time and make an accurate carcass. My drawing table consists of a permanently joined plywood carcass which holds the drawer and trays. To this, I attached (with knock-down fasteners) the panels that form the sides, the back, the storage compartment, and the shelf under the drawing surface. A really fine carcass should be made about ⅛ in. wider at the back than at the front so that the drawer action won't stiffen up from increasing friction as the drawer is pushed in. There are a couple of ways to do this. If your carcass is solid wood, you can join it up square and hand-plane a few shavings off the thickness of the back inside third of each carcass

Fig. 1: Drawer-hanging methods

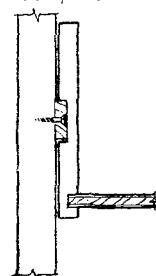


1A: Bottom-hung drawer



1B: Side-hung drawers

Side-hung drawers don't need kickers—runners support drawer and keep it from tilting when it's opened.



1C: Ball-bearing runners

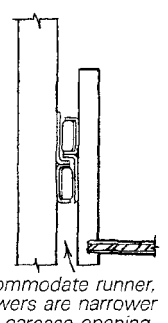
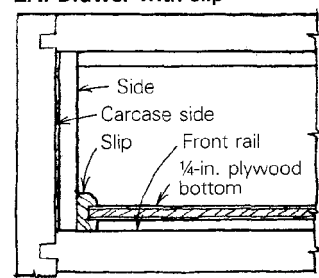


Fig. 2: Drawer details

2A: Drawer with slip



2B: Sliding tray

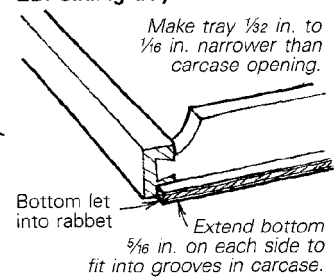
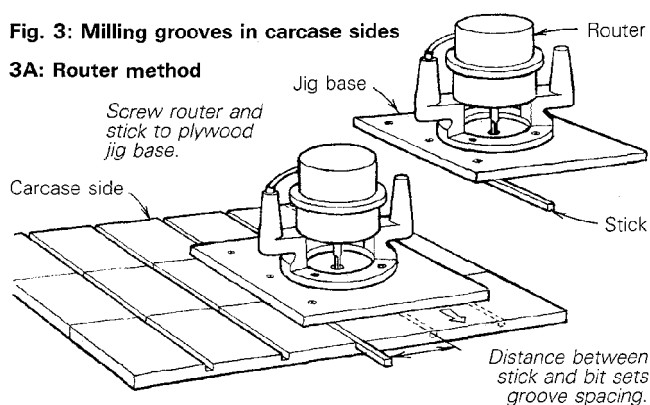
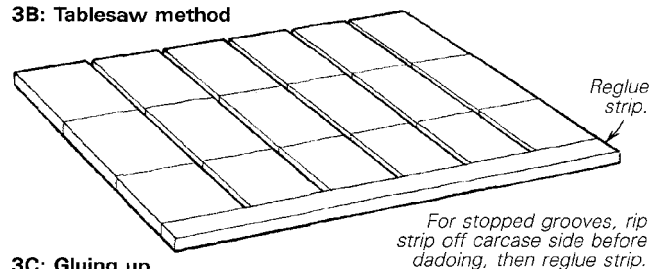


Fig. 3: Milling grooves in carcase sides

3A: Router method



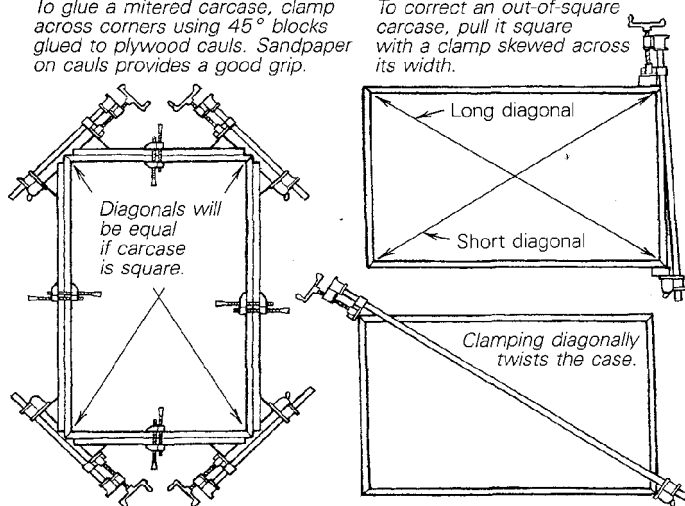
3B: Tablesaw method



3C: Gluing up

To glue a mitered carcass, clamp across corners using 45° blocks glued to plywood cauls. Sandpaper on cauls provides a good grip.

