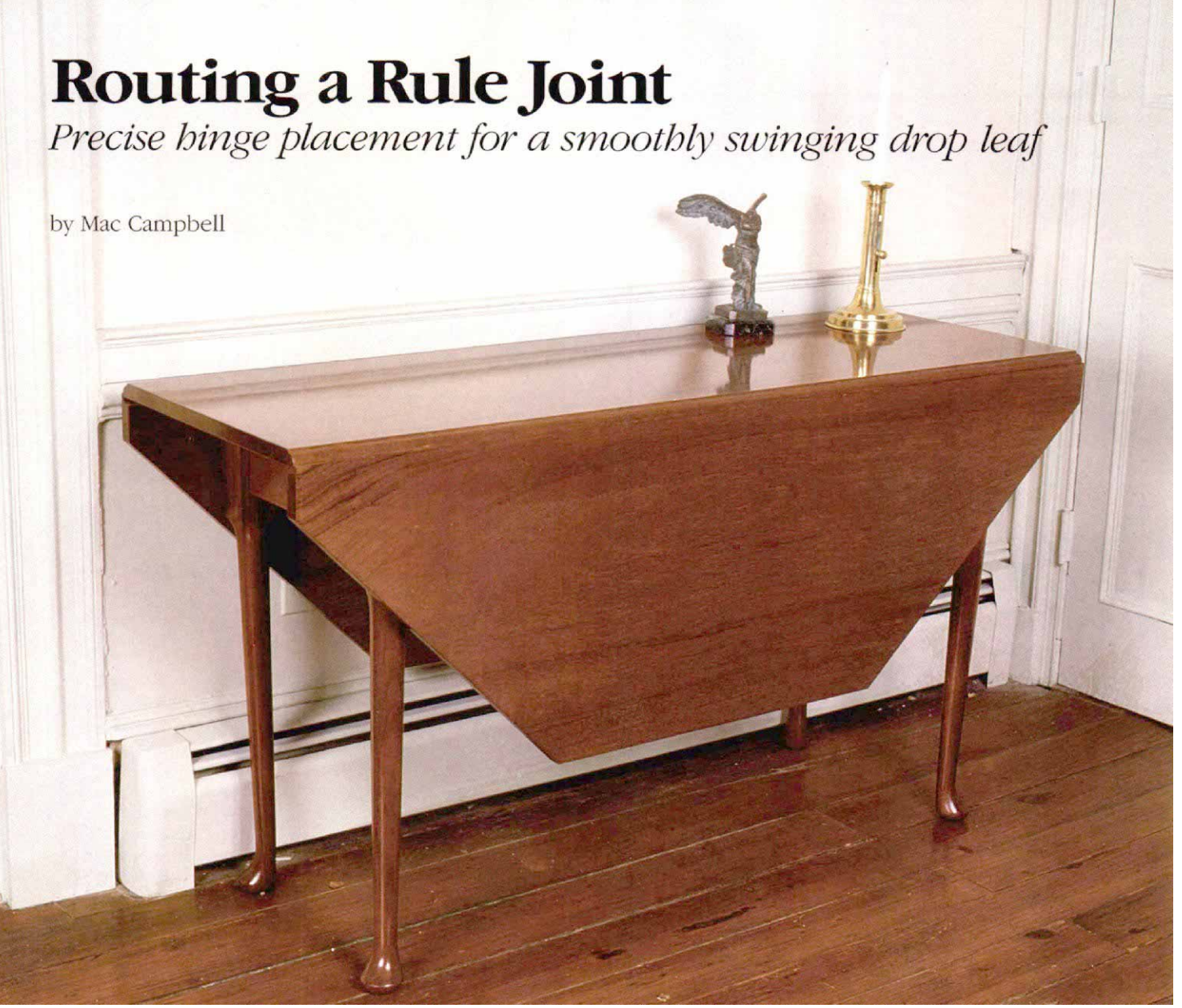
Routing a Rule Joint

Precise hinge placement for a smoothly swinging drop leaf

by Mac Campbell



A rule joint is the traditional method for shaping the mating edges of a tabletop and a drop leaf. The cove on the leaf rests on the roundover of the tabletop to help support the raised leaf; when the leaf is down, the rule joint forms a decorative molding.

