

# HISTORIC AMERICAN TIMBER JOINERY

## A Graphic Guide

### *V. Roof Joinery Excluding Trusses*

*THIS article is fifth in a series of six to discuss and illustrate the joints in American traditional timber-framed buildings of the past, showing common examples with variations as well as a few interesting regional deviations. The series was developed under a grant from the National Park Service and the National Center for Preservation Technology and Training. Its contents are solely the responsibility of the author and do not represent the official position of the NPS or the NCPTT. Previous articles, which appeared consecutively in TF 55-58, covered Tying Joints: Tie below Plate, Tying Joints: Tie at Plate, Sill and Floor Joints, and Wall and Brace Joints. The remaining article in the series will cover Scarf Joints.*

**I**N the design of timber-framed buildings, the roof is the dominant element. The structural system necessary to support its expanse greatly influences the total building design. In masonry buildings, the roof structure may be the only timber-framed element. The carpenters who timber framed America hailed from European countries where roofs were predominantly thatch, tile and stone. In America, the abundance of excellent timber and the economy of working it led to a preponderance of board and wood-shingle roofs. The timber quality also affected the framing choices. In Europe, efficient use of timber was essential. Timber-framed buildings included members of all sizes, shapes and lengths, making the best use of the forest. Here, time and labor constraints dictated timber selection. In general, using longer, straighter timber required less joinery work. Thus it made sense to use the best, burning the rest in the fireplace. One can easily see how the abundance of wood here changed roof carpentry.

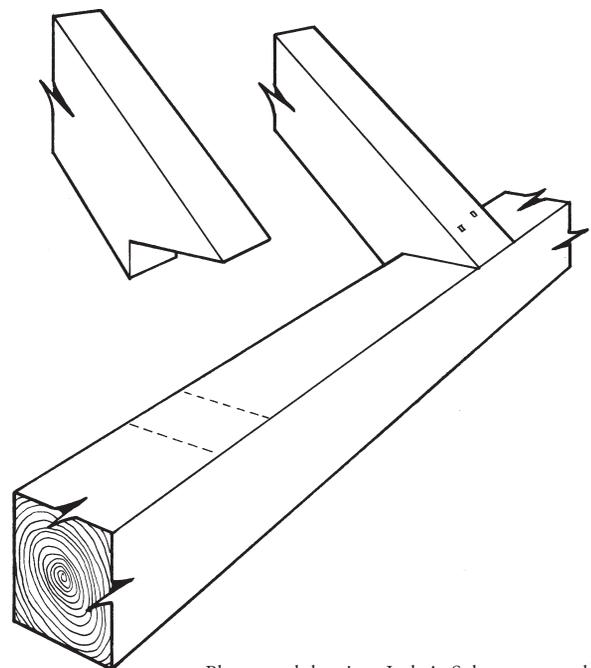
**COMMON RAFTERS.** The simplest roof system comprises only rafters spanning from plate to peak. When all rafters carry a similar share of the roof load, they are referred to as *common rafters*. Common rafters occur frequently on gable-roofed buildings up to about 30 ft. wide. Beyond that width, the rafters become excessively long and heavy, and the outward thrust on the plates becomes unmanageable. Many common-rafter roofs have collars connecting every rafter couple. Contrary to popular belief, these collars aren't ties to prevent spreading; they function as struts to stiffen a long rafter span.

On wider gable roofs, the span of the common rafters was shortened by introducing a pair of purlin plates, usually at the mid-span of the rafter. These purlin plates also reduced the outward thrust at the plates considerably. We will look at the joints where common rafters meet the plate, peak and purlin plate.

**Rafter-plate Joints.** The simplest joint between rafter and plate is a level cut on the rafter and no cutting on the plate, a *butt joint*.

Nails, pins or both are used to secure the joint. Though hardly to be classified as joinery, it could be effective and economical if well secured. Examples of this connection survive from all periods.

A better solution was to cut a *birdsmouth* in the rafter to bear against the inside edge of the plate (Fig. 1). This simple joint, named after its similarity to the open beak of a bird, could handle



Photos and drawings Jack A. Sobon except where noted

*Fig. 1. With a birdsmouth cut to fit the inside of the plate, roof thrust is adequately resisted. Here the joint is secured with nails.*

the thrust without loading the nails or pins. Unfortunately, the roof thrust in tandem with the natural checking tendency of a boxed heart rafter causes a split to develop at the mouth that can be its ruin. The situation is further exacerbated by shrinkage. Acute angles on the ends of timbers become more acute as they season and shrink; thus the load is borne by the feathered extremes of the birdsmouth. The same weakness can be worsened by a waney or out-of-square plate.

To counter these concerns, some builders used a *housed birdsmouth* joint (Fig. 3). The lower edge of the rafter is supported in a pocket, increasing its shear strength substantially. Occasionally, the top of the plate had a gain to receive the rafter. This may have been done to get a good bearing on a roughly hewn plate, or to increase the overhang slightly.

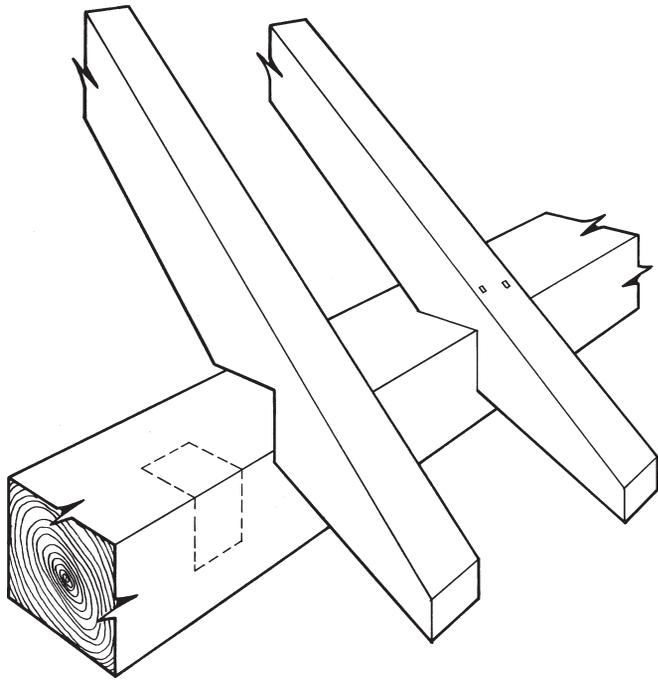


Fig. 2. As is popular today in conventional framing, the birdsmouth in this late 19th-century barn in Root, New York, is cut to fit the outside of the plate. Though the fastenings must resist thrust, there can be a substantial overhang.

In many New York State Dutch barns, the large-section (7x7, 8x8) rafters terminated in 2-in. stub tenons (Fig. 4). Sometimes they were barefaced (as shown), sometimes double-shouldered. Though the resulting mortise is strange (one expects a mortise to run parallel with the grain), the joint functions much like a housed birdsmouth. On the gable end rafters there can be relish between the mortise and the end of the plate. These joints often had no fastenings.

**Rafters with Tails.** To keep rainwater off the side of a building, builders used rafter-plate joints that allowed the rafter to project beyond the plate. These extensions, called "tails," could support a boxed-in cornice or could be exposed, as on a barn.

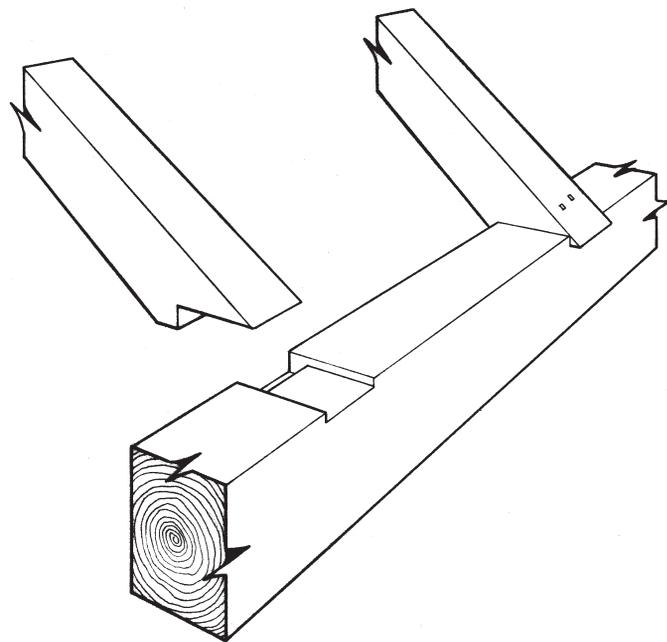


Fig. 3. The housed birdsmouth supports the lower side of the rafter and eliminates the tendency of the rafter to split up the mouth. This example is also housed into the top of the plate.



Rafters from a Great Barrington, Massachusetts, carriage shed showing a housed birdsmouth. This joint could be completely sawn.