To correct an out-of-square carcass, pull it square with a clamp skewed across its width.



For a perfect fit, Frid fits the drawer parts individually before he assembles them, first trimming the drawer front to a tight fit in the carcass opening. If the drawer front's length can't be scribed from inside the case, mark it directly from outside.

side before final assembly. Or, in solid wood or plywood, you can cut each end of the carcass top and bottom slightly out of square. An article in *FWW* #21, pp. 73-76, tells more about this type of carcass construction.

The drawing table has only one drawer, so I didn't bother making my carcass wider at the back. I cut the parts I needed out of a sheet of $\frac{3}{4}$ -in. veneer-core cherry plywood, squaring each panel carefully and joining the carcass with tongue-and-groove joints. Where the raw edges of the plywood would be exposed, I glued on a $\frac{1}{4}$ -in. thick by $\frac{7}{8}$ -in. strip of solid cherry, planing it flush with the plywood and sanding it after the glue had dried.

Next I cut the grooves for the solid-oak drawer runners and the sliding trays. This step is a critical part of making the carcass—the runners (and so the grooves) must be square to the front edges of the carcass and spaced the same distance apart on both carcass sides. Some people mount the drawer runners in a sliding dovetail joint, which is stronger. But it's a lot of extra work, and since the load is all downward, you don't really need that much strength. You could avoid grooves altogether by screwing the runners directly to the carcass, though this method isn't as accurate. For the trays, I decided to make lots of grooves relatively close together so that there would be maximum flexibility in tray arrangement.

The grooves can be crosscut with a dado blade in the tablesaw, or with a router, using the jig shown in figure 3A. I usually use the router because it's easier for an old guy like me, and if I don't want the grooves to show at the front edge of the carcass, I can stop them short. If you use the tablesaw, be sure to mill each pair of mating grooves in both carcass sides before you change the fence setting. Figure 3B shows how to stop a tablesawn groove.

If I were making a chest of drawers, I'd cut the joints for the front rails at this point. In solid wood, I'd join the rails to the sides with a twin tenon, as shown in figure 1. I usually mill the twin mortises with a router. Then, with a marking gauge, I lay out the tenons on the rail and cut them (by hand or on the tablesaw) to a tight fit. A rail can be joined to plywood with a tongue that stops short of the front edge of the carcass, so it won't be seen. For extra strength, you can tenon the runner into the back edge of the rail.

Assembling the carcass comes next. A tongue-and-grooved plywood carcass, such as my drawing table, is easy to glue up with clamps and battens. When I'm joining solid wood, I usually use dovetails or splined miters. If they fit right, dovetails don't need to be damped at all. You just put some glue on and tap them home. Miters should be clamped across the corners, or else the pressure of the clamps might distort the case. I use the clamping fixture shown in figure 3C, and I check the carcass for square by measuring diagonally from corner to corner. If both diagonals measure the same, it's okay. Don't try to correct an out-of-square carcass by clamping the corners diagonally, or else you'll twist it. Instead, clamp across the width of the carcass, with the clamp angled slightly to pull in the long corner.

When the carcass comes out of the clamps, you can install the drawer runners. Plane or sand them smooth first, otherwise the little ripples left by machine-planing will make your drawers noisy. Because the drawing-table carcass is plywood, which won't shrink and swell, you can glue the runners right in, all the way across. If the sides of your piece are solid wood, runners should be glued only at the very front.

Fitting the drawer—Getting a wooden drawer to work like it's gliding on ball bearings is not all that difficult if you take the time to do it right. The trick is to fit the drawer *before* you make it. First, rough-mill all the drawer parts you will need. I like to use maple, oak, cherry and walnut for drawer parts. Pine and poplar are too soft. For drawer sides higher than 10 in., $\frac{1}{2}$ -in. Baltic birch plywood is good because it is less liable to warp. I make the sides and backs of small drawers $\frac{3}{8}$ in. thick, and their fronts $\frac{5}{8}$ in. thick. Larger drawers should have $\frac{1}{2}$ -in. sides and backs, with $\frac{3}{4}$ -in. fronts.