A drop leaf dramatically increases or decreases a table's size quickly and easily, while at the same time eliminates the hassle of storing loose table leaves. Drop leaves are adaptable to either modern or traditional tables, but the key to making this design tool work well is the traditional rule joint.

The principle of a rule joint is very simple: The tabletop has a shouldered roundover cut along its edge, and the hinged leaf has a corresponding cove cut along its edge. When the leaf is raised, the cove rests directly on the roundover so the weight of the leaf, plus serving dishes, elbows or any other objects that might get placed near the joint, is carried by the joint itself and not just the hinge screws. When the leaf is down, the rule joint forms a decorative ovolo molding along the edge of the table. A cross section of this molded edge resembles the brass joint on a traditional carpenter's rule, hence the name rule joint.

To operate properly, a rule joint requires a specially designed hinge (see figure 1 on the facing page). One side of the hinge is longer than the other to span the radius of the cove on the table leaf. Screw holes are countersunk on the reverse side from the knuckle, the opposite of a normal hinge. In use, the hinge knuckle is mortised into the underside of the tabletop so the center of the hinge pin can be placed at (or near) the center of the arc of both the roundover and the cove.

Theory versus reality—Before getting into how to cut and fit a rule joint, it is worth looking at the areas where the theory of the joint, and the reality of making it work, part company. Certainly, you can make a rule joint exactly as shown in figure 2A on the facing page, with the roundover's arc traveling through exactly 90°, so the arc's center is on the underside of the tabletop. On a ¾-in.-thick top with a ⅛-in. quirk, for example, this would require a ⅝-in. radius cutter for the roundover. However, with this arrangement, the tabletop and extension leaf will rub throughout their full range of motion. At the very least, this abrasion will wear and scratch the finish on these parts, especially if any small crumbs or debris get caught in between the pieces, and the damage will seriously detract from the decorative molding formed by this joint. Also, if the leaf should distort due to seasonal humidity changes, the fit can become so tight it will be unworkable. In addition, because the hinges are mounted on the bottom surface of the leaf,

Fig. 1: Table hinge

Q, height of quirk
R, radius of roundover
A, height of hinge pin center above face of hinge leaf

To determine the depth of the hinge mortise, add the height of the quirk, the radius of the roundover and A, the height of the hinge pin center above the hinge leaf, and subtract the total from the thickness of the tabletop.

