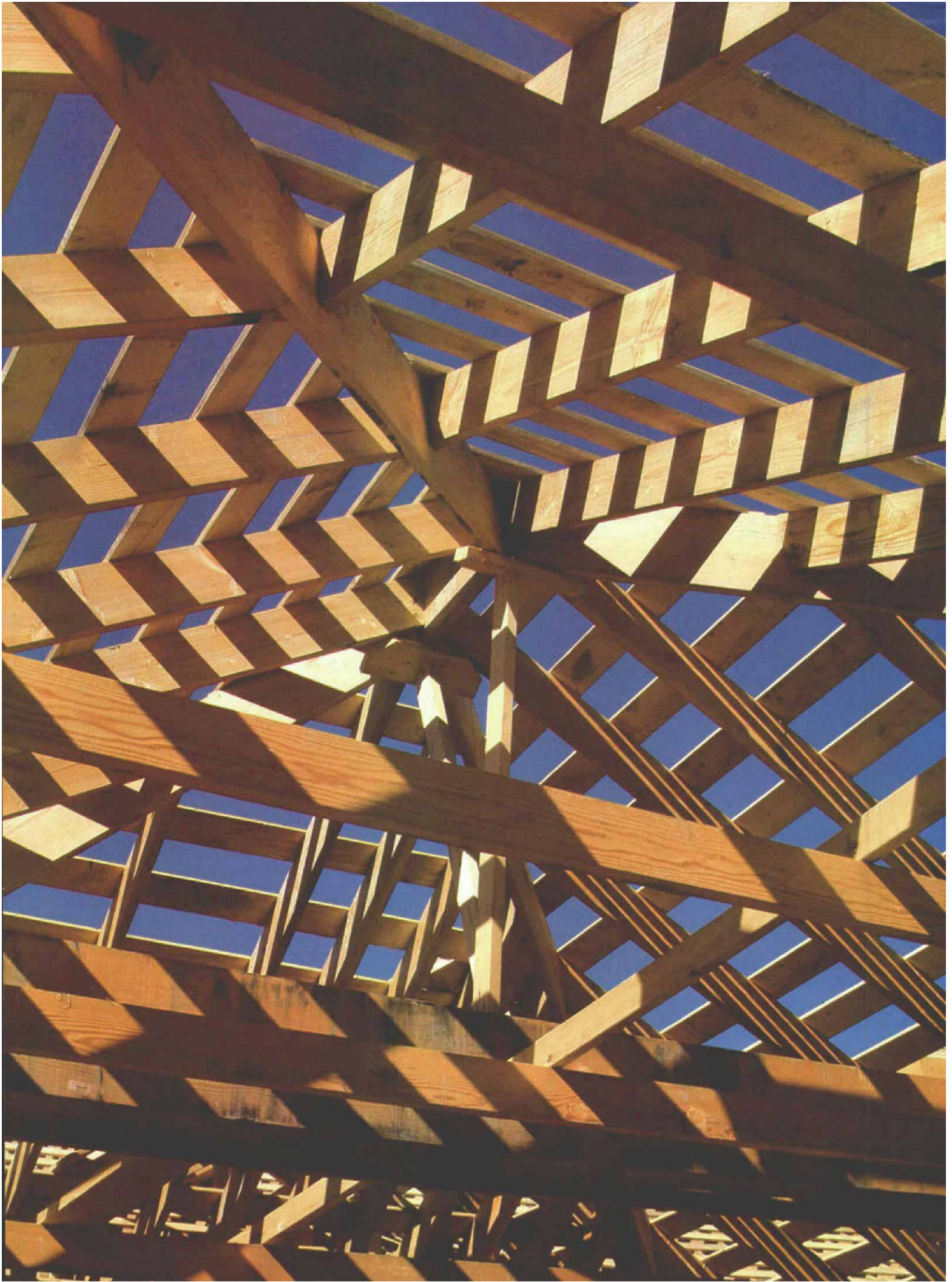


Putting the Lid On

A primer on production cutting and raising a hip and gable roof

by Don Dunkley

One of the most satisfying events in building a house is the completion of the roof. Some builders borrow from European tradition and nail a pine tree to the peak in celebration. At the least, it is usually the excuse for a party. There are good reasons to celebrate. Framing a roof can be perplexing, physically taxing and sometimes dangerous. However, with thoughtful organization of rafter layout, production rafter-cutting techniques and carefully built scaffolding and bracing to help raise the ridge and rafters, your celebrating doesn't have to come out of a sense of relief.

The best way that I know to share my knowledge of roof framing is to describe the steps involved in building a simple hip and gable roof, like the model roof that is shown in plan, below. This article will cover most of the problems that are encountered in a rectangular building—laying out and assembling common rafters, hips and jacks, along with the ridge, purlins and collar ties.