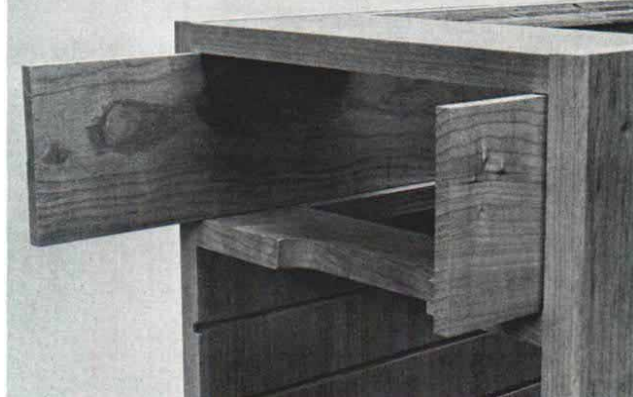
The drawer front should be fitted first. Cut the wood to width so that it will just about go into the opening, then finish the fit with a hand plane. Now cut the front to length: Square one end (if it isn't already) and fit it into the opening, then mark the other end by scribing the back of the drawer front from inside the case. Cut it a hair long at first, then trim it to fit. If for some reason you can't reach inside, mark the length by holding the front outside the case, as shown in the photo on the facing page. The drawer front should fit so snugly that it can be just pushed in halfway. Mark and cut the drawer back exactly the same length as the front, but make the width less, to leave space for the drawer bottom to slide in and also to allow a little space to make fitting easier later on. I usually make the back about $\frac{3}{4}$ in. narrower than the front.

Fit the drawer sides the same way as you did the front, by planing the width until they will just slide in snugly. Crosscut the back ends square, then push the drawer sides back as far as you want them to go. Drawer sides should not go all the way to the back of a solid-wood carcass because when the carcass sides shrink, the drawer will pop out a little. Also, I don't like to stop a drawer against the back of the carcass unless I have to—it sounds clunky. I allow about $\frac{1}{4}$ in. between the back of the drawer and the carcass. One way to make sure the clearance is right is to place a scrap shim temporarily against the case back as you push the sides in.

When the drawer front, back and both sides have been fitted, the drawer is ready to be assembled. But before I do that, I mark the parts as shown in figure 4.

Assembling the drawer—The traditional joint for a drawer is a half-blind dovetail at the front and a through dovetail at the back. Other joints will do, but they aren't as strong. The box on p. 36 shows some examples. Some craftsmen use solid wood for drawer bottoms, but I think that $\frac{1}{4}$ -in. hardwood plywood is better. It's more than strong enough and quite stable. Although it doesn't really matter, running the grain of the bottom in the same direction as that of the front looks nicest. In my best furniture, I mount the bottom in grooved strips, called drawer slips, which are glued inside each drawer after assembly, as shown in figure 5. This technique allows me to work with thin drawer sides, which are better-looking, and still leave a wide wearing surface for the drawer to slide on. To prevent the bottom from sagging in really wide drawers, use thicker plywood, or make the bottom in two pieces and support it with a rail down the middle of the drawer.

Normally, I put slips only on the sides, letting the bottom into a groove cut in the drawer front. But on my drawing table, the finger pull routed in the bottom edge of the drawer front would have exposed the groove, so I glued a slip on at the front as well. For quick drawers in kitchen cabinets, I just mill a groove directly in the drawer sides and fronts. Cut the grooves before you lay out your joints, so a groove



The drawer sides should be made equally snug, then trimmed to a length that will stop them from banging against the back of the carcass.