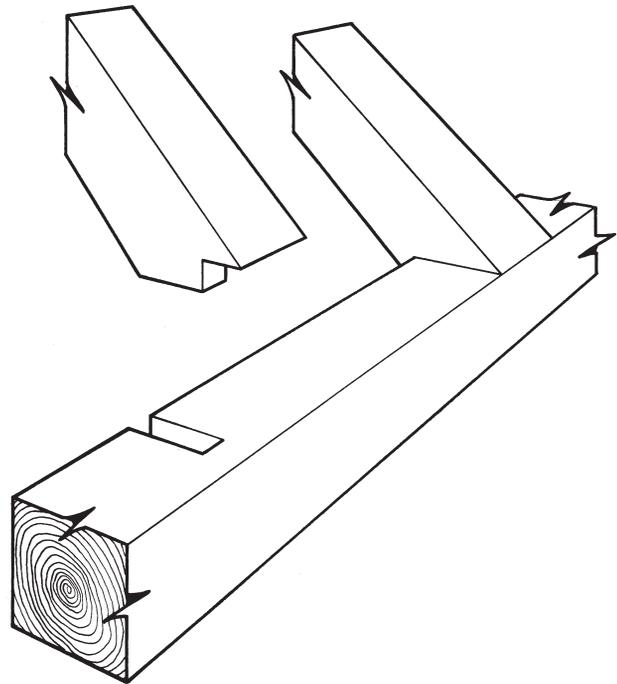
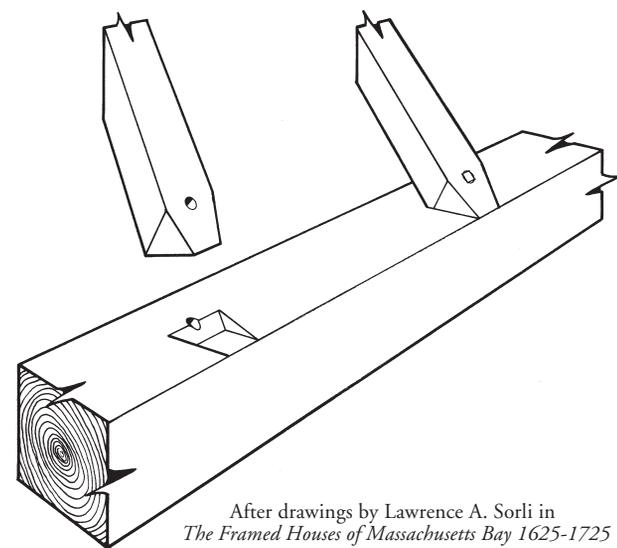


Fig. 4. On large Dutch barn rafters, a birdsmouth stub tenon is common. This example is barefaced.



After drawings by Lawrence A. Sorli in *The Framed Houses of Massachusetts Bay 1625-1725*

Fig. 5. Unusual rafter feet found in the ca. 1637 Fairbanks house in Dedham, Mass., and the Samuel Pickman house in Salem (before 1681). The dovetail matrix is apparently designed to resist roof thrust.

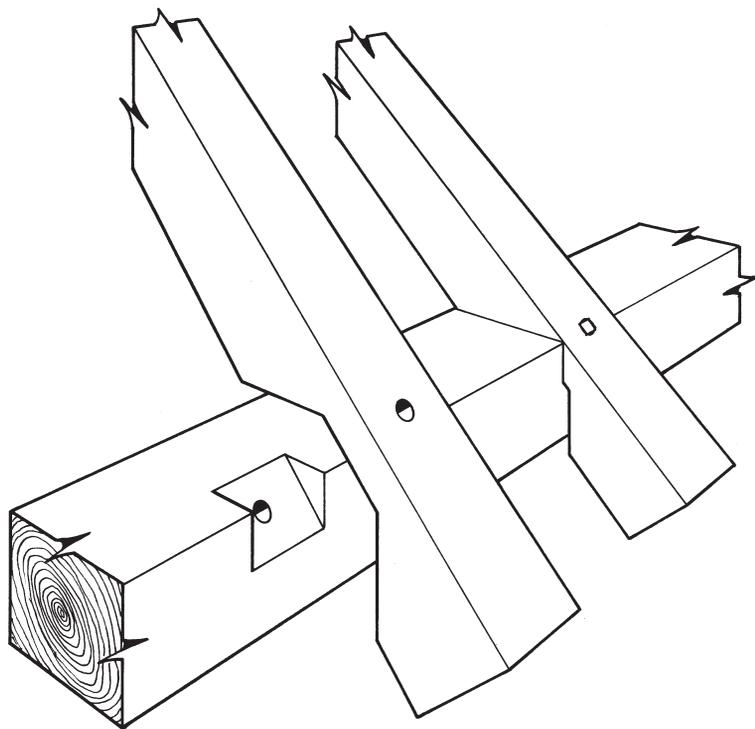


Fig. 6. In a mid-19th-century house in Shelburne, Massachusetts, the rafters have a level cut with a through tail to support a cornice.

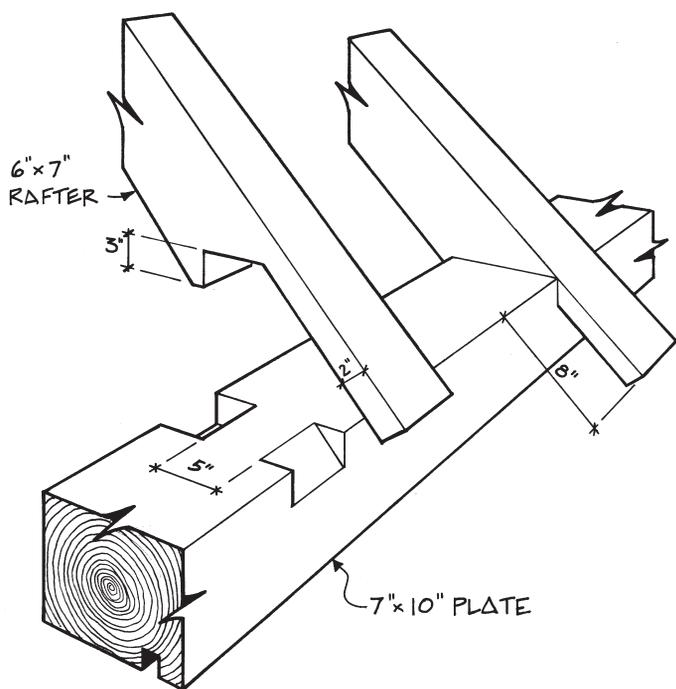


Fig. 7. These housed birdsmouth rafters with through tails were found in a well-crafted 18th-century barn formerly in Hoosac, New York. The rafters were supported at mid-span by a purlin plate and joined to a ridge at the peak. The groove in the underside of the plate was for vertical wall boarding.

The simple level-cut butt joint can be provided with a tail. To minimize cutting, the roof plane is raised a couple of inches to allow the tail to extend past the plate. If the roof plane touches the corner of the plate (an arrangement that builders seemed to prefer), then the plate must be notched to allow the tail to pass. As with the butt joint, the thrust must be resisted by the fastenings.

A stronger solution is the *birds-mouth with through tail* (Fig. 7). This requires more notching in the plate but resists the roof thrust well. Its disadvantage is that the level cut on the rafter cannot be



Rafter with housed birdsmouth and through tail from 18th-century Dutch house in Muitzenkill, New York. Three of the five cuts could be sawn; the other two had to be chiseled.

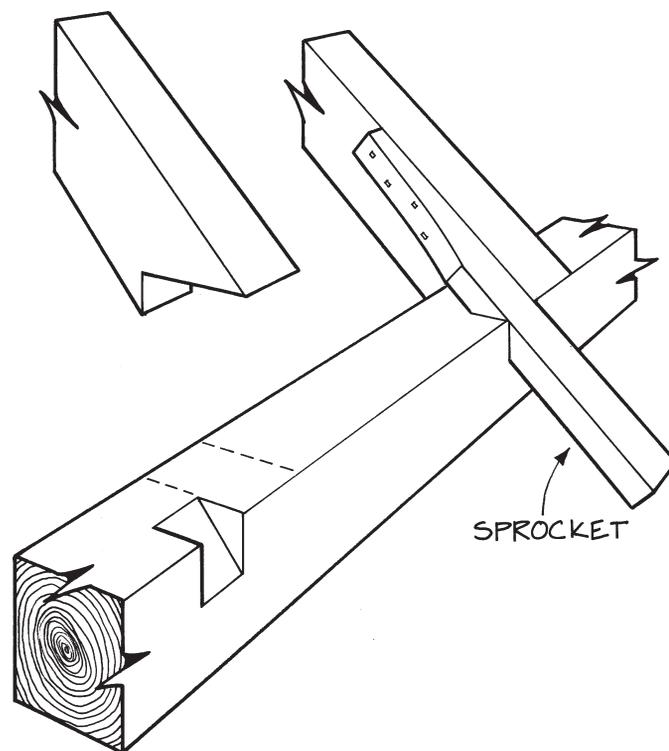


Fig. 8. Tails were often added to rafters to provide an overhang. These tails or sprockets are nailed or pinned in place. They can also be angled to provide a pitch change at the eave.

sawed out; it has to be chiseled. The tediousness of this operation would seem to account for the rarity of this joint.