Preparation—The roof is ready to frame once all the walls are built, plumbed up and braced off. The exterior walls must be lined very straight, because any irregularities in the span will show up on the roof frame. Before you start sorting through your framing stock, study your roof plans carefully. They should show an overhead (plan) view on a scale of ⅛ in. or ¼ in. to 1 ft. They will tell you the type of roof (gable, hip or gambrel), the pitch or slope, the length of overhangs (eave and gable end), the layout of the rafters, their spacing (16 in. on center, 24 in. o.c.), and the sizes of the framing members.

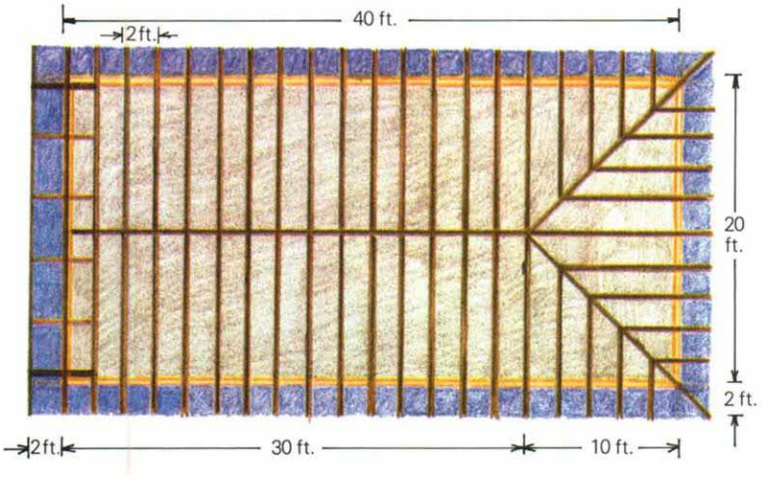
Layout—Job-site layout begins with measuring the span of the building. Always measure from the top (double) plate height. There are usually slight variations between the span shown on the plans, the actual span at the bottom-plate level, and the one at the double plate. Since rafter lengths are calculated down to ¼-in. changes in span, use the double-plate measurement. A 100-ft. tape is the tool for this job.

First, as shown in the photo below, the positions of the rafters must be marked on the top of the double plate. This lets you properly locate the rafters when erecting the ridge. The layout is also necessary to distinguish the positions of the rafters from those of the ceiling-joist layout, which should be placed so they can be used as ties to which the rafters can be nailed. Starting with the hipped end of the roof, lay out the positions of the three king common rafters. Strike a line 10 ft. in from each corner down the length of the building, as well as one midway along the width, and write the letter C (for center) on the plate over each of these lines, which will serve as centers for the king commons. Next, lay out hip-jack rafters on 2-ft. centers from the corner of the building toward the king common rafters.

The common rafters are laid out similarly on the plates, starting at the gable end. I usually mark one side of the rafter position with a line across the top plate. If ceiling joists are also on 2-ft. centers, you don't need to lay them out, because they will be installed beside the rafters. If joists are on 16-in. centers, you would start the layout with the tape held 1½ in. past the end of the top plate. This way, a joist will tie into a rafter every 4 ft.

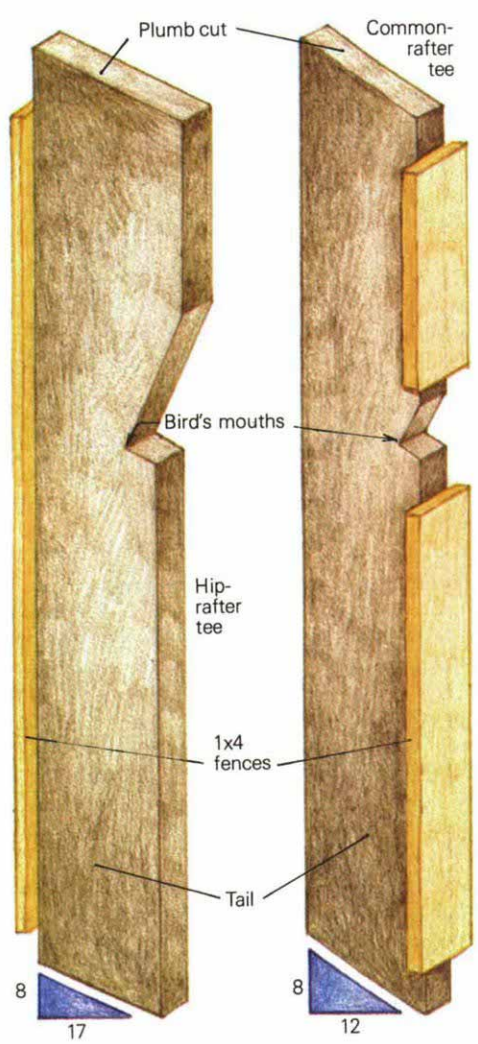
The ceiling joists that sit on the exterior wall will stick up above the rafters, and can be trimmed along the pitch of the roof after the rafters are up, and before the decking is applied. On the hip, the ceiling joists close to the end wall can't be nailed in place unless you notch them or cheat them off the layout, because the hip will interfere. They should be laid flat on their layouts and installed after the hips and jacks are in place.