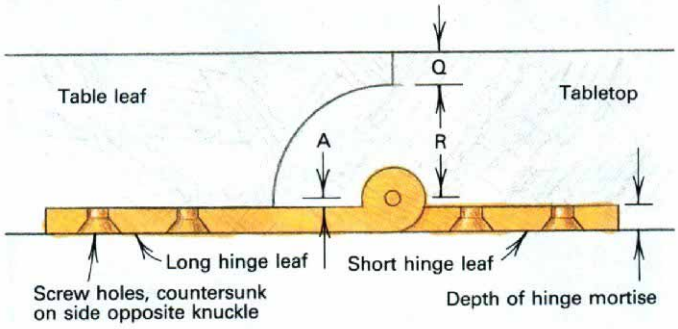
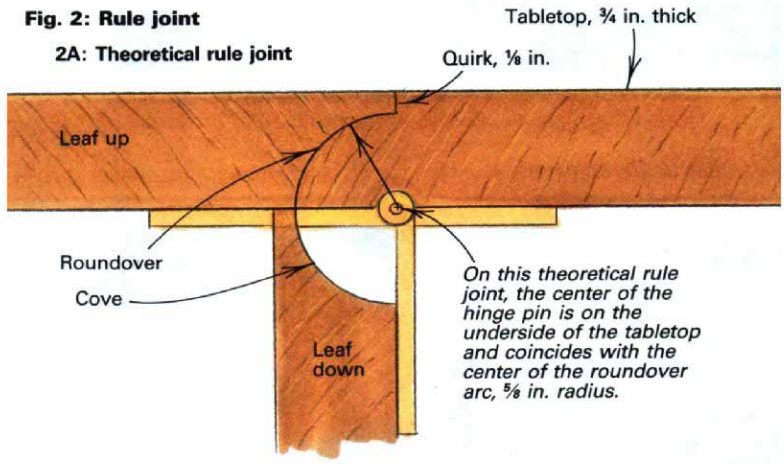
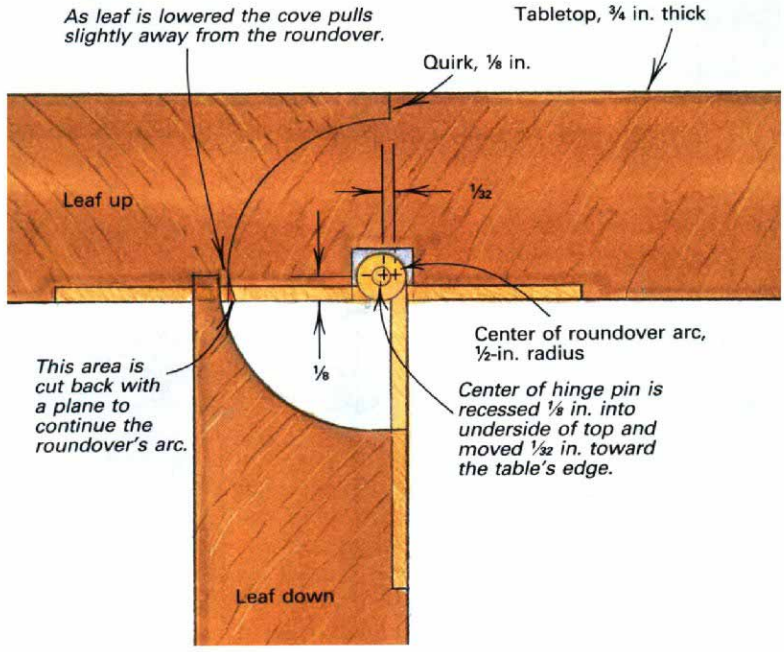


Fig. 2: Rule joint

2A: Theoretical rule joint



2B: Practical rule joint



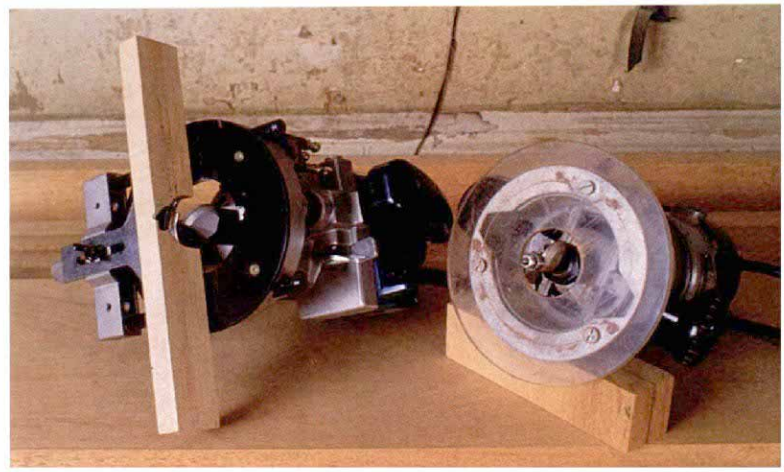
the leaf does not hang straight down, but swings in slightly toward the table base. If the joint is constructed as in figure 2A, this extra tilt will open up a gap between the edge of the leaf and the table and spoil the continuity of the edge.

The solution to these problems is to slightly alter the layout of the joint and the placement of the hinge pin as shown in figure 2B at right. Again, assume you have a ¾-in.-thick top and an ⅛-in. quirk; if a ½-in.-radius roundover is used instead of one with a ⅝-in. radius, the center point of the roundover will be moved up ⅛-in. from the bottom of the tabletop. Reducing the radius and raising the center point of the hinge in this way significantly affect the joint by raising the edge of the leaf when the leaf is down, so that it overlaps the roundover. This overlap eliminates the open gap caused by the leafs tilt in the down position. In addition, raising the center point of the hinge pin lets you recess the hinges into the bottom surface of the top and leaf. Although recessing the hinges is not necessary—many older tables have their hinges surface-mounted with only the knuckles recessed—it does give the table's underside a more finished look.