Fig. 4: Marking drawer parts

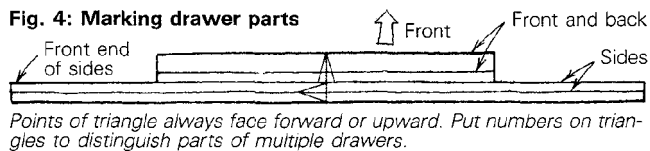
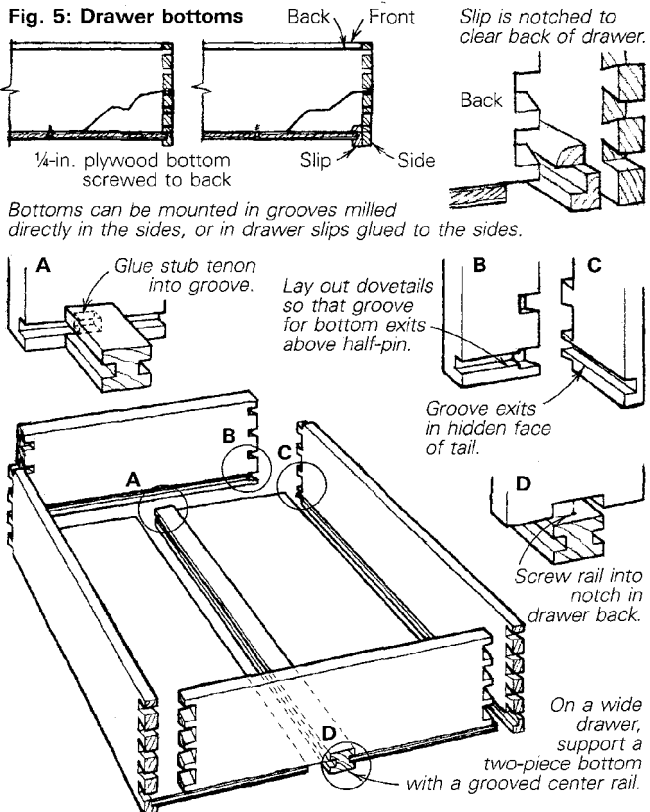


Fig. 5: Drawer bottoms

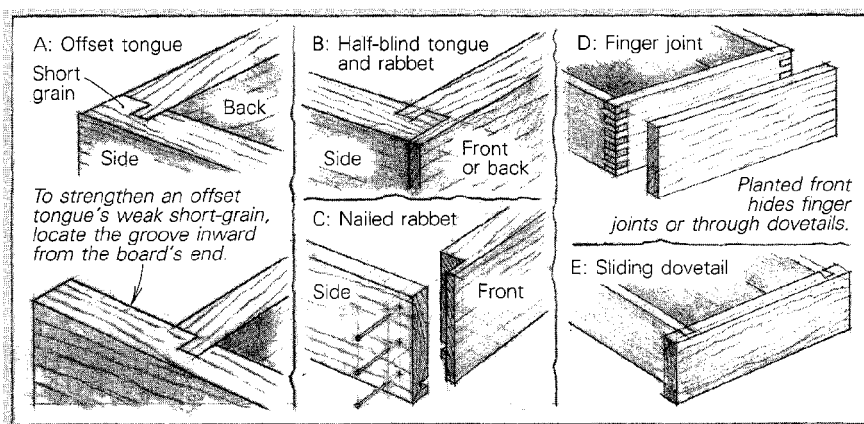


A finger pull that Frid routed in the drawing-table drawer front would have exposed the groove into which the plywood bottom is normally let—a problem Frid solved by gluing a slip to the front, as well as to the sides. The carcass rail, visible at the bottom of the photo, is relieved to give access to the pull.

Instead of dovetails. . .

Whenever I can, I prefer to join a drawer with handcut dovetails, half-blind at the front and through at the back. This combination of joints is mechanically strong against all the pushing and pulling that happens to a drawer, and it's quite attractive, especially if you use different colored woods for the drawer sides and front.

Other easier-to-make joints are okay for drawers, too. But remember that when a drawer is pulled out, the front-to-side joint bears most of the load, so it must be designed to resist this stress and should be strong mechanically, without relying entirely on glue. You could, for example, use dovetails at the front and a tongue-and-rabbit or a half-blind tongue-and-rabbit at the back. For quick drawers in a set of kitchen cabinets, the half-blind tongue-and-rabbit would also be okay for the drawer fronts. But if you use it, stop the drawer at the back instead of at the front, otherwise the weak short-grain of the grooved piece might crack off. Both of these joints can be



made on the tablesaw. Remember to allow for them when you cut the drawer sides to exact length. A rabbet reinforced with Swedish dowels (nails) is fine for quick drawers, too.