Layout tees—The layout tee is a handy tool that lets the builder lay out rafters accurately and quickly. It also helps eliminate steps in rafter-length calculations. Layout tees should be made for the bird's mouth and tail of both



The roof plan of the model, above, shows a gable end using a barge rafter and outriggers for a 2-ft. rake overhang, and a hipped end with a 2-ft. eave. The 2x6 rafters are on 24-in. centers, and the roof pitch is 8-in-12. The span in this case is 20 ft. Right, a carpenter lays out the joists and rafters by walking the plate, something that should be done only after the walls have been plumbed, lined and well braced.

Illustrations: Frances Boynton



common and hip rafters (drawing, above). There should also be a plumb cut at the top of the tee above the bird's mouth to use as a pattern for the top plumb cut.

Tees should be made of the same width stock as the rafters, so in this case the layout tee for the common rafter should be made from a 3-ft. scrap of 2x6. After you scribe the plumb cut at the top of the tee, move the square about 12 in. down from the top plumb mark and scribe out a bird's mouth. Next, mark the tail cut by measuring along the body of the square for the length of the overhang, which is 2 ft. in this case. Then make a mark and scribe the plumb tail cut, for an 8-in-12 pitch in our example. Cut out the pattern and nail two pieces of 1x4 along the bottom of the tee, one staying clear of the bird's mouth and the other not projecting past the top plumb cut, as shown above. When the tee is being used, the 1x4 fence registers against the bottom edge of the rafter stock for marking out the bird's mouth and plumb cuts.

The hip-rafter tee in this example is cut from a 3-ft. 2x8. On one end, scribe an 8 and 17 plumb mark. Move the square down about 12 in. and scribe the seat cut. Since this is a hip, the seat cut must be dropped (cut more deeply) to bring the top edge of the hip into the same plane as the jacks. To determine the amount of drop, lay the square at the top of the 2x8 on an 8 and 17. Where the 17 mark intersects the top of the lumber, measure down the body of the square half the thickness of the hip (here ¾ in.) and make a mark. Then measure down from the top of the lumber, perpendicular to the edge, to this mark (5/16 in.). This is the drop needed. Make the hip seat cut 5/16 in. deeper than the common seat cuts.

The width of the tail of a hip must equal the width of the common rafter, so the wood past the seat cut must be ripped down from a 2x8 to a 2x6. Measure down from the top edge of the rafter 5½ in. (the actual dimension of a 2x6), mark the length of the rafter tail, and rip the excess 2 in. off the rafter's bottom edge. Since this rip creates a step in the bottom edge, both pieces of 1x4 fence should be nailed to the top of the tee. When using this tee, place it on the top edge of the rafter stock.

The next job is working up a cut list for all the rafters. Count the rafters on your plans, and calculate their lengths. The cuts can then be scribed using the rafter tees, and all the pieces can be cut before beginning the actual installation. This approach requires both confidence and intense concentration, but doing all the cutting first speeds up the process by letting you put your head down and frame without having to stop and figure.

The rafter book—I wouldn't want to be without a rafter book when framing roofs. Mine contains 230,400 rafter lengths for 48 pitches. I can look up any building span under the appropriate pitch, and quickly determine the rafter length and angle of cut. This book saves a lot of labor, and eliminates many costly errors.

Calculating common-rafter lengths—In the rafter book under 8 in 12, the common-rafter table shows that our span of 20 ft. requires a rafter length of 12 ft. ¼ in. from heel cut to plumb cut. This measurement doesn't account for the ridge reduction, because ridge thickness is not a constant. With a 2x ridgeboard, the reduction along a level line is ¾ in. But measured along the rafter edge, ¾ in. measures 7/8 in. on an 8-in-12. Rather than laying out a shortening line on the stock, I subtract the ridge reduction measurement from the rafter-book length to get the corrected rafter length down to the bird's mouth—in this case, 11 ft. 11⅜ in.