Another minor alteration in the placement of the hinge pin solves the problem of the parts rubbing on each other as the leaf is raised or lowered. If the hinge pin's center is moved 1/32 in. toward the leaf, the leaf will still close tightly to the quirk at the surface of the tabletop when it is up, but will gradually draw away from the roundover as it is lowered (see figure 2B). This also allows a little leeway for seasonal distortion, but still retains the joint's load-carrying capacity.

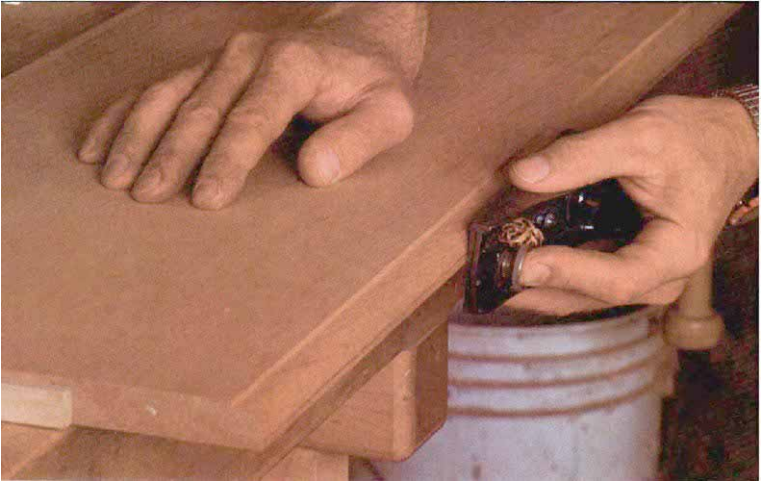
Cutting a rule joint—Before putting tool to wood, you must obtain the hinges. When selecting hinges, the critical factor is that the distance from the knuckle to the nearest screw hole on the long hinge leaf must be greater than the radius of the joint so the hinge leaf can span the cove that was cut on the table's drop leaf (see distance R in figure 1). Hinges on old tables were usually made of iron, since they can't be seen on the finished table, but you can get brass drop-leaf hinges from Paxton Hardware Ltd., 7818 Bradshaw Rd., Upper Falls, Md. 21156 or Lee Valley Tools, Box 6295, Station J, Ottawa, Ont., Canada K2A 1T4, and several other supply houses.

A rule joint can be cut entirely by hand (for more on this see *FWW Techniques 3,* The Taunton Press, *1981),* but it is much easier to use power equipment. I use a hand-held router for cutting the cove and the roundover and for recessing the hinges. To cut the roundover on the tabletop, I use a bearing-guided roundover bit, and to cut the cove on the leaf, either-a bearing-guided cove bit or



Shown above are two setups for routing the cove on the extension leaf. Whenever possible, the author uses a bearing-guided cove bit, as shown on the right. However, because he was unable to find a cove bit with a radius larger than ½ in., he uses a ¾-in.-radius core-box bit with a guide fence clamped onto the router base, as shown on the left, for thick tabletops.

Photos except where noted: Scott Landis; drawings: Roland Wolf



A few passes with a block plane are required to round over the flat portion of the table's edge left uncut by the roundover bit.

a core-box bit, as shown in the photo on the previous page. Because I couldn't find a bearing-piloted coving bit with a radius larger than ½ in., I was forced to turn to the core-box bit when I needed a ¾-in. cove for a 1¼-in.-thick tabletop. To cut a cove with the core-box bit, mount a fence on the router with an arc cut out of the fence, so that half of the bit's cutting edge is exposed, and run the fence along the leafs edge. I have mated pairs of cutters in ½-in. and ¾-in. radii. By varying the size of the quirk and the depth of the hinge mortise, these two radii work for most tabletop thicknesses. For a ¾-in.-thick top, I use a ½-in.-radius, set of cutters, and leave a ⅛-in. quirk; for a 1¼-in. top, I use the ¾-in.-radius set, and leave a quirk of about ¼ in.