A box or finger joint is another good drawer joint that can be cut on the tablesaw. I might use this joint for drawers in a tool chest, but I wouldn't want it in furniture because I think that the end grain of the exposed fingers is ugly. To hide the fingers, or the end grain of through dovetails used on a drawer front, you could glue on a planted front

If a drawer is narrower than the inside of the carcase—as it would be if you were using ball-bearing runners—or if you wanted the drawer front to overhang and cover the front edges of the carcase, a sliding dovetail is a good choice for joining the drawer front to the sides. Sliding dovetails work well in both solid wood and plywood. If you set up to make this joint, you can also use it to join the back to the sides —T.F.

For more on joints, see FWW #5, pp. 30-36, and #27, pp. 68-75.

Drawer-stop ideas from three makers

Sometimes it's not practical to install a stop that works against a drawer's front, as Frid does. In this case, I stop a drawer at the back by gluing and screwing small wooden eccentrics inside the carcase, as shown in the drawing below. Before the glue dries, I rotate the eccentrics so that the drawer stops just where I want it to.

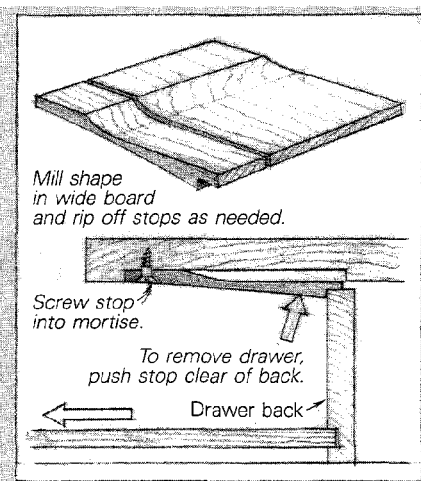
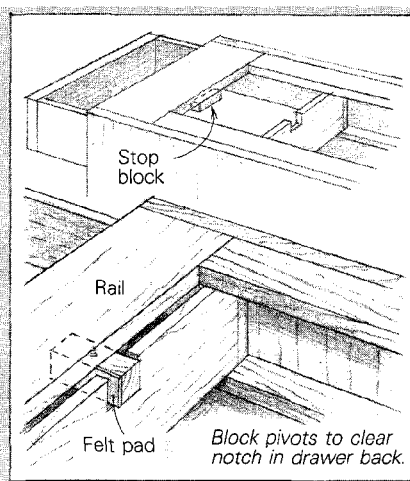
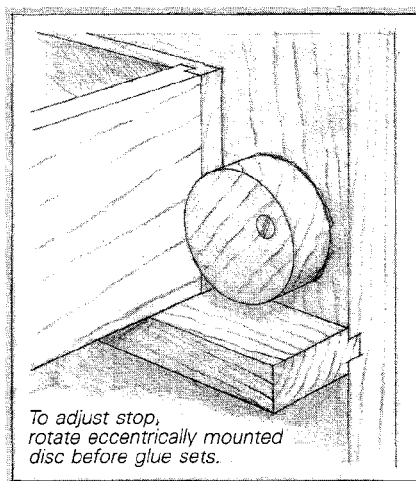
—David Hannah, Newtown, Conn.

Drawers in really well-made furniture should have outward stops, but I don't like to spend a lot of time making them. Usually, I use the method in the drawing below, which works for practically any style drawer. The stop is a small block screwed to the rail (or to the inside of the carcase top) above the drawer. As the drawer is opened, its back strikes the block and stops. So that the drawer can be inserted, the block pivots to align with a notch cut into the back. A felt pad glued to the block gives the stop a quieter action.

—Ben Mack, Mt. Tremper, N.Y.

I learned about the outward drawer stop shown below from Stephen Proctor, my teacher at the Wendell Castle workshops. It consists of a notched wooden leaf spring let into a mortise in the rail above the drawer. If you need a lot of stops, it's easy to mill the shape into a wide board, ripping the leaves off to the required width. For strength and springiness, ash is the best wood to use. Locate the stop where you want the drawer to stop, then scribe and cut the mortise. A countersunk wood screw holds the stop in place.

—Wendy Stayman, Scottsville, N.Y.



won't come out in middle of a dovetail pin.

I had only one drawer to dovetail for my drawing table, so I did it by hand. If there are a lot of drawers to do, I use a dovetail fixture with my router, sanding or planing the inside of the drawer parts before the joints are cut. I don't dry-assemble drawer joints because if they are as tight as they should be, testing them will compress the wood fibers and the joint will be too loose later. Put just a little bit of glue on the top of the pins and front edge of the tails, and tap the joint together with a hammer. Check your drawer for square and put it on a flat bench to make sure it isn't twisted. When the glue is dry, cut the drawer slips to length and glue them in.