The overhang length from the heel cut to the tail cut can be taken off the rafter tee or determined from the rafter book by adding the overhang for each run to the span. A 2-ft. overhang will add 4 ft. to the span. In the rafter book, the 24-ft. span at 8 in 12 reads 14 ft. 5⅛ in. Deduct from that figure the full rafter length of 12 ft. ¼ in. This leaves 2 ft. 4⅞ in. in length from the heel cut to the toe of the tail cut. The overall length of the rafter will be 14 ft. 4¼ in.

Calculating lengths of hips and jacks—Use a large pad of paper to organize your calculations for the hips and their jacks, since they involve a bit of figuring. On the job, keep your building plans clean. Don't scribble math all over them. Using the rafter book, an 8-in-12 hip at a span of 20 ft. is 15 ft. 7⅝ in. A ridge reduction is necessary, and this 45° thickness measures 1 3/16 in. along the rafter edge at 8-in-12. This reduces the rafter length to 15 ft. 6 7/16 in. from plumb cut to heel cut.

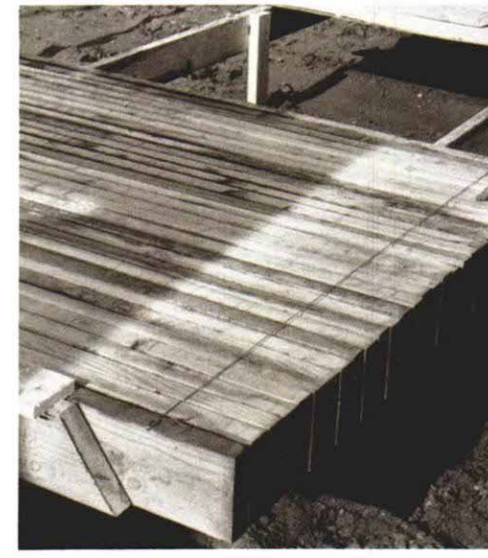
To find the overhang or tail length, add 4 ft. to the span, just as for the common. The rafter book lists 18 ft. 9⅛ in. for a 24-ft. span. This leaves a rafter tail of 3 ft. 2½ in., and an overall length of 18 ft. 8 15/16 in.

To calculate the lengths of the hip jacks, look up jack rafters on 2-ft. centers at 8-in-12. Both the square and the rafter book read 2 ft. 4⅞ in. This distance is the common difference, or how much longer one jack will be than the previous one. This is also the length of the first jack before the deductions. If you are using my system of subtracting the ridge reduction (measured along the edge of the rafter) from the rafter-book length, then subtract 1⅜ in. on an 8-in-12 jack to get 2 ft. 3½ in. from plumb cut to heel cut. Only the first jack needs to be figured for the deduction since the rest will automatically follow, as the common difference is added to each one.

Cutting the rafters—With all the calculations complete, the next step is to lay out and cut the rafters. You can use production techniques that save a lot of time without sacrificing accuracy. I use a rafter bench, an oversize, site-built sawhorse that holds ganged rafter stock up off the ground for easy marking and cutting. I try to set up my benches close to the lumber stack, which should be fairly close to the building. You will be worn out before you start if you have to carry a ton of rafters a great distance.

Stack all the rafters of one type on the bench with their crowns down. The crown is a convex edge seen by sighting down the lumber. Crowns should be placed up in construction to help deflect the load placed on the rafters or joists; they are stacked crown down on the rafter bench so you can scribe cut-lines with the

A chalk line snapped across ganged common rafters marks the heel of the plumb-cut line. As indicated by the layout tee (bottom left) the rafters are stacked with their bottom edges up, and their ends even and square. The layout tee will be used on each rafter to scribe the plumb cut, bird's mouth, and tail cut.



Jack rafters stacked on a rafter bench show the common difference of 2 ft. 4⅞ in. on an 8-in-12 pitch using a 24-in. spacing. The diagonal lines indicate the direction of the side cut that will produce pairs of jacks (left and right) for each hip rafter. The bird's mouth and tail will be marked with the common-rafter layout tee.

layout tees. When you stack the rafters on the bench, keep their ends flush so they can be squared up easily with a framing square by drawing a line across their edges. Then use the layout tees to mark the plumb cut at the top, and bird's mouth and tail cuts at the bottom on each of the outside rafters of the stack. Measure the length you have calculated between the plumb cut and the bird's mouth several times, and then connect the marks across the stack with a chalk line (photo facing page, bottom). Lay the first outside rafter down flat on the bench, scribe the plumb, seat and tail cuts with the rafter pattern, and cut them out.

When all the common rafters are cut, they should be dispersed along the exterior walls according to the layout. Before spreading the rafters out, it is a good idea to set a 16d nail at the top plumb cut. This toenail will come in very handy during assembly.

