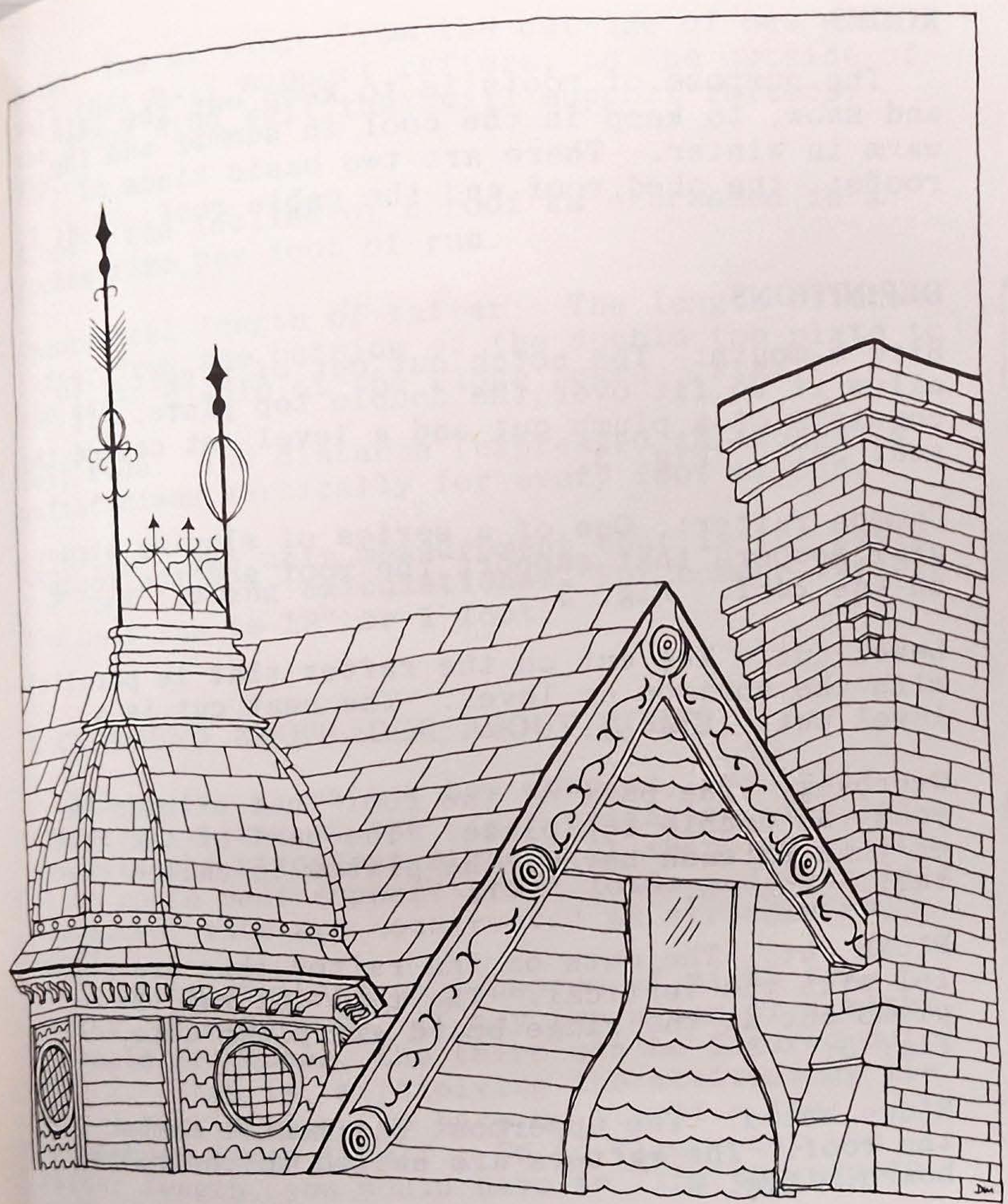


Chapter 8

Roofs

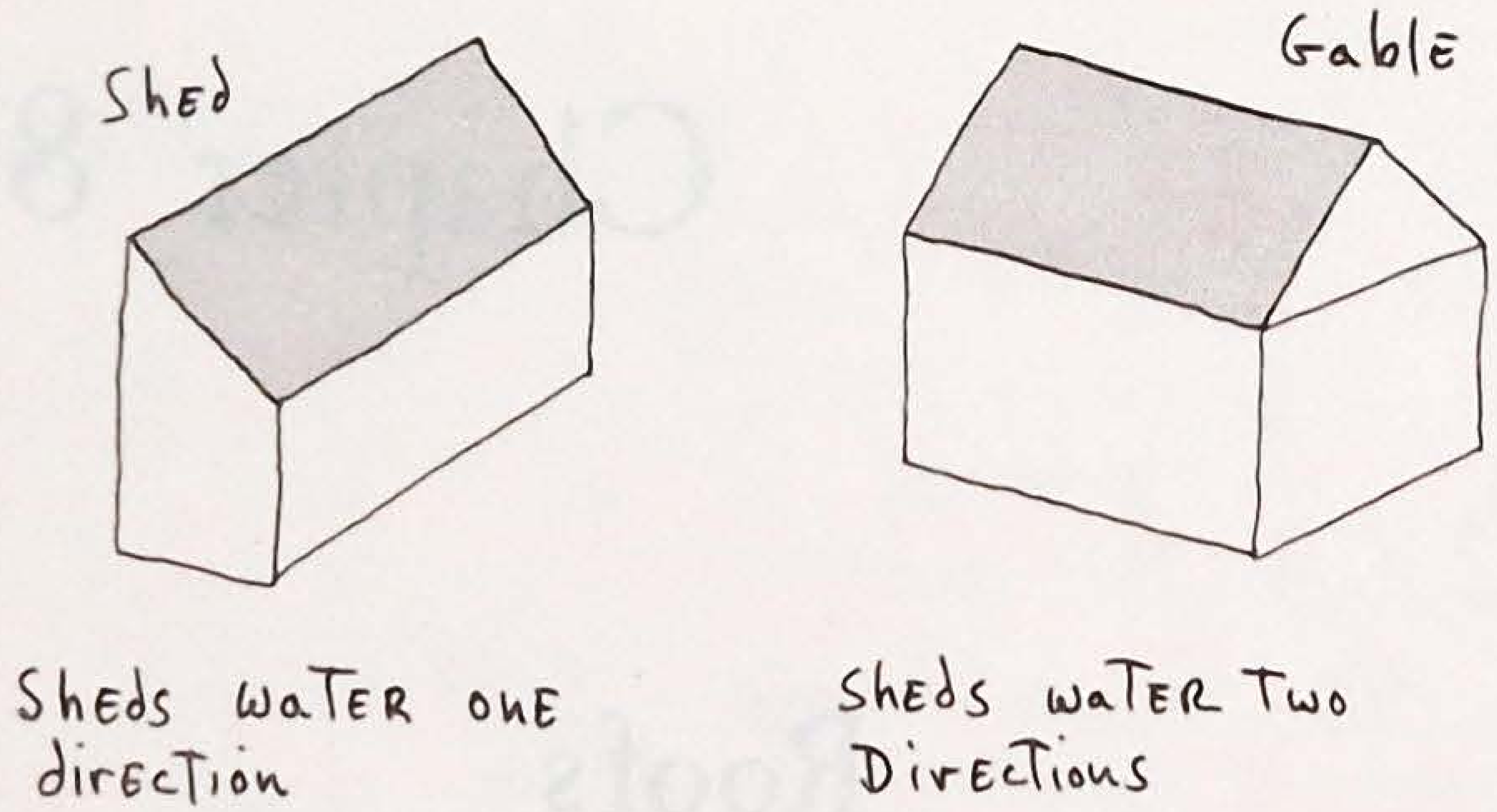


Fig. 1 – Two Basic Types of Roofs

ROOFS

The purpose of roofs is to keep out the rain and snow, to keep in the cool in summer and the warm in winter. There are two basic kinds of roofs: the shed roof and the gable roof. Fig. 1.

DEFINITIONS

Bird's mouth: The notch cut out of a rafter to allow it to fit over the double top plate. It consists of a plumb cut and a level cut called the seat cut. Fig. 3.

Common rafter: One of a series of sloping structural members that support the roof and the loads on the roof. Fig. 3.

Level cut: The cut on the rafter that is parallel with the horizon or level. The seat cut is a level cut. Fig. 5.

Overhang: The part of the roof that extends beyond the double top plate. The part of the rafter that extends beyond the plates is called the tail. Fig. 5.