Next, I clean up the joints by sanding lightly with a belt sander, and planing or scraping the top and bottom edges of the sides and front. To hold the drawer for sanding, I prop it over a wide board clamped between two bench dogs, as shown in figure 6. After sanding, I try the drawer. Usually it will slide right in. I move it in and out a few times and remove it. Where the drawer binds against the runner, kicker or carcass side, there will be a shiny spot on the wood. I scrape or plane off these spots until the drawer fits perfectly.

If I'm making a drawer in January, I'll make the fit a little loose so that the drawer will still work when the wood swells up in August. Don't take too much off, or the drawer will end up too loose and will bind instead of sliding. To plane the top of a drawer, start at one end of the front and plane toward the back. When you get to the joint between the front and side, just turn the corner in one continuous motion. If you want to finish the inside of the drawer, you can do it at this point. I use two coats of 2-lb.-cut shellac. I wouldn't use oil—it smells too strong and will bleed out of the wood later.

When everything fits, slide the bottom in and fasten it with screws driven into the drawer back. To locate the drawer stops, set a marking gauge to the thickness of the drawer front and scribe a line on the top surface of the rail. Glue two 3-in. by 1-in. by $\frac{3}{16}$ -in. blocks to the rail. Don't make the stops smaller, or someone slamming the drawer might knock them off. I don't use outward stops, but many woodworkers like them. The box on the facing page shows some good methods.

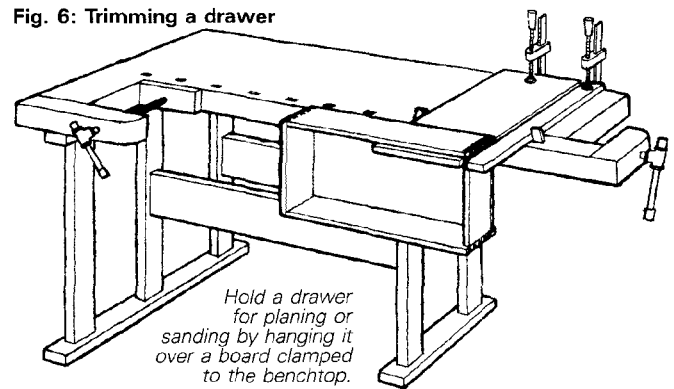
Rub paraffin on the runners, kickers, slips and inside of the carcass. Don't put any other kind of finish on the outside of a drawer or the inside of a carcass where drawers will go, unless you are using ball-bearing runners. The finish will just gum up the works and might cause the drawer to stick.

Making the trays—Making the trays is a lot easier than making the drawers. The tray parts can be kept small in dimension because the assembly is solidly glued and screwed to the plywood bottom. You don't have to fit the parts first, just cut them so that there will be $\frac{1}{32}$ in. to $\frac{1}{16}$ in. between the side of tray and the inside of the carcass (figure 2, p. 33). No grooves or slips are needed for the bottom, but you should let it into a rabbet milled in the tray front.

When you assemble a tray, make sure that it is square and that the bottom overhangs equally on each side. Complete the final fitting by testing the trays in the grooves and sanding the plywood lightly where necessary.

Correcting problems—Sometimes drawers won't work right, no matter how careful you are. Bowed sides are one reason. If you notice this before you assemble the drawer, position the

Fig. 6: Trimming a drawer



Plane the drawer's top edge in one continuous motion, starting at the front and moving toward the back.