The best solution to connecting rafter and plate, at least to this author and builder, is the *step-lap rafter seat* (Fig. 9 facing page), the joint found more often than any other. It was used on one of England's oldest buildings, the Barley barn at Cressing Temple, ca. 1200 (see Cecil A. Hewett's *English Historic Carpentry*), and was a standard here in America. It performs well in all respects, including economy. Though it appears complex, it is fairly simple to fabricate. The rafter has only one sawcut (not including the end of the tail), and that at 90 degrees. The axe or adz can be used to swiftly shape the surfaces toward that sawcut. The plate notches involve sawing and chiseling but can be cut quickly, with the inner V-notch presenting the only difficulty. The step is usually either 1½ or 2 in. and the tail thickness the same. The shape of the tail varies depending on the cornice detail and the builder.

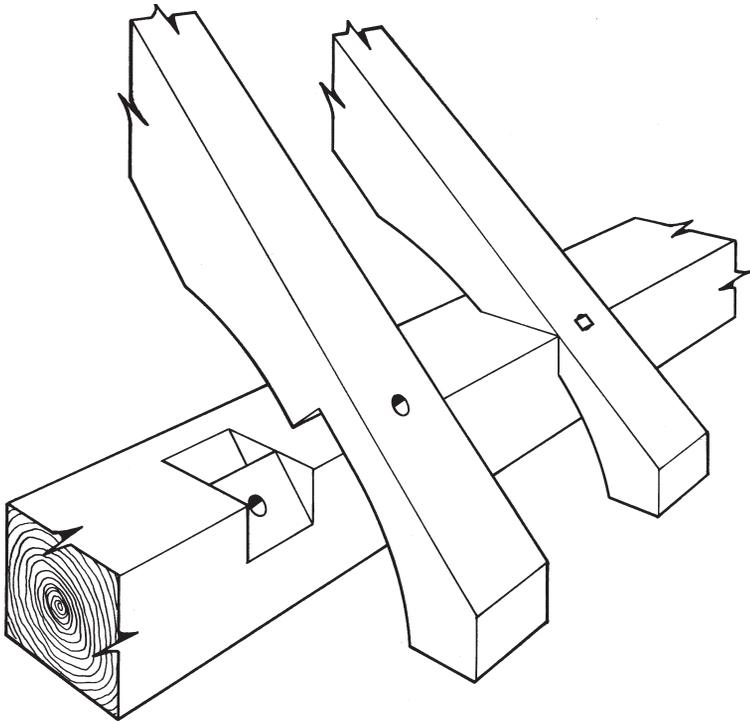
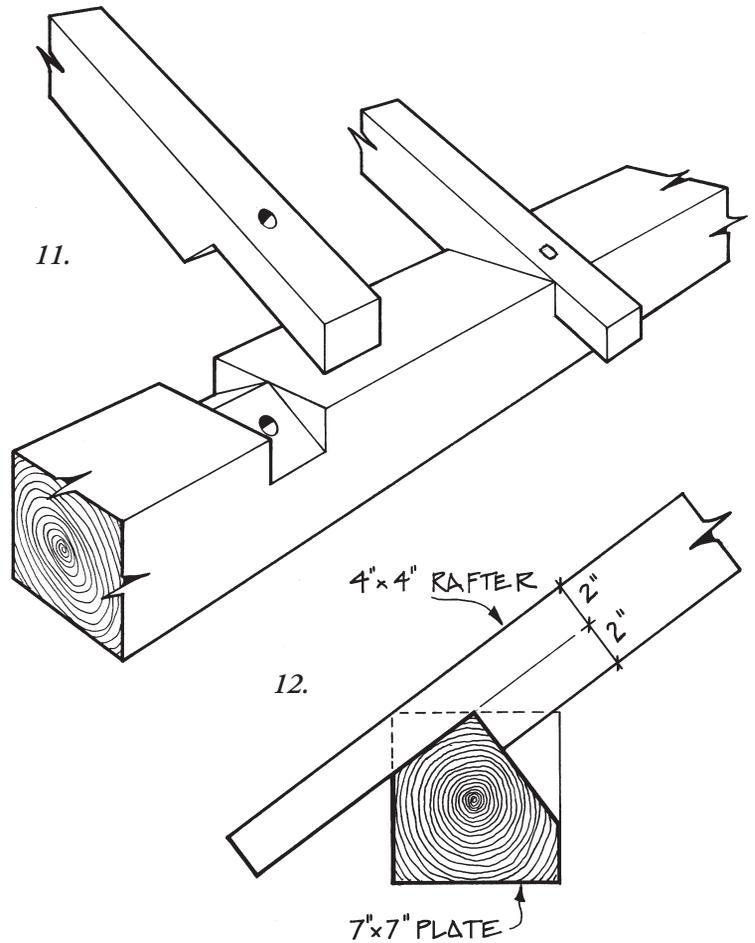


Fig. 9. The step-lap rafter can be shaped with an adze. Here the tail has a plumb and a level cut to support a cornice. A squarish pin through the tail secures it.



Figs. 11 and 12. The builder of a 19th-century South Lee, Massachusetts, barn (11) attempted to improve the step-lap seat by making it easier to cut. Here both parts of the seat could be sawed full depth. But the obtuse-angled rafter abutment tends to ride up and over the plate from the thrust of the roof. Fortunately, the roof loads in this 20x20 barn are small. The builder of a Rowe, Massachusetts, barn addition (12) also re-designed the rafter seat. Unfortunately, with its lower edge unsupported, the shear strength of the rafter is severely diminished, and the plate is also weakened, by losing its remaining upper arris.

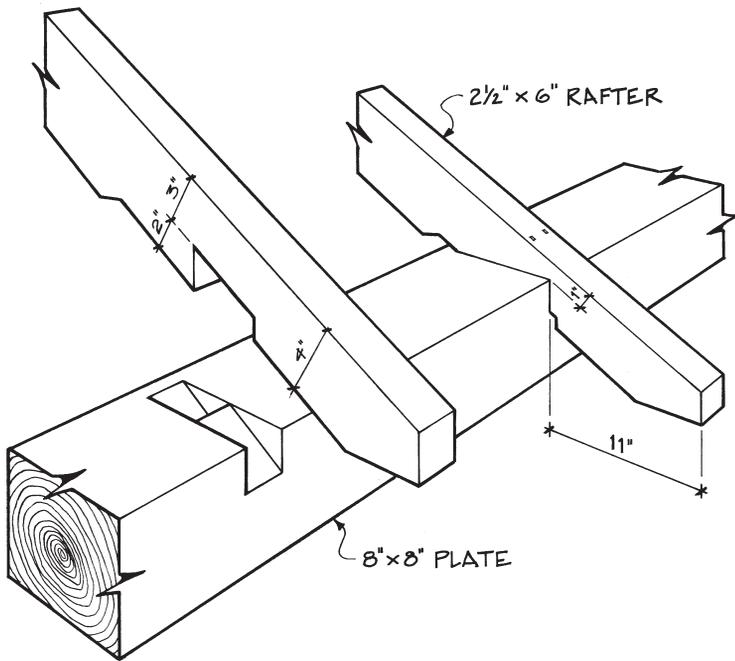


Fig. 10. Variation of the step-lap with plumb abutment. The roof plane is also elevated above the edge of the plate to increase the tail strength in this mid-19th-century carriage barn in Adams, Massachusetts.

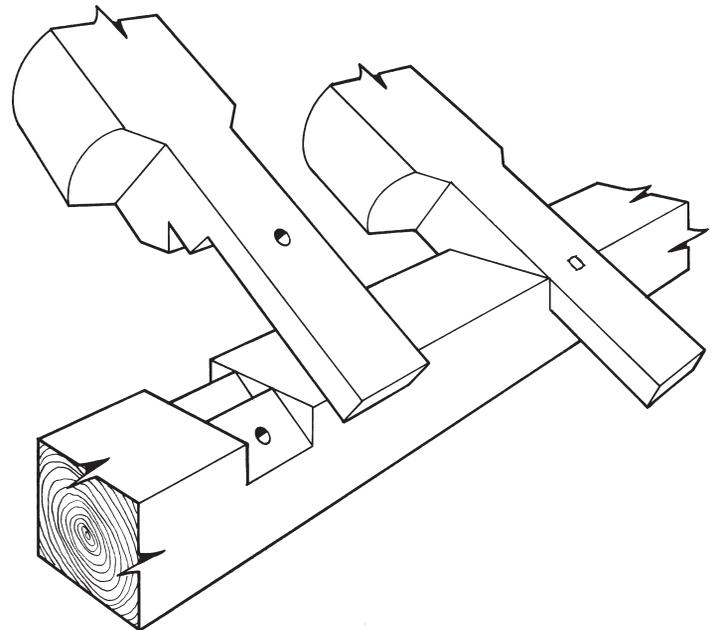


Fig. 13. The ultimate rafter-plate joint must be this example found in an 18th-century barn in Sheffield, Massachusetts. It combines the step-lap with the housed birdsmouth to create this magnificent but obviously time-consuming joint.

Step-lap rafter seat at the end of a plate from a house in Windsor, Mass., from the early 1800s. The squarish pin, here to be driven through the rafter body rather than the tail, kept the rafter from slipping off the end of the plate.