Plumb cut: The cuts on the rafter that are parallel with the vertical. The tail cut and the plumb cut at the ridge board are plumb cuts. Fig. 5.

Ridge board: The uppermost horizontal member of the roof. The rafters are nailed to the ridge board. Fig. 3.

Run: One-half the span of the building. Fig. 3.

Span: The distance from the outside of one stud wall that will support rafters, to the outside of the other stud wall that will support rafters. Fig. 3.

Slope: The incline of a roof as expressed in X inches rise per foot of run.

Theoretical length of rafter: The length of the rafter from the outside of the double top plate to the exact middle of the ridge board. Fig. 5.

Unit rise: The distance (expressed in inches) a rafter rises vertically for every foot of run.

Unit run: The unit measurement that is the basis for roof framing calculations. For common rafters the unit run is 12" or 1 foot.

BACKGROUND KNOWLEDGE ABOUT ROOFS

All roofs, no matter how complex, are built using variations of the right triangle. The triangle is the strongest structural shape in nature. Since roofs must support great loads and span long distances, they are constructed as strongly as possible.

Using the Pythagorean theorem of right triangles, $A^2 + B^2 = C2$, if any two sides of a right triangle are known, the third can be figured out. Fig. 2. That is, multiplying the altitude by itself + multiplying the base by itself = the hypotenuse times itself. So to figure out the rafter length, you would have to find the square root of the hypotenuse.