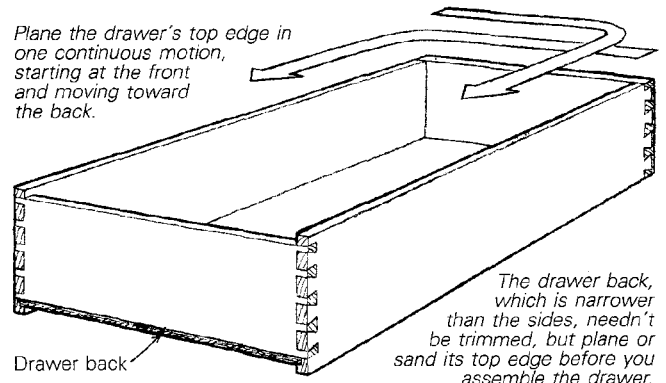
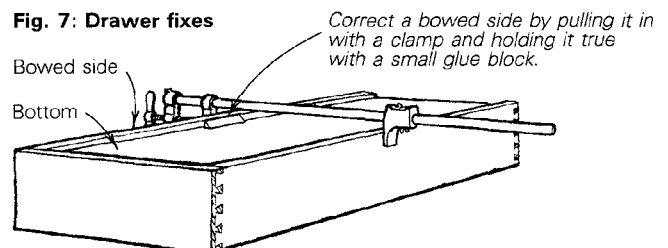
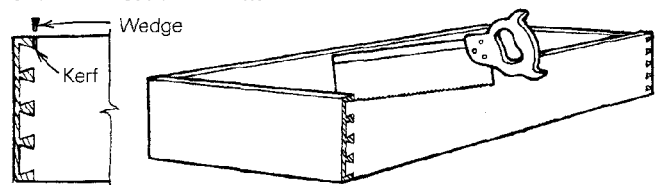


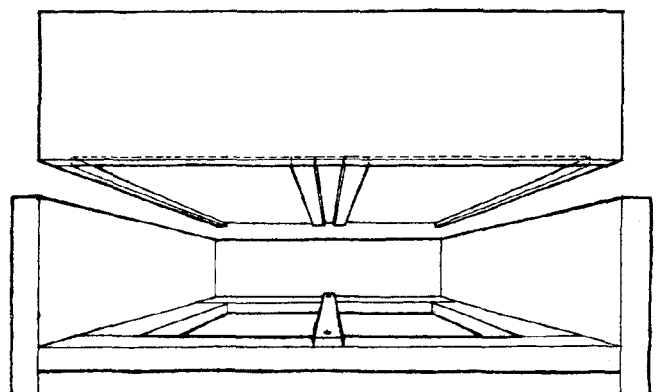
Fig. 7: Drawer fixes



Correct twist by first kerfing the high corners to the depth of the first tail. Then insert wedges to partially flatten the drawer, planing the rest of the twist out of the bottom.



Excessively sloppy drawers can be corrected with a center guide, which fits into a track glued to the drawer bottom. Mount the guide between the front rail and a rail added to the back of the carcass.



A slightly out-of-square drawer will usually be forced into true when the bottom is put in. Just make sure the bottom is truly square and fits exactly to the bottom of the grooves, and put the bottom in before you do final-fitting. A twisted drawer, which won't sit flat but teeters on two corners, is more difficult to fix, but it isn't hopeless. Take some of the twist out by driving small wedges into kerfs sawn at opposite corners in the joints between the sides and the front and

A drawer that really rattles around—either because you planed too much off or because the carcass is too wide—can be fixed with a center guide, or by gluing veneer shims inside the carcass. Shims work best when the looseness is mostly at the back of the drawer. I don't like to use the center-guide method unless I have no other choice. □

Besides teaching one day a week, Tage Frid is building furniture which he'll write about in his third book for The Taunton Press. For more on drawers, see FWW #9, pp. 49-51, and #11, pp. 50-53.

Top View: Shows the overall dimensions of the table top. The total width is 44 inches and the total depth is 30 inches. The central storage compartment is 13 inches wide and 16 1/2 inches deep. The side compartments are 2 inches wide and 11 1/2 inches deep. The distance between the side compartments is 14 inches. The distance between the side compartments and the central compartment is 2 inches.

Side View: Shows the table's profile. The total height is 38 1/2 inches. The table top is 1 1/8 inches thick. The storage compartment is 6 1/2 inches high. The table base is 6 1/2 inches high. The table top is 13 1/4 inches wide. The table base is 12 inches wide. The table top is 3 inches wide. The table base is 18 inches wide. The table top is 2 inches wide. The table base is 3 inches wide.

Detail B: Tabletop shows the assembly of the tabletop. It includes a 3/16-in. T-nut, a glue bored-out dowel into a hole, a stove bolt, a frame, a continuous hinge, and a 1/4-in. edge-banding.

Other Labels: "Drawing surface is plywood let into a solid-wood frame and covered with vinyl.", "Groove spacing is optional.", "Table-elevation mechanism", "A", "B".