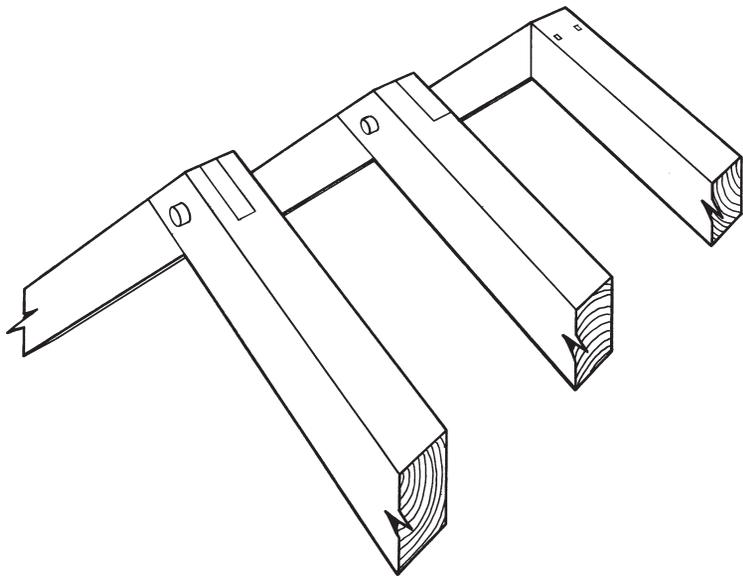
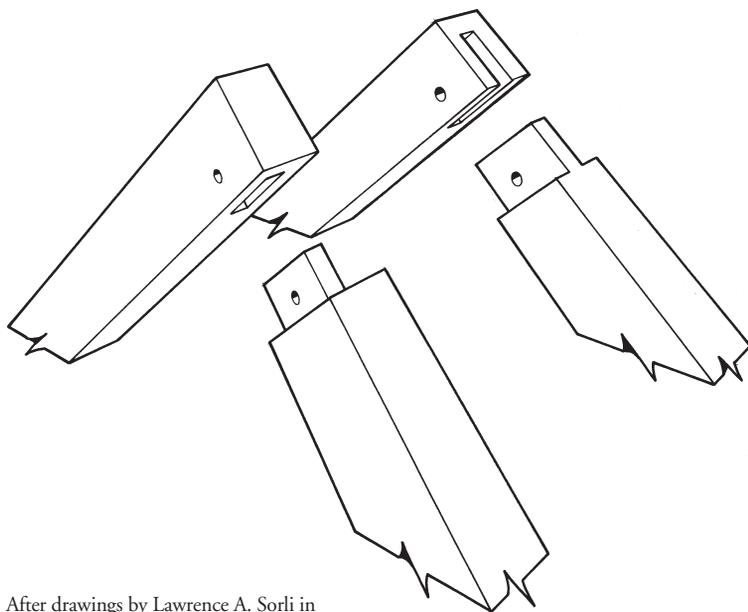


Fig. 14. Above, from left, three forms of joint for common rafters at the peak: open mortise and tenon, half-lap, butt.



View down the ridge beam of a mid-19th-century 40x50 barn in Hinsdale, Massachusetts. The 3x4 rafters have barefaced tenons.



After drawings by Lawrence A. Sorli in *The Framed Houses of Massachusetts Bay 1625-1725*

Fig. 15. On deeper section rafters, there may be some economy to these variations of the mortise and tenon. At left above, principal rafters in the ca. 1665 Gedney house, Salem, Massachusetts; at right, principal rafters in the Fairbanks house (1637), Dedham.

**Rafter-to-Peak Joints.** Where common rafters reach the roof peak, they may be joined to each other or to a ridge beam or a ridge board. When joined to each other, they are butted and secured with nails, half lapped with a pin, or mortised (open or blind) and pinned (Figs. 14 and 15). Of these, the mortised joints perform the best but require the most time to execute.

Ridge beams often appear in common rafter roofs. They are continuous members, occasionally scarfed, and typically cut out to permit a center chimney in houses. Though there are more joints to cut, the use of a ridge evens out any slight variations in rafter length to create a straight ridgeline and makes possible wind bracing down to the rafters.

The sides of the ridge are perpendicular to the roof slope and, unless the roof pitch is 12/12, the cross-section usually ends up five sided (Fig. 16). Pin holes are offset toward one edge of the joint so they don't intersect the opposing ones. As a result, all rafters are

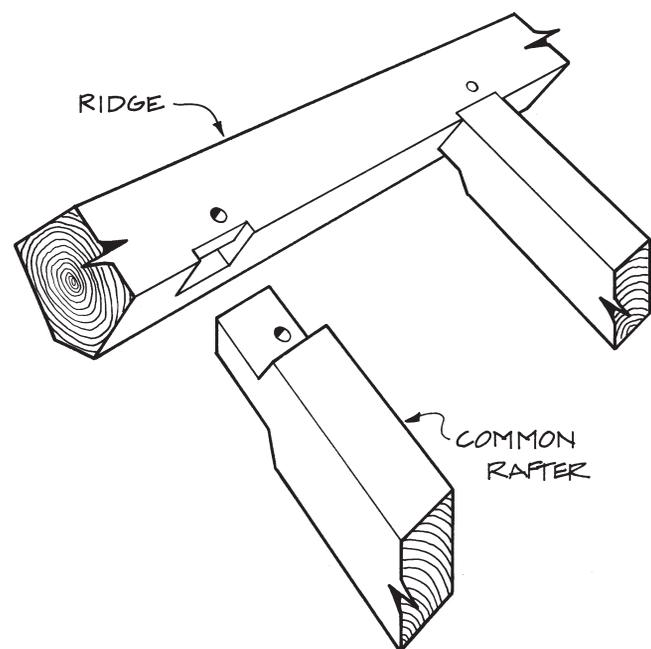


Fig. 16. The typical ridge beam, here a Square Rule example, is sized to accommodate the rafters. Pin holes are offset to avoid intersecting in material below mortises. The end of the tenon is cut plumb to provide maximum relish beyond the pin hole.

identical except the gable ones. They have narrower tenons to accommodate relish in the ridge mortises. In a few structures, the ridge ran uninterrupted below the rafters. Then the rafters joined each other above. A less satisfactory but still effective ridge was a ridge board. Here, the rafters butted a board or plank and were nailed (Fig. 17, facing page). This arrangement became common in the late 19th century and early 20th century, and is typical of stick framing today. A variation has shallow gains cut into a plank ridge to set the spacing and resist twisting of the rafters.

**Rafter-to-Purlin Plate Joints.** On wide buildings with purlin plates, if the purlin plate is set level, connections similar to the rafter-to-plate joints may be used. Because support from the purlin plate reduces the outward thrust of the roof, the joinery here may be quite simple. A simple notch to fit around the purlin plate (a modern birdsmouth) with a substantial pin is common in Dutch barns (Fig. 18). Also common is a through notch where the rafter may pass through undiminished or be reduced to a consistent size (Fig. 19). In some Dutch barns, this through notch is not sawn but shaped with an adze as a sort of chamfer a couple of feet long.

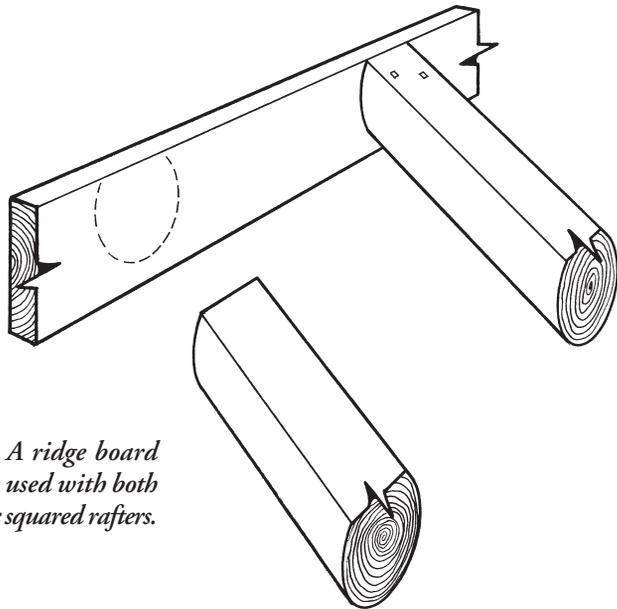
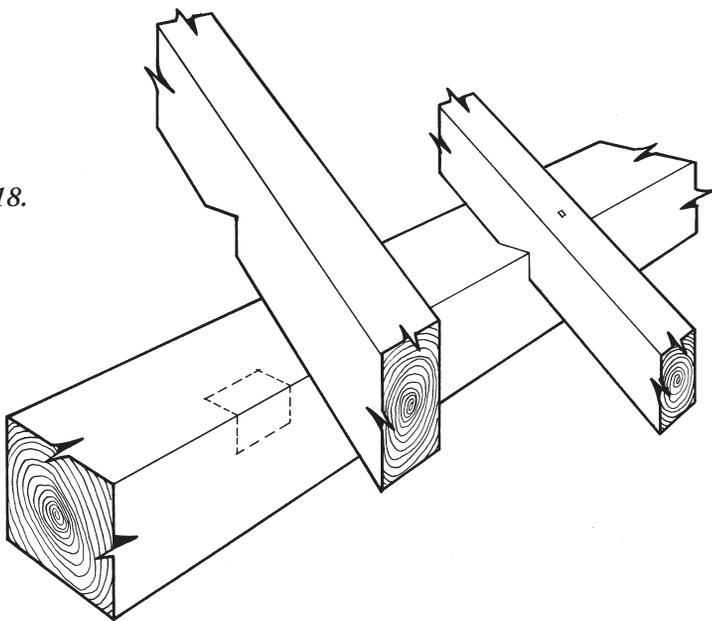


Fig. 17. A ridge board could be used with both round or squared rafters.