Cut hip rafters using the same procedure, but make double side cuts at the top (for laying out double side cuts, see pp. 58-59). These cuts can be made easily on 2x stock with a circular saw set at 45°. For larger timbers or glue-lams, the angle of the top edge of the stock must be laid out, and the cut made with a handsaw.

With the double side cut complete, measure down from the top of the rafter the distance calculated, 15 ft. 6$\frac{7}{16}$ in. Mark this length on the center of the rafter's top edge. Slide the tee to this point on the rafter, and scribe the seat cut and heel cut. Mark the rest of the board, scribing along the tail of the pattern. Rip the tail down to the proper width.

Use the common-rafter tee for the jack layout. Group the jacks on the bench according to length—for the model roof, there will be four sets of four. Load the longest first and work down to the shortest set. Only the tail ends can be squared up. Lay the common-rafter tee on this end and scribe the tail and seat cuts on the outside rafter. Then lay out the rafter on the opposite side of the stack and snap lines.

To lay out the plumb cut at the top of the jack, measure the length of common difference—2 ft. 3½ in.—up from the seat-cut line for the shortest set, and add 2 ft. 3½ in. progressively to each set of jacks. Square these marks on the top edge of the rafters, and lightly mark two of each set with a 45° line indicating the direction of the angle. Mark the other two with the opposite angle (photo left). The side cut must be laid out this way because the length of a jack is measured from its centerline. Scribe a 45° line in the direction of the light line drawn previously through the center of the plumb-cut line on the top edge of the rafter. Then place the layout tee at the end of the 45° line that intersects the edge of the board farthest down the rafter, and scribe the plumb cut on the face of the rafter. This method creates a slight inaccuracy in the length of the jack on a moderately pitched roof, but it is much faster than marking the precise angle (which can be found in the rafter book or on the square) on the top edge of each rafter.

After cutting all the jack pairs, set them on the roof, paying particular attention to the correct placement of right and left-hand rafters. Drive a 16d nail into the smaller jacks, and hang the head and shank of the nail over the double plate so that the jacks hang along the wall, out of the way but still accessible.

The last roof members to get cut are the ridgeboards and purlins. The 30-ft. ridgeboard on the example here is made from two pieces. Pick straight stock, and cut so the break falls in the middle of a common-rafter layout. The board that includes the hip end of the building should be left long by 6 in., and all cuts should be square.

Assembling the roof—The reward for all the calculating, laying out and cutting is a roof whose members fall right into place once the ridge is up. This is the stage with the largest element of danger, and safety is a primary concern. While nailing joists and laying out the top plate, you'll start to develop "sea legs," gaining confidence in walking around up there. Make sure no loose boards stick out more than a few inches beyond a joist, and keep the top plates between joists free of scraps and nails.

Establishing the ridge height—Before doing anything else, calculate the ridge height to see if you need scaffolding to install it. This is done by multiplying the unit of rise (8 in our example) by the run of the building (10). The bottom of this ridge is 80 in. from the top plate. Ridges 6 ft. or more above the plate need scaffolds. A good scaffold is about 4 ft. lower than the ridge. It must be sturdy, well braced, spanned with sound planks, and running down the center of the building. To make room for the placement of ridge supports and sway bracing, leave a 1-ft. wide space between the scaffold planks.

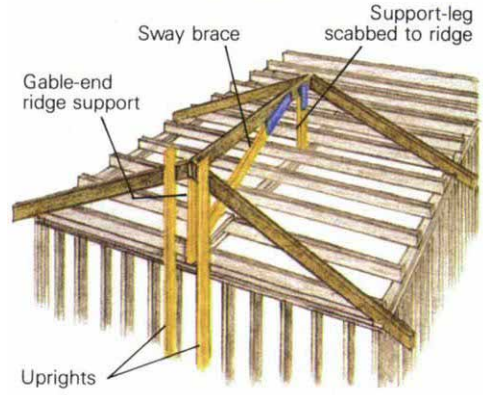
Raising the gable end and ridge—First, put the tools and materials where you need them. Saws, nails and other tools can be kept handy on a sheet of plywood tacked on the joists. Pull the ridgeboards up on the joists alongside the scaffolding. You'll need several long 2x4s for braces and legs. Stack them neatly on the joists along with 2x8 bracing for the purlins. To support the gable-end rafters in the initial stage of assembly, nail two uprights to the gable-end wall, perpendicular to the top plate and a foot on each side of the center.