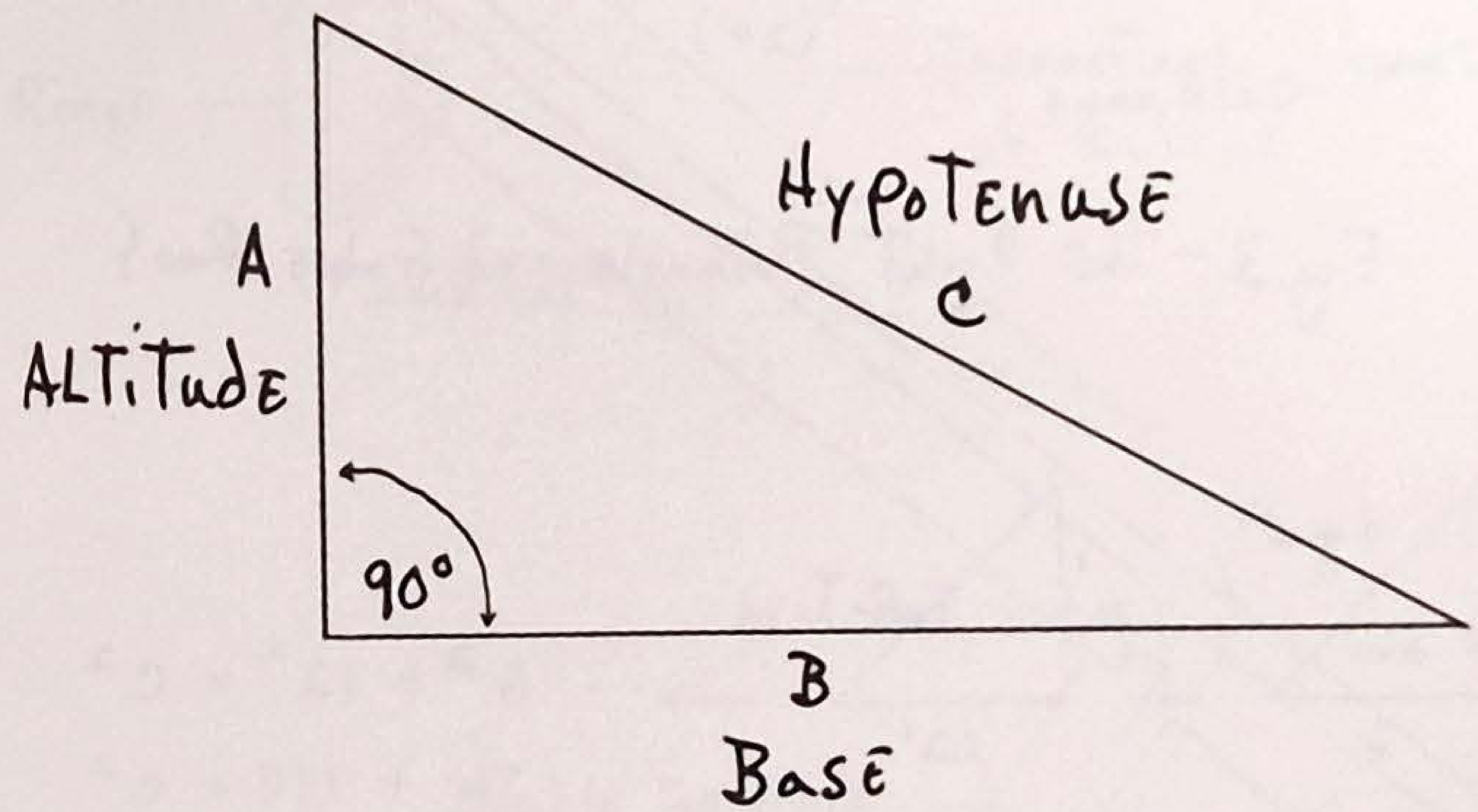


Fig 2 - A Right Triangle