18.



Figs. 18 and 19. Above (18), a simple birdsmouth cut on the outside of the purlin plate is quite common in Dutch barns. A pin or spike is used to secure it. Below (19), rafters are reduced to a consistent, smaller size where they pass over the purlin plate. Only the pin resists thrust.

19.

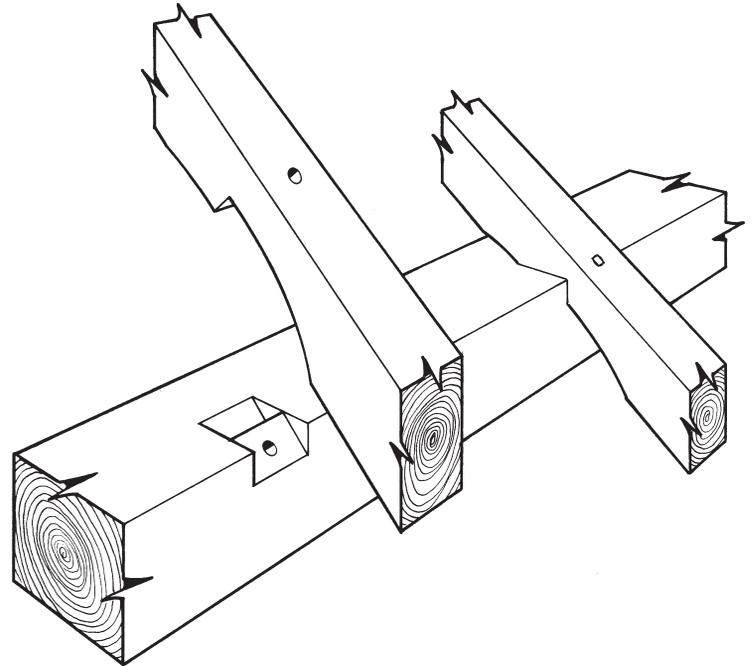
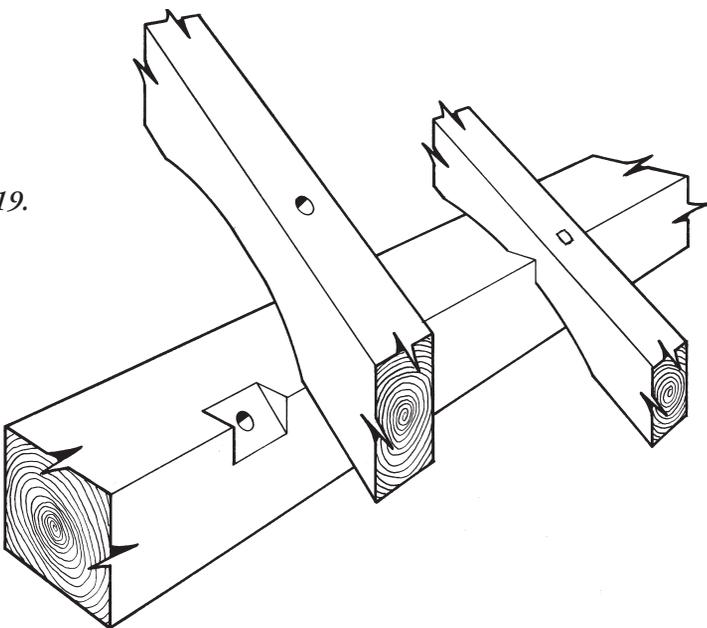


Fig. 20. The step-lap works equally well on purlin plates, but the rafter cross-section at the through point is thicker than the tail at the plate. Note how the rafter stands above the corner of the purlin plate.

In buildings with the step-lap rafter seat at the plate, the purlin plate will often have the same seat (Fig. 20). The rafter, however, is elevated above the corner of the purlin plate to maintain sufficient rafter thickness.

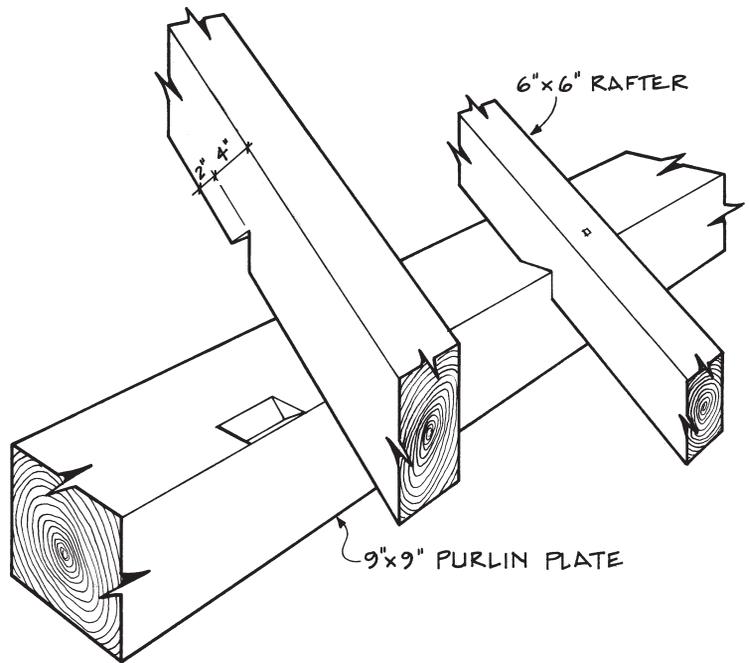


Fig. 21. This purlin plate joint was found in a 45-ft.-square barn in Middleburg, New York. It is simple and effective.



Mid-19th-century Hinsdale, Massachusetts, barn before dismantling. The continuous purlin plate assembly is canted perpendicular to the roof and the purlin plate is flush with the roof. The rafters tenon into both upper and lower faces of the purlin plate.

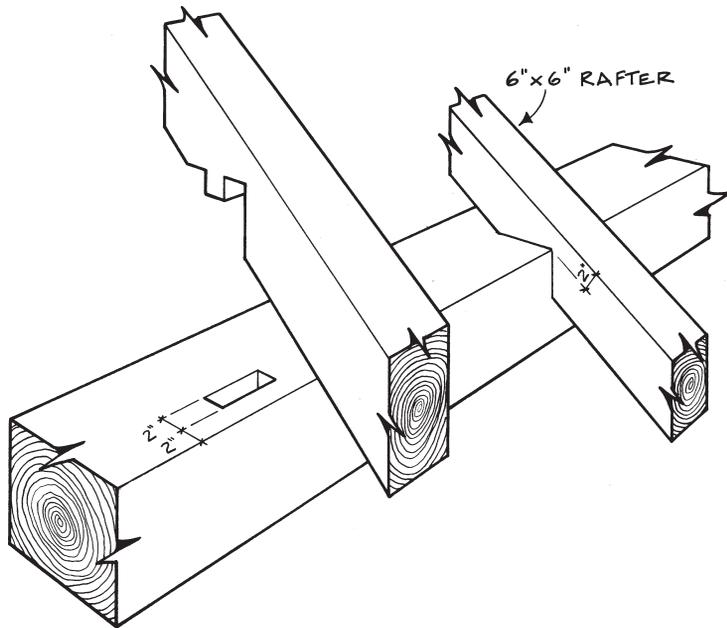


Fig. 22. A re-used rafter in a ca. 1825 Somerset County, N.J., barn implied this unusual purlin joint in its original location. Because of short grain in the tenon, its application would be best for roofs steeper than 45 degrees. The rafter section is reduced to one-third at the joint.

In the mid-19th century, when purlin plates and their canted posts were framed perpendicular to the roof slope, as shown at top, the rafter joints were simplified. In many barns, rafters continued across the purlin plate undiminished and secured with nails. Often they were sized down to a consistent section, where a shallow square abutment increased thrust resistance (Fig. 23). Or, they could be two short rafters simply butted over the purlin plate.

If the purlin plate was flush with the roof plane, the rafters could join with a simple mortise and tenon (Fig. 24).