For setting the gable and ridge, you need a crew of four—two carpenters on the scaffold, and one at each end of the span. Starting at the first rafter on the gable end, the carpenters on the outside walls pull up the gable-end rafters, setting the top plumb cut on the scaffold. A small 2x4 block 7½ in. long, the height of the ridgeboard, should be nailed to the plumb cut of one of the rafters. This block temporarily takes the place of the ridgeboard. Make sure the block is flush with the top of the plumb cut. The carpenters on the scaffold pull up the rafters until the seat cuts sit flush on the top plate. The carpenters on the outside walls nail the rafters down, keeping the outside of the gable-end rafter flush with the outside wall. Toenail each rafter to the double plate with two 16d nails on one side and one 16d on the other (back nail). At the plumb-cut end, the rafter with the temporary block must align with the other rafter so that the cuts are nice and tight to the block.

When the gable-end rafters are in position, nail each rafter to the uprights with 16d nails. You'll need to insert a temporary support under the ridge. Measure down from the bottom of the block to the top plate on the gable-end wall to find its length (drawing, below). Nail the leg down to the plate where the 10-ft. center is marked. You'll need another leg under the joint in the ridgeboard, but before you cut it, look for something to set it on. If there isn't a wall directly below the ridge, lay a 2x6 or 2x8 across the joists to carry the leg. After this leg is cut, the block can be removed from the gable end and replaced with the ridgeboard. The carpenter on the other end of the ridgeboard should rest it on the support leg, and scab an 18-in. 2x4 onto the leg and ridge. The scab should stop at least 1 in. below the top of the ridgeboard.

After one end of the ridge is raised, install the common rafter pair that is one layout back from the other end of the first length of the ridgeboard. When you're nailing rafters to the ridge, use three 16d nails to face-nail the first

Supporting the gable end and ridge



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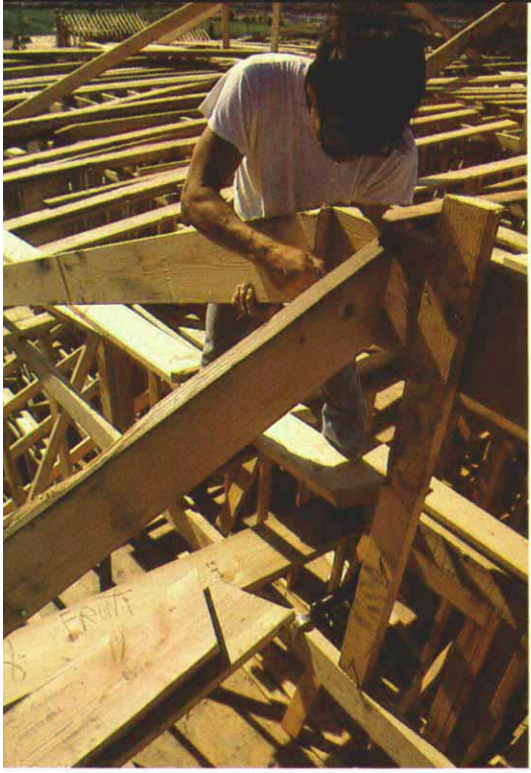
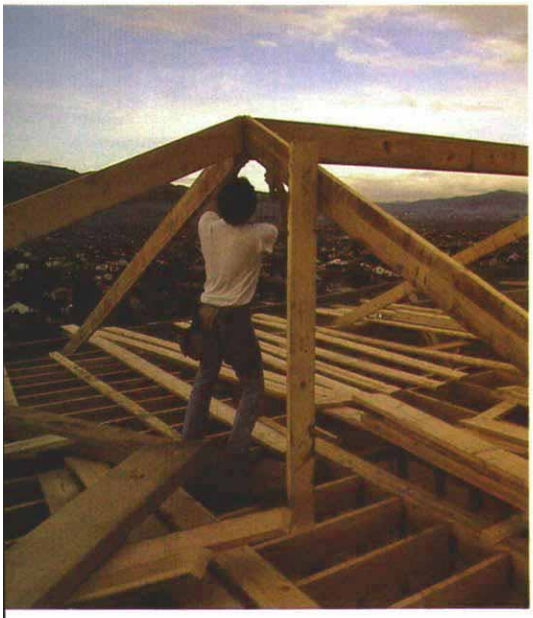
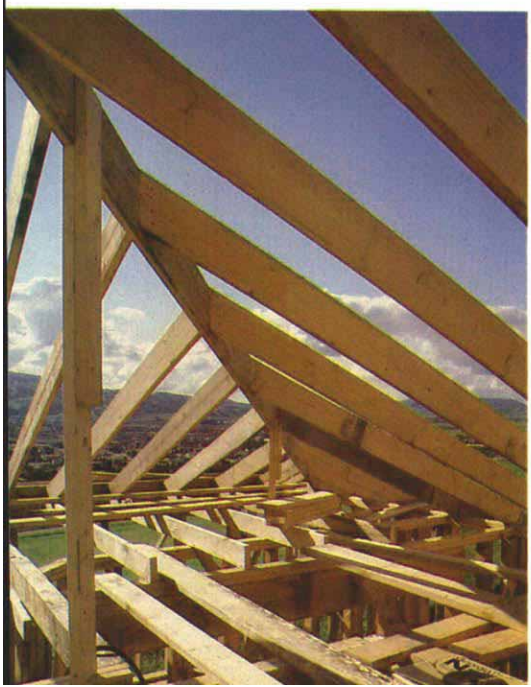