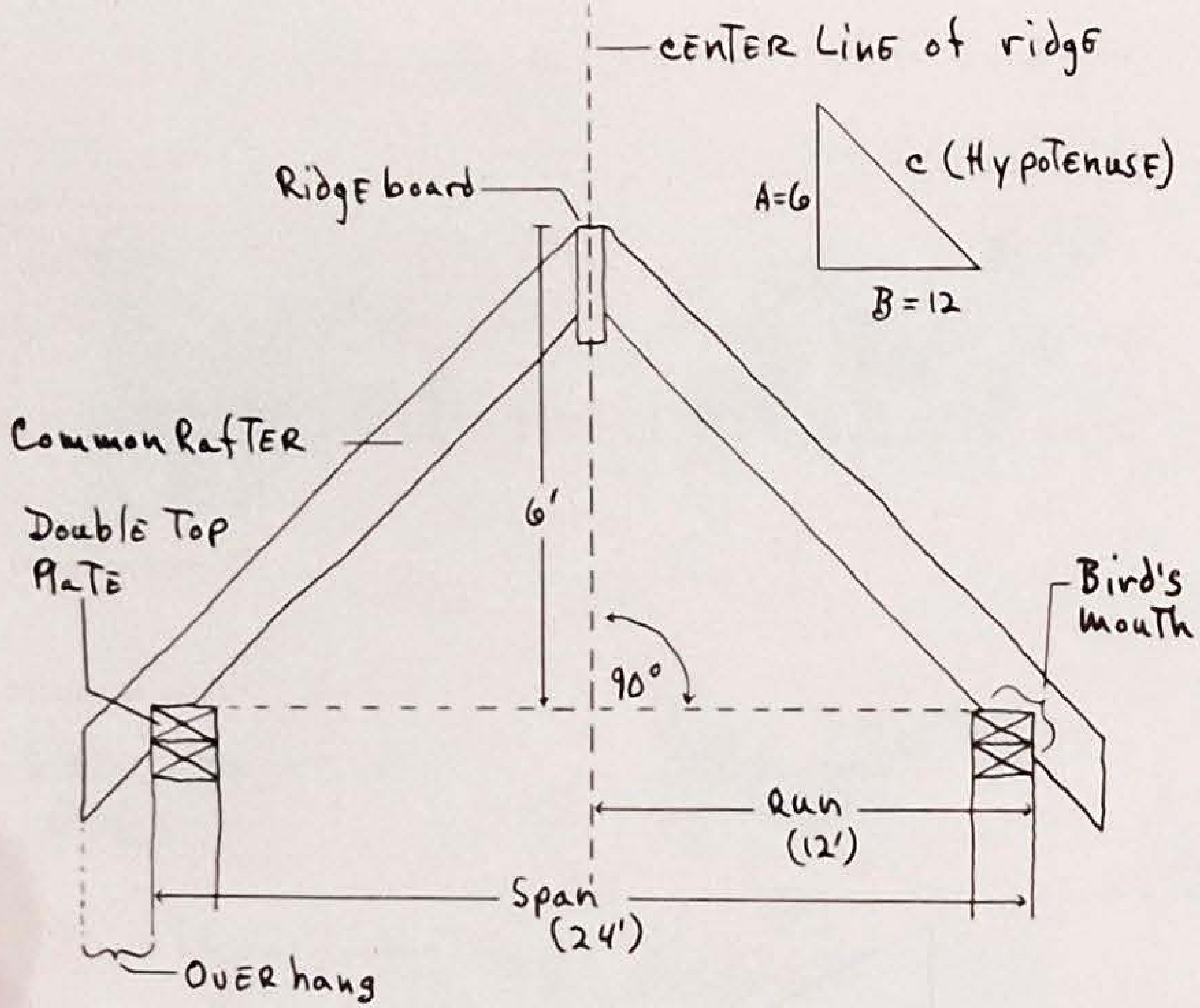
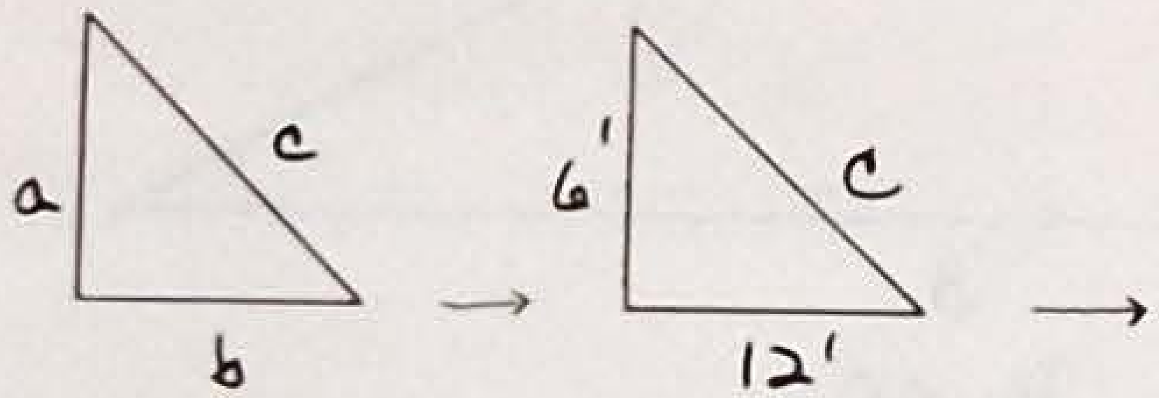