Begin by jointing the mating edges carefully, as you would for a glue joint; these edges are used to guide the router cuts, so your final fit will be only as good as the original edge-to-edge joint. Bear in mind that some wood is removed so the leaf can overlap the top. For this reason, it's best to work the joint and recess the hinges before final-sizing the top and leaves. This is essential to end up with a continuous curve on the edge of a round or oval table.

Once you have your hinges and decide on the radius of the arc and the size of the quirk, you're ready to begin. When using a router to cut the joint, it's not necessary to actually lay out the joint on the wood; instead, you can just rout the roundover on the table and fit the cove on the leaf to it. Make several passes to cut the roundover, lowering the bit a little each pass until you've reached the desired depth based on the height of the quirk. The final pass should be very light (around 1/32 in.) to give the smoothest possible surface. While you're at it, cut the same profile on a piece of scrap to use as a sanding block for cleaning up the cove on the leaf. It's not necessary to leave the quirk on the sanding block.

Next, change bits and cut the cove on the leaf, again making several passes. If you're using a core-box bit, make sure the fence clamped to the router base leaves exactly half the bit exposed so you get a true 90° cove. As you approach the final depth, hold the leaf up to the edge of the table and check the fit. The top surfaces of the table and leaf should be flush when the cove is resting on the roundover. Again, cut a duplicate cove profile on a piece of scrap for a sanding block. After both profiles are cut and fitted, smooth away any machining marks with 150-grit paper wrapped around the sanding block. Remove as little wood as possible to avoid loosening the fit.

The two pieces should now snugly fit together when the leaf is up. However, as the leaf is lowered, it will not rotate smoothly through its arc because of the uncut area near the bottom edge of the table where the pilot bearing of the roundover bit ran on its last pass (see figure 2B on the previous page). This uncut area must be rounded over to at least continue the arc of the router cut. I prefer undercutting it slightly more than that, so when the leaf is down, any small debris that falls into the crack will fall all the way through. I usually shape this area with a block plane, as shown in the photo at left, and finish up with a scraper and sandpaper.

Laying out and fitting the hinges—Now you're ready for the heart of the process: fitting the hinges. To lay out the hinge locations, place the tabletop and leaves upside down on the bench, and clamp them together along the rule joints. For joints up to about 4 ft. long, I usually use two hinges, each placed one quarter of the joint length in from the end. For longer joints, I often use three hinges: one centered and the others a little less than a quarter of the total distance from each end. After marking the location of each hinge, place one of the hinges upside down (so the knuckle won't interfere) at each mark in turn, and draw pencil lines along the sides of the hinge on both the tabletop and the leaves. Don't mark the ends of the hinge leaves at this time; you must first determine the exact placement of the hinge knuckle. To do so, unclamp the top and leaves.

As pointed out earlier, the center of the hinge knuckle should be 1/32 in. from the center of the roundover arc measuring toward the edge of the tabletop. Set a marking gauge to this measurement (15/32 in. for a ½-in.-radius roundover) and scribe a line on the underside of the tabletop at one of the hinge locations. Carefully place a hinge on this scribe line with the hinge's short leaf pointing toward the center of the table and the center of the hinge pin exactly over the scribed line. Scribe along the end of the short hinge leaf with a sharp scratch awl. Now, with the marking gauge's fence against the table's edge, reset the gauge to this scribed line, and mark the end of the hinge leaf at each hinge location. To finish the layout, reclamp the tabletop and leaves together, place a hinge, upside down, exactly on the lines you just marked out and scribe the location of the long end of the hinge on the table leaf. Again, separate the pieces, set your marking gauge to this line and mark at each hinge location. You now have a complete layout for the hinges and you're ready to rout the recesses for them.