The king-common rafter that butts the end of the ridgeboard is try-fitted and used to scribe a line for cutting the ridgeboard in place (left). The rafter in the foreground is a king-common that will be nailed at the end of the ridgeboard, perpendicular to the rafter being used for scribing. The skeleton formed by the three king-commons (center left) supports the ridgeboard so the common rafters can be nailed up with frieze blocks. The vertical 2x8 in the foreground is a temporary gable-end brace.

Bottom left: The underside of a hip rafter shows the jack-rafter pairs in position. The upright brace under the hip is placed over a wall. Hips are cut from stock 2 in. wider than common rafters to accommodate the width of jacks cut at compound angles. The added width gives strength for the long span required of hips.

rafter in the pair; then toenail the second. When these rafters are secured, the gable end should be plumbed, and temporarily secured with a swaybrace, a 2x4 with one end cut on a 45° angle, that reaches from the plate (or a 2x8 nailed to the joists above) to the ridge.

Installing hips—The remaining length of ridgeboard is set next. This is easily done by nailing another support leg at the end of the new ridge piece and setting the two king common rafters that define the hip. The third king common, the one that nails to the end of the ridge, is next (photo top left). The hip end of the ridge should extend about 6 in. beyond the king-common layout to allow for final fitting. Do not nail the third common yet, but slide it up to the ridge and scribe the ridge at the plumb cut when the rafter is flush to the top of the ridge and seat cut is up tight (photo center left). Set the rafter down and cut the ridge off, then nail it in place. The resulting frame should be plumb and strong, and ready for the hips.

Raise the hip, pushing its double side cut into the slot at the ridge, and toenail it at the corner and at the ridge. If the hip is spliced, haul the pieces separately on the roof and nail a 2x4 cleat to the bottom edge of the hip at the scarf joint. Position it on the bottom edge so it doesn't interfere with the jacks. Pull a string from the top center of the hip at the ridge, down to the center of the hip at the seat cut. Nail in a temporary upright under the center of the hip and align it with the string. This should eliminate any sag. If it is spliced, cut a leg to fit under the cleat (photo bottom left). Now you can nail the jacks and their frieze blocks.

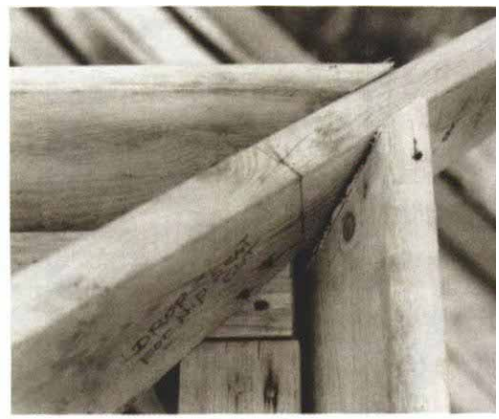
Jacks, commons and frieze blocks—Start with the smallest jacks and work up. Nail in pairs, to avoid bowing the hip. Then nail the seat cut.

The remaining common rafters can now be filled in, followed by the frieze blocks that go between the rafters at the double plate. The blocks for a 2-ft. o.c. spacing should be cut $22\frac{7}{16}$ in. and driven tight. Frieze blocks that fit against the hip will have a side cut on one end (photo right). Frieze blocks that are to be nailed perpendicular to the rafters should remain full height. However, if they are to be nailed plumb, they will have to be beveled on the pitch. This is most easily done on the table saw, but you can do it with a skill saw. In either case, use rafter off-cuts and discarded rafter stock for frieze blocks. For repeated crosscuts, use a radial arm saw, or set up a simple cut-off fixture for your circular saw (see *FHB* #8, p. 12). The blocks for our example are held to the outside of the top plate, square with the rafter (not plumb) and toenailed flush at the top of the rafter. The next rafter on layout is then pulled up, set in place, nailed at the seat cut and the ridge, and then nailed through the side into the frieze block behind it. Drive two 16d nails for 2x6s; three 16d nails for 2x8s. Whenever a ceiling joist lands next to the rafter, drive three 16d nails through the rafter into the joist.