**P** RINCIPAL RAFTER-PRINCIPAL PURLIN-COMMON RAFTER ROOFS. This most elaborate roof system includes purlins supported by principal rafters. The purlins may be tenoned between the principal rafters or run over them, and the common rafters then span between the principal purlins (Fig. 24), or run over them (Fig. 25). The advantages of such a design to warrant the extra cutting work are that the common rafters can be shorter and of lighter scantling, and bracing can be conveniently framed in to

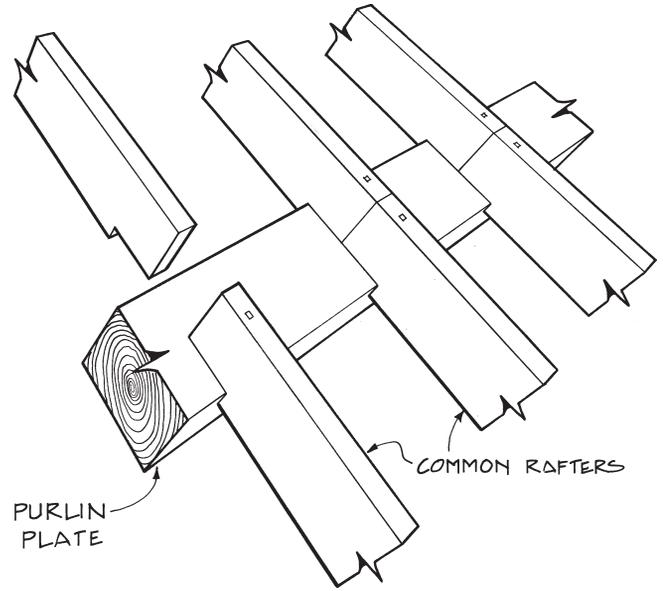
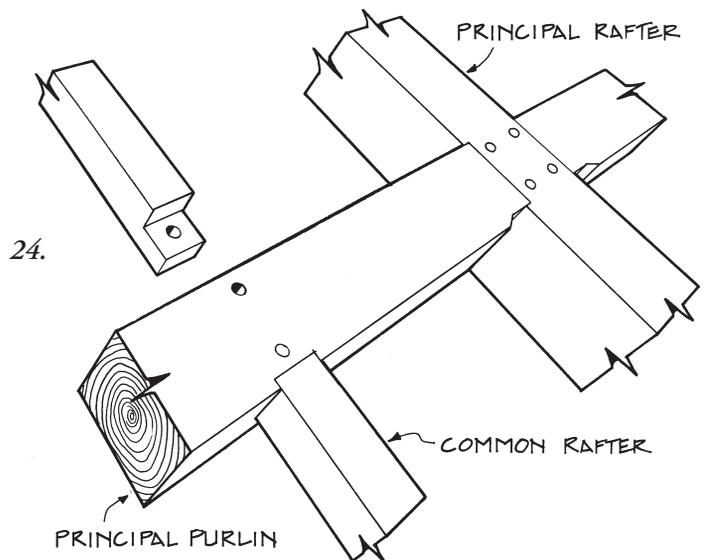
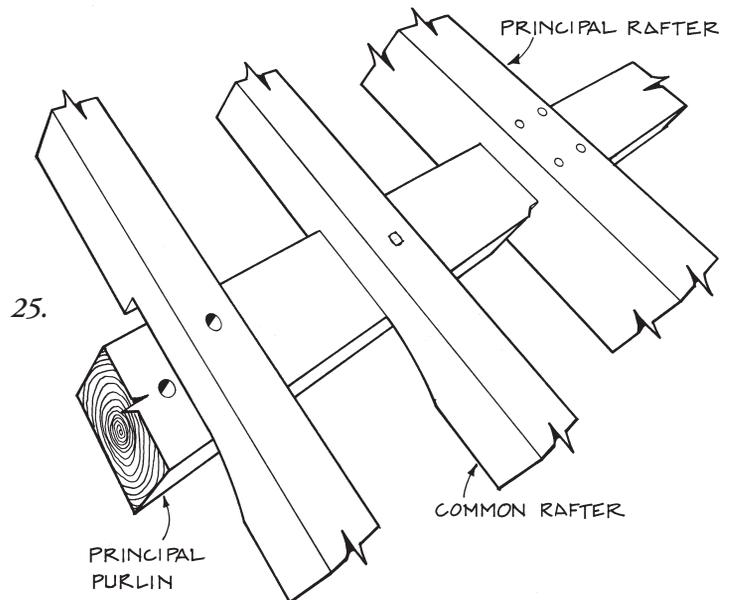


Fig. 23. Canted purlin plates eliminate considerable cutting since rafters (here sized and butted) can pass over the purlin plate.



Figs. 24 and 25. Above (24), a flush principal rafter-principal purlin-common rafter roof, with rafters tenoned into the purlin, itself tenoned to the principal rafter. Below (25), purlin framed below principal rafter and through rafters notched where they cross the purlin.



stiffen the roof. (Since many 17th-century roofs were not sheathed completely with boards, the roof framing required bracing.)

The principal rafters were typically tenoned at their feet into tie beams, creating a rigid triangle at each cross frame. (See the second article in this series, "Tie at Plate," in TF 56.)

The joinery that accompanies this roof type varies depending on whether all or some of the members are flush with the roof plane as seen in Figs. 24-27. Common rafter joints at plate and peak are unchanged from those already addressed.

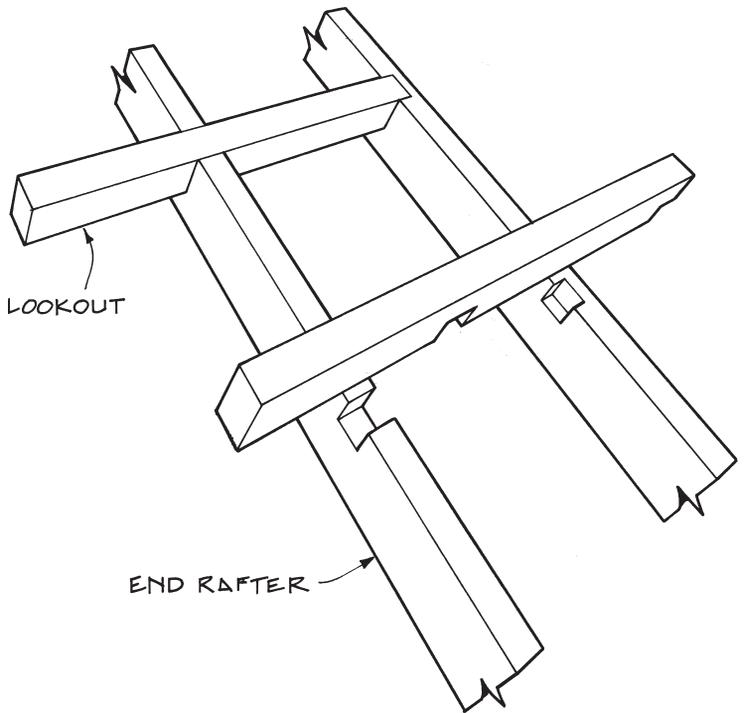


Fig. 28. In common-rafter roofs where a substantial rake overhang is required, "lookouts" are framed to cantilever out.

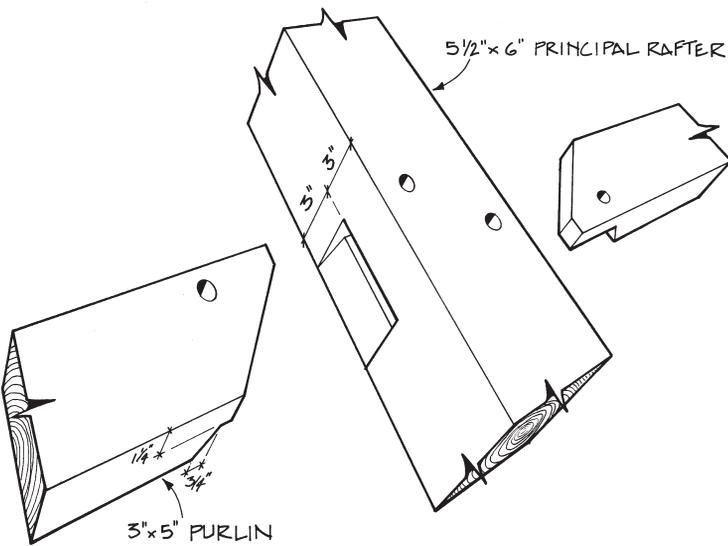


Fig. 26. This unique purlin-to-principal rafter joint appears in the 1668 Turner House (House of the Seven Gables) and the 1665 Gedney house, both in Salem, Massachusetts. Its advantage lies in the way a fairly narrow principal rafter could accommodate two purlin tenons with sufficient pin hole relief to be effective.