The depth that the hinges are to be recessed is critical to the correct placement of the hinge pin, so you must first measure the exact distance from the face of the hinge to the center of the hinge pin (distance A in figure 1). Add this measurement A to the radius of the roundover and the height of the quirk, and then subtract that total from the thickness of the tabletop to give you the depth of the hinge mortise.

The hinge mortises can be cut with a number of different methods, but I prefer a router because of the precise depth control. Using a ¼-in. bit, set the router to the depth you calculated earlier. Because the placement of the hinge is so critical, mount a fence on the router base to stop the cut just as you get to the scribe line at the end of the hinge mortise (see the photo on the facing page). You could set up a jig to register the router side to side, but I prefer to rout the mortises freehand, stopping just short of the layout line on each side of the mortises and cleaning them out with a chisel later.

Rout and clean out all the hinge mortises, and then clamp the tabletop and leaves together again and check each mortise for fit with an upside-down hinge. Trim with a chisel where necessary. Now, you have only to rout a deeper mortise to recess the hinge knuckle.

Once again, separate the top and leaves. Select a router bit at least as wide as the hinge knuckle. The bit may be as much as 1/16 in. wider without hurting anything, because a tight fit side to side isn't important, although adequate depth is. Set the depth of cut equal to the depth of the hinge mortise plus the height of the hinge knuckle above the face of the hinge. Then, clamp a fence on

the router so the distance from the fence to the center of the bit is equal to 1/32 in. less than the radius of the joint's arc. Carefully rout a recess for the hinge knuckle in each mortise in the tabletop, and square off the ends of these mortises with a chisel. A plunge router is useful for this operation, but not essential since the bit diameter and depth of cut are small and the fence on the router base provides the needed stability when starting the plunge cut with a regular router.

Clamp the leaves and the top together, and test fit a hinge into each mortise. I've found enough variation in overall size and screw hole placement from one hinge to the next to warrant numbering the hinges and the mortises to make sure the same hinge goes into the same mortise each time. With all the hinges in their mortises, set a screw in one of the holes closest to the knuckle of each hinge. Don't drill all the pilot holes yet, in case minor adjustments must be made later. At this stage, I use steel screws that are the same diameter and 1/8 in. shorter than the ones used in the final assembly. This helps to ensure that the holes aren't stripped out when removing and replacing the screws. Using the preliminary steel screws is especially important when finishing up with brass screws because the steel screws can be driven and removed with less danger of breakage.

With one screw in each leaf of each hinge, carefully turn the whole assembly over and, with the top resting on the bench, raise and lower each leaf. It is possible that everything will work perfectly, but it's more likely that there will be a few stiff spots. The easiest way to locate the points where the joint is binding is to slip a piece of carbon paper in the joint when the leaf is down, and then raise and lower it a couple of times. Do this along the length of the joint, and then remove only a little wood at the carbon-marked spots with sandpaper or a cabinet scraper. Repeat this procedure as often as necessary until the joint works smoothly. Now, you can mark the ends of the top and leaves and, if necessary, disassemble them and trim them to length or, in the case of a curved or round top, bandsaw the final shape of the table. Then, reassemble the parts and set the rest of the screws, again using slightly short steel screws.

With the hinges fully installed, set the whole assembly right-side up on the bench, and use a long level or straightedge to make sure the top and leaves are perfectly flat. If the table base and leaf supports (see the sidebar below) are already built, you can place the top assembly on this. Because there will probably be slight variations where the leaves meet the top, use a cabinet scraper or a handplane (or, when nobody is looking, a belt sander) to smooth the joint between the two; then, rout a decorative profile on the table's edge if it gets one. Finally, sand the whole top in preparation for applying the finish.

To ensure proper hinge placement, Campbell uses a fence when routing the hinge mortises.

Your rule joint is now complete. Remove the hinges and finish the top and leaves separately. When the finishing process is complete, reinstall the hinges with, the proper screws and make a final check of the action of the leaves. Depending on your original fit and the thickness of your finish, there may be a trace of rubbing. If so, it can usually be relieved by going over the joint with steel wool. A light coat of wax should eliminate any squeaks.