Purlins—Purlins are required where rafter spans are long. Purlins run the length of the building at the center of the rafter span. They are usually made of the same stock as the ridge, and should be positioned once all the rafters have all been nailed in place. If the commons are 18 ft. or over, it's much easier to handle them if the purlins are installed beforehand. To put up the purlin, first string a dry line across the path of the common rafters to check their sag at the center of their span. Start a purlin at one end, and toenail it into the bottom edge of the rafter, while it's being held by two carpenters. It is held square to the edge of the rafter and perpendicular to the rafter slope. Toenail it to the rafters in several places. Then cut legs (kickers) to fit under the purlin (small photo, facing page). The kickers must sit on the top of a wall, and to avoid deflection should not be placed in the middle of a ceiling-joist span.

Finishing up—Gable roofs are also reinforced with collar ties—horizontal members that connect one rafter in a pair to its opposing member. Collar ties should be no lower than the top one-third of the rafter span. Measure down from the ridge along the slope of the rafter and make a mark about one-third of the way down. Now mark the same distance on the opposite rafter. Hold a 2x4 (or wider board) long enough

This hip rafter has been toenailed in place. The frieze blocks required a single side cut for their intersection with the hip. In cutting the bird's mouth for the hip, the amount of drop had to be calculated. This meant taking a deeper cut so that the top edge of the hip is in the same plane as the other rafters.



The purlin in the foreground (above) is supporting the span of common and hip-jack rafters. Braces positioned at interior walls are perpendicular to the slope of the roof.

Standing on the outriggers (right), a carpenter nails the barge rafter. The frame has been notched for the flat 2x4 outriggers, which are face-nailed to the first rafter inside the gable end, and flat-nailed to the gable-end rafter. The rafters are the top chords of Fink trusses.

to span the two rafters at the marks, and scribe it where it projects past the top of the rafters. Using this as a pattern, cut as many collar ties as you need.

The gable ends must be filled in with gable studs placed 16 in. o.c. Each gable stud fits flush from the outside wall to the underside of the gable rafter. You can make the gable stud fit neatly under the rafter by making square cuts with your saw set on the degree that corresponds with the pitch of the roof. For an 8-in-12 pitch, the corresponding angle is 33¾°. You can find the degrees in the rafter book under the pitch of the roof. Gable studs are best cut in sets and, like jack rafters, they advance by a common difference.

The example shows a rake of 2 ft., with a barge rafter and outriggers. Unlike the fly rafter and ladder system shown in the glossary (p. 63), a barge rafter usually isn't reduced for the ridge; it butts its mate directly in front of the end of the ridge board. The outriggers support the barge overhang. They are typically 2x4s, 4 ft. o.c. from the ridge down, extending from the barge rafter across the gable-end rafter and beyond one rafter bay. The outriggers are notched into the gable rafter, laid in flat and face-nailed to the common rafter in back, as shown in the photo at right.

To put in outriggers, first lay out the top of the gable rafter 4 ft. o.c., starting from the ridge. The layout should be for flat 2x4s (3½ in. wide). Then notch the layout marks with several 1½-in. deep saw kerfs and a few quick blows from your hammer. Make these cuts down on the rafter bench. Let the outriggers run long and cut them along a chalked line once they are up to ensure a straight line for nailing the barge rafter. □

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ERRATA

Figuring the common difference

I'm confused about the instructions given by Don Dunkley *(FHB* #10, p. 67) regarding the calculation for length of the jack rafters cited in his example. The common difference is calculated to be 2 ft. 4⅞ in. before the hip-rafter reduction; 2 ft. 3½ in. after the reduction, as Dunkley figures it (measuring along the edge of the rafter), In column 2, line 3. it is stated that 2 ft. 3½ in. should be added progressively to the length of each set of jacks. Shouldn't you instead add the original common difference (2 ft. 4⅞ in.) to the length of the first jack to calculate the correct length for the next? If 2 ft. 3½ in. is progressively added, it appears to me that the ridge correction of 1⅜ in. is progressively being subtracted from each subsequent jack, and that those rafters will fall short of their mark. Have I calculated this correctly? Or is the information in the article correct as stated? *– Ward Sherwood, Sierra Vista, Ariz.*

Don Dunkley replies: You have indeed found an error. It should read 2 ft. 4⅞ in., the common difference at 2 ft. o.c. As stated on p. 66, "Only the first jack needs to be figured for the deduction since the rest will automatically follow, as the common difference is added to each one." The common difference once determined for a certain pitch and rafter spacing never changes. Only one rafter will be adjusted for the shortening allowance: the common difference is added to each rafter thereafter.