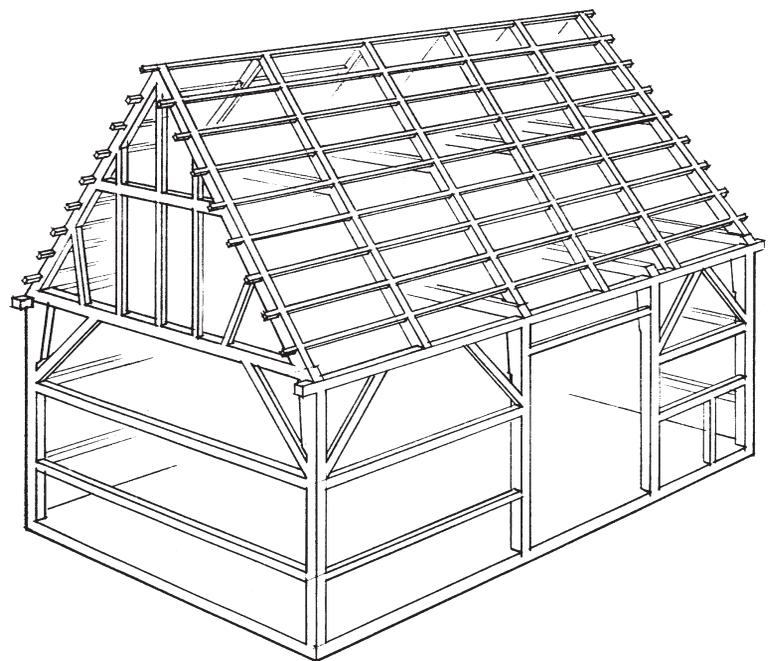
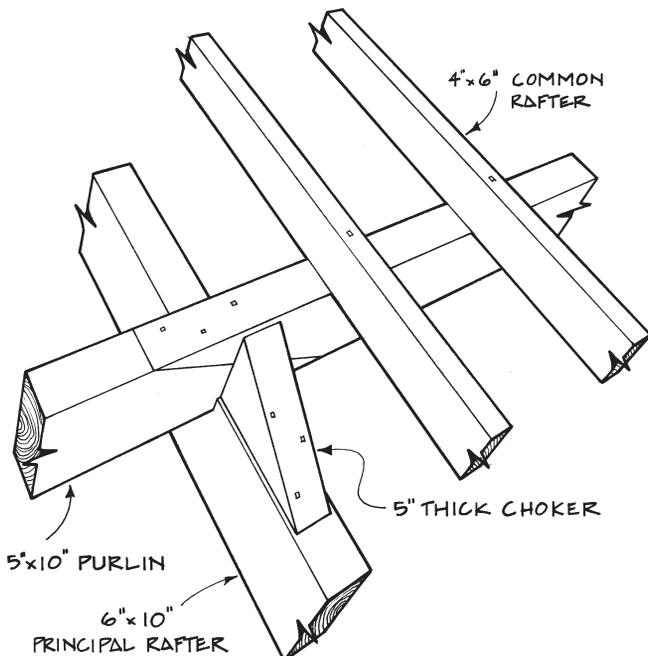


Fig. 29. This 17th-century barn in Seekonk, Massachusetts, has principal rafters spaced a little over 6 ft. apart with 2x3 common purlins spaced about 2 ft. on center. The purlins extend past the gable to provide an overhang.



After drawings by Lawrence A. Sorli in *The Framed Houses of Massachusetts Bay 1625-1725*

Fig. 27. In trussed roof buildings, the purlins may bear on top of the principal rafters, as shown here in the Cabildo in New Orleans. The deep-section cypress purlins are scarfed over the principal rafter in what the French refer to as a "whistle cut." The purlin end cut is then recycled as a sort of cleat, a "choker," to keep the purlin from rolling.

**P** RINCIPAL RAFTER-COMMON PURLIN ROOFS. This roof type is most common in eastern New England. The oldest common purlin roof remaining from the Massachusetts Bay colony is on the Coffin house at Newbury, ca. 1654 (see Abbott Lowell Cummings, *The Framed Houses of Massachusetts Bay 1625-1725*). In the earliest examples, this roof type was not sheathed with boarding but covered with thatch or riven shakes. In some later examples, the roof sheathing, running vertically, was a weathertight board-on-board. The additional expense of framing a common purlin roof instead of a common rafter roof was apparently justified by the savings of a board covering compared with a shingled one.

Common purlins usually run continuously across the rafters and often extend at the gable to support the rake overhang. In two-bay houses and smaller barns, the purlins typically run the full length of the building and are often hewn from slender trees. Common purlins up to 40 ft. long are not unusual, but in larger structures they more often are made up of two or more lengths, hewn or sawn. Where purlins meet, they may be staggered or scarfed. Because the chimney normally runs through the peak, the ridge purlin in houses can be in two lengths and doesn't require a scarf.

The typical common purlin-to-principal rafter joint is a through trench in the rafter with a pin to secure it. The purlins may pass at full size or be reduced or halved in the trench (Figs. 30-34). Fig. 35 on the back cover shows the special case of a hip roof. Common purlins are often small (1½ in. x 2½ in. up to 3x5) and are usually laid flat.

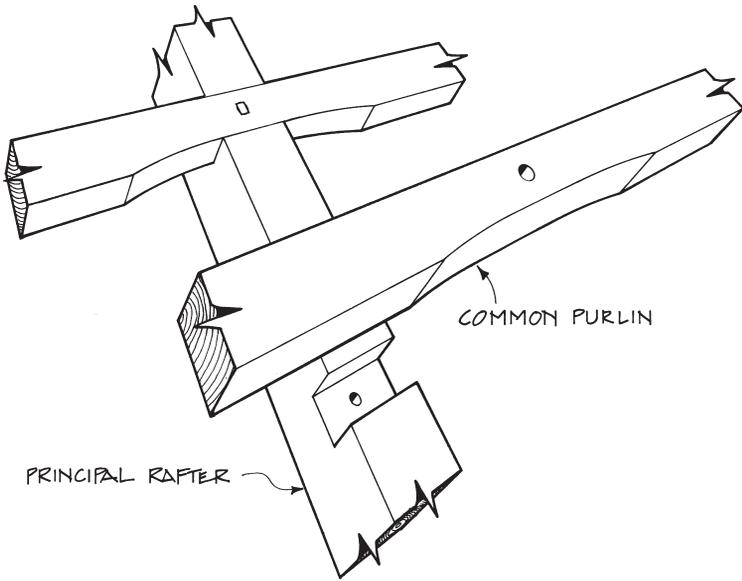


Fig. 30. Common purlins are typically trenched across the rafters and secured with a squarish pin. Here they are reduced to a consistent width with an adze.

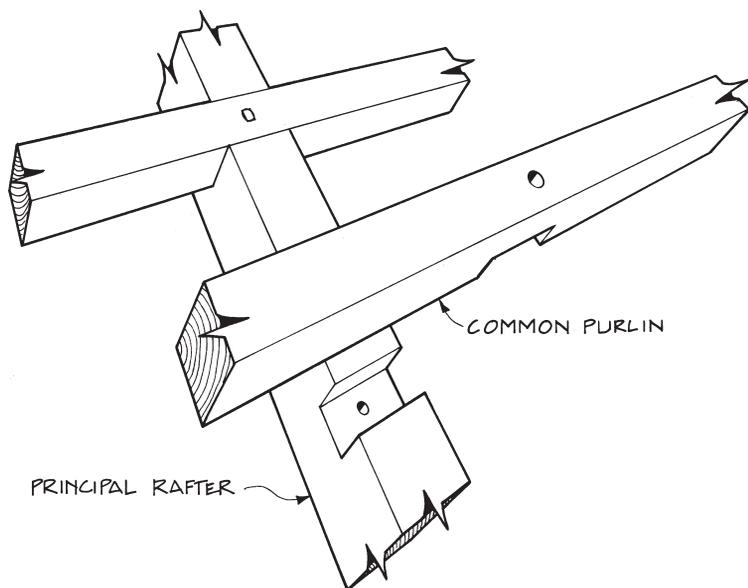


Fig. 31. To avoid unduly weakening principal rafters, deep-section purlins are notched or halved where they cross.

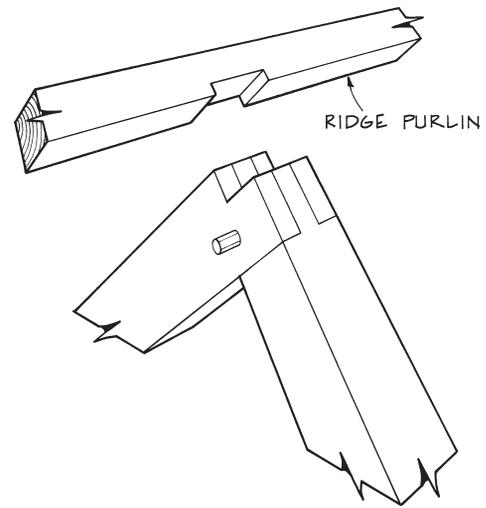
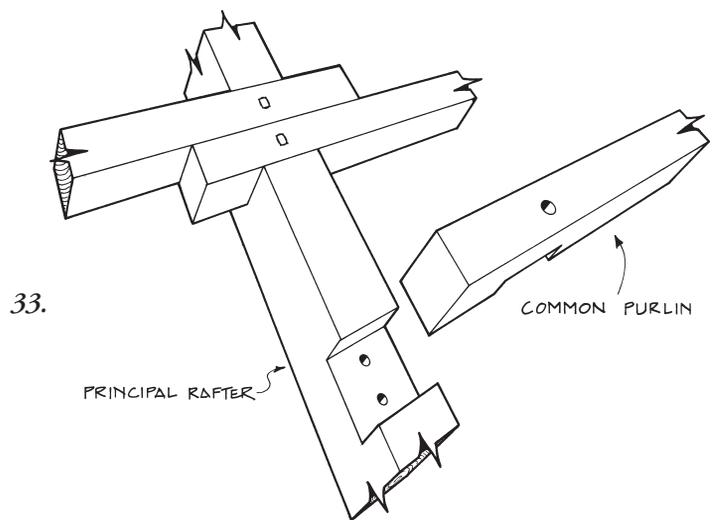
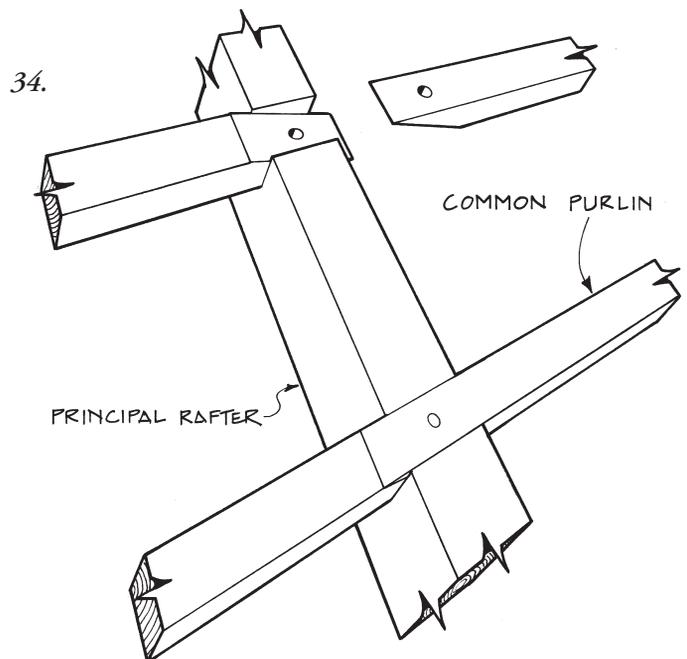