There is one more thing to consider when designing a drop-leaf table. The wood for the leaves must be as stable as possible, since the leaves just hang, completely unrestrained against movement. If they are to be made from one or two wide boards, try to pick a very stable wood, and avoid reaction wood or wood cut from an area of the tree near knots or other defects. No matter how attractive the figure, these pieces are more likely to distort over time. Clear, straight-grain mahogany or walnut are the ideal choices. If you are laminating from narrower stock, try to alternate the direction of the annular rings so any cupping will produce a washboard effect, but leave the overall line of the leaf flat □

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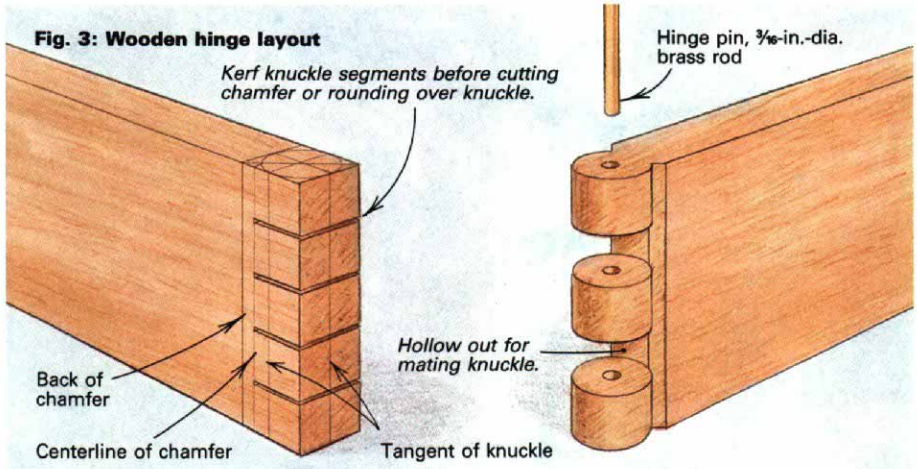
Supporting a drop leaf

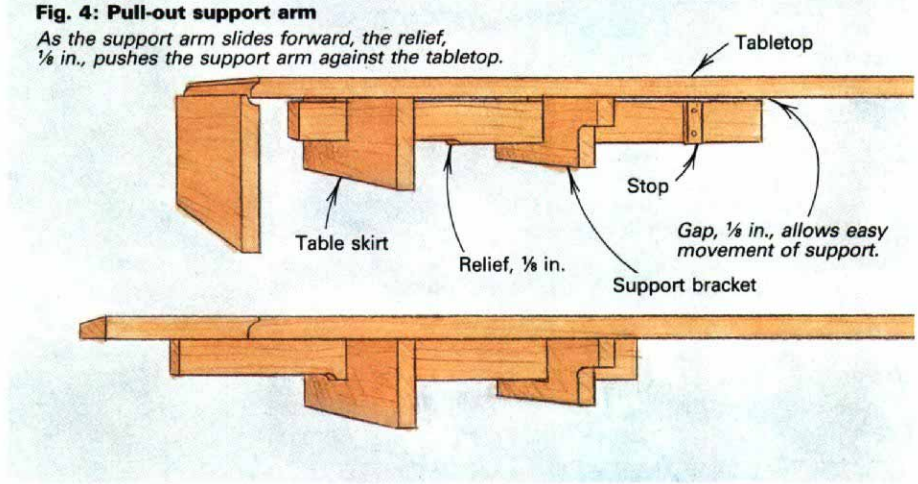
Once you've mastered the intricacies of the rule joint, you still need a way to support the leaf in the raised position. Though the solutions are limited only by your ingenuity, there are three basic systems that have been developed through the years: gate leg, pull out and swing arm.

The gate-leg support is probably the best known of the three. In this system, a table leg is attached to an arm that is hinged in some way to the table frame. To operate it, hold the leaf in the raised position with one hand, -while you swing the leg out under it with the other. The movable leg may be one of the four main legs, as in the table shown in the photo on p. 48, or an extra leg tucked in behind one of the main legs. In either case, it is usually attached to the table skirt with a wooden hinge.