Fig. 32. The mortised rafter receives the notch for the ridge purlin.



33.

Figs. 33 and 34. Above (33), many buildings have the purlins staggered to avoid scarfing. Here, purlin relish beyond the halving augments the pinned connection and ties the roof longitudinally. Below (34), purlins may be skived (scarfed) in line and secured with a pin.



34.

**O**THER ROOF JOINERY. Lean-to-roofed additions are common on old structures, some built simultaneously with the main frame. By lessening the pitch of the lean-to roof—to produce a *broken back* roof—the rafter connections are simplified. The lean-to rafter can bear on the plate or on top of the main roof rafters (Figs. 36-38).

The Dutch and Germanic barns built in New York and New Jersey often had *pentice* roofs (see TF 43) over the main doors at each end and occasionally over the smaller side-aisle doors. Various techniques were used to support such a roof. In the simplest design, triangular blocks 1½ to 2 in. thick were nailed onto the sides of the studs over the doorway and supported board sheathing (tenoned variant, Fig. 39). In other designs, joists spanning the end bays cantilevered over or through the gable anchorbeam to support a plate and rafters (Fig. 40). These 2-ft. to 3-ft. pentice roofs protected the doors and sill below from the weather. —JACK A. SOBON

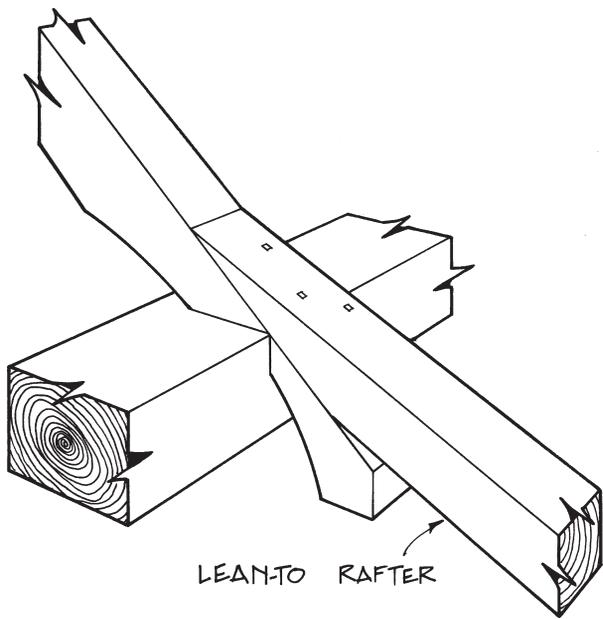


Fig. 36. Dutch houses often had “broken back” lean-tos, where the lean-to pitch was lower than the main roof pitch. A simple, effective solution was to bear the lean-to rafter on the back of the main rafters and secure the connection with a pin or nails.

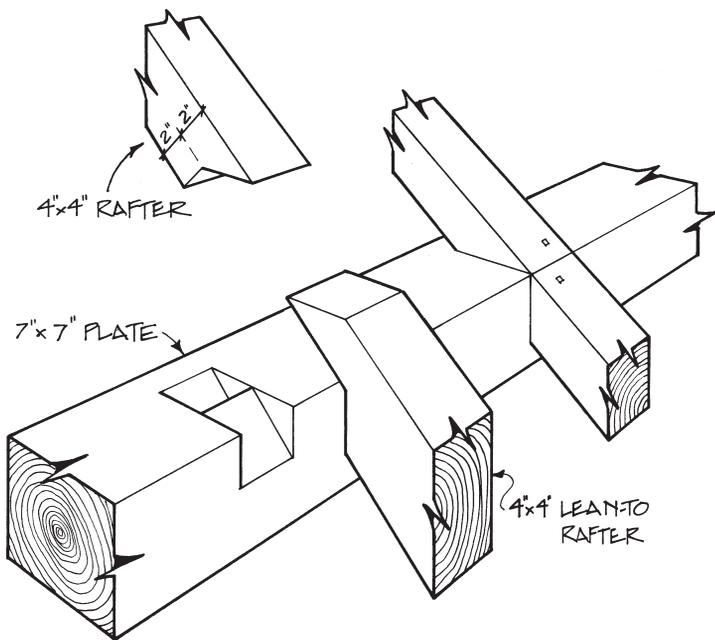


Fig. 37. In this early 19th-century Pittsfield, Massachusetts, house, the lean-to pitch matches the main roof pitch and the rafters are beveled in the step-lap seat.

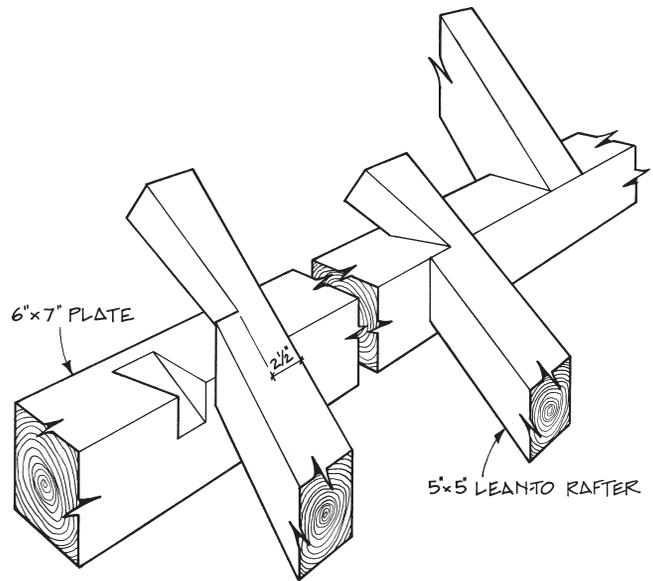
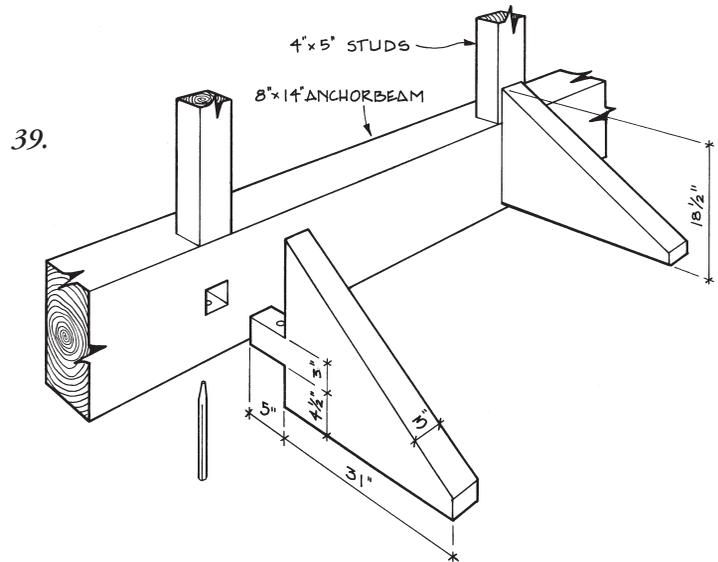


Fig. 38. In this ingenious and singular example from a barn in Seekonk, Massachusetts, the lean-to rafters are half-dovetailed in both width and thickness to lock into the main plate.



Figs. 39 and 40. Above (39), many end anchorbeams have tell-tale mortises, but only one example of this type has been found with all pentice parts intact, on a 44x45 barn that originally stood in Berne, N.Y. Though the 3x3 tenon 5 in. long would seem undersized, it worked for over 200 years. Below (40), many Dutch barns had cantilevered pentice arms mortised full-size through the gable anchorbeam. Four or five of these supported the pentice plate and rafters.