The hinge, which is little more than a rotating finger joint, is relatively simple to make. The layout for the hinge is shown in figure 3 on the following page. Draw a circle on the edge of each piece so that it is tangent to both faces and the end of the piece. Next, draw diagonals from the corners of the piece so they intersect at the circle's center and continue to the edges of the piece. With a square, carry three lines down both sides of each piece: The line where the diagonals meet the edges indicates the back of the chamfer, the line that is carried down from the point where the diagonals intersect the circle will be the centerline of the chamfer and the line that designates where the circle is tangent to the edges of the board is where no wood should be removed when rounding over the knuckle.

Next, I lay out the knuckles for the hinge, so each knuckle is about as high as the board is thick. Make the saw cuts be-





A hinged swing arm supports a drop leaf that extends a cabinet top. A small wedge glued to the extension leaf lets the arm swing freely through most of its arc and, when used with an adjustable stop, provides a way to fine-tune the level of the leaf.

tween the knuckles, but don't chisel them out yet. First, cut the chamfers and round over the ends of the boards to form the knuckles' shape. I use a chisel and a rabbet plane to cut the cross-grain chamfer; and to prevent tearout, I score a line with the marking gauge along the pencil line at the back of the chamfer. This chamfer can also be cut with a backsaw and chisel or with the tablesaw tilted to 45°. The ends of the boards may be rounded now as well, using either a small plane or a roundover bit in a router.

After both mating pieces have been chamfered and rounded, chisel out the alternate knuckles just as you would for a dovetail. Once the waste is removed, hollow out the base of each cut to provide clearance for the mating knuckle/to fit into.

When all the shaping is completed, assemble the hinge with the two pieces at right angles to each other. Carefully line up the knuckles and, using a drill press, make a hole for the hinge pin. I use a 3/16-in. uncoated brass brazing rod for a pin, and peen a head on what will be the upper end. Drilling from both the top and bottom of the hinge toward the middle minimizes any misalignment. Insert the pin in the hole and try the action of the hinge. There are usually a couple of tight spots to clean up; shave a little here and there until the action is smooth. Make sure the knuckles on the moving arm don't project past the inner face of the fixed arm as the hinge opens; this will cause the hinge to bind once installed on the table.

If a gate-leg support doesn't fit your design, the most common alternative is a pull-out support. This support rides in a slot cut in the skirt, and by using the skirt as a fulcrum, transfers the weight of the leaf to upward pressure on the bottom of the tabletop. For ease of action, relieve the bottoms of the pull-out arms except where they actually bear on the skirt (see figure 4 above). For heavy leaves, use two or three pull outs and connect them with crosspieces to form a pull-out frame.

The final alternative for supporting a drop leaf is the swing arm, as shown in the photo above. This is ideal when extending the top of a cabinet with a drop leaf because the arm is simply hinged to the cabinet side and swung out -when needed. I used brass hinges on the swing arm in the photo, but a wooden hinge can be substituted by setting individual knuckles to the cabinet side at the top and bottom of the swing arm and using separate short hinge pins. In this case, the long grain of the swing arm should run perpendicular to the side of the cabinet to keep the grain from splitting at the base of the hinge knuckle. The problem with this approach is that if the wood of the swing arm contracts during the dry times of the year, the hinge will loosen and the leaf will sag.

The swing arm can also be used on tables, but because of the large torque it exerts on the skirt to which it is attached, this support system should be used only for small, relatively lightweight leaves. A spreader installed between the table skirts where the arms are hinged will help resist the tendency for the skirts to deflect. For this type of swing arm, cut a wooden hinge as described for the gate leg.

All of these support systems have one potential problem in common: since the rule joint prevents the leaf from being raised above the level of the tabletop, the support system drags along the bottom of the leaf as it's pulled into position. My solution in all cases is to screw a small wedge to the bottom of the leaf where it will rest on the support. By screwing the wedge to the leaf through a slot, or adding an adjustable stop, as shown in the photo above, you can regulate where the support rests on the wedge and thereby compensate for any sag or wear that will develop over time. In addition, this wedge system lets you cut the gate leg or swing arm just a hair low, making it much easier to move into position. —*M.C.*