Fig.3 - The Right Triangle and Gable Roof



$$6^2 + 12^2 = c^2$$
$$36 + 144 = c^2$$
$$180 = c^2$$

Theoretical Length of Rafter $= 13.419' = c$

Fig. 4 - The Pythagorean Theorem

FINDING THE LENGTH OF RAFTER USING THE PYTHAGOREAN THEOREM

If you have to build a gable roof on a structure that is 24' across, and you want the height of the midpoint of the roof to be 6' (6' from the top edge of the double top plate to the top edge of the ridge board), using the Pythagorean theorem, $A^2 + B2 = C^2$, you can find what length the rafters have to be.

In a gable roof each pair of rafters makes up one large triangle that contains within it two right triangles--the rafters are the hypotenuses of these triangles. For the above roof with a total rise of 6', the run is 12' (half the span). Fig. 3. We now know two sides of the triangle and can use the Pythagorean theorem to figure out the third--the theoretical length of the rafter. Fig. 4.

Rafter Tables

Luckily you don't have to go through all this figuring every time you want to build a roof. It has been done already and arranged in tables. The tables can be found in special rafter books or on the framing square. The tables in books tell the specific rafter length for roofs with hundreds of varied rises and runs. The tables on the framing square give the length of the hypotenuse for the triangles with a base of 12" but rises of varying lengths. This number must be multiplied by the number of feet in the total run of the roof to arrive at the length of the rafter.

Unit Rise And Unit Run

Another way of expressing the specifications of a roof is in unit rise and unit run--that is, how many inches the slope of the roof rises for every foot that it travels horizontally. This is the way roofs are commonly characterized, and a framing square is the tool used to transcribe the relationship between these two numbers (unit rise and unit run) into an actual roof.

To describe our roof (Fig. 3) with a total run of 12' and a height (total rise) of 6' in this way, we would say it has a unit rise of 6" for each foot of run. The unit of run is always 12" for common rafters, but the rise changes, thereby making steeper or more gently sloping roofs. A slope of 6" of rise in 12" of run is not overly steep ($26\frac{1}{2}^{\circ}$). 4" in 12" is quite gentle ($18\frac{1}{2}^{\circ}$) and 12" of rise in 12" of run forms rafters with a 45° angle with the double top plate. Fig. 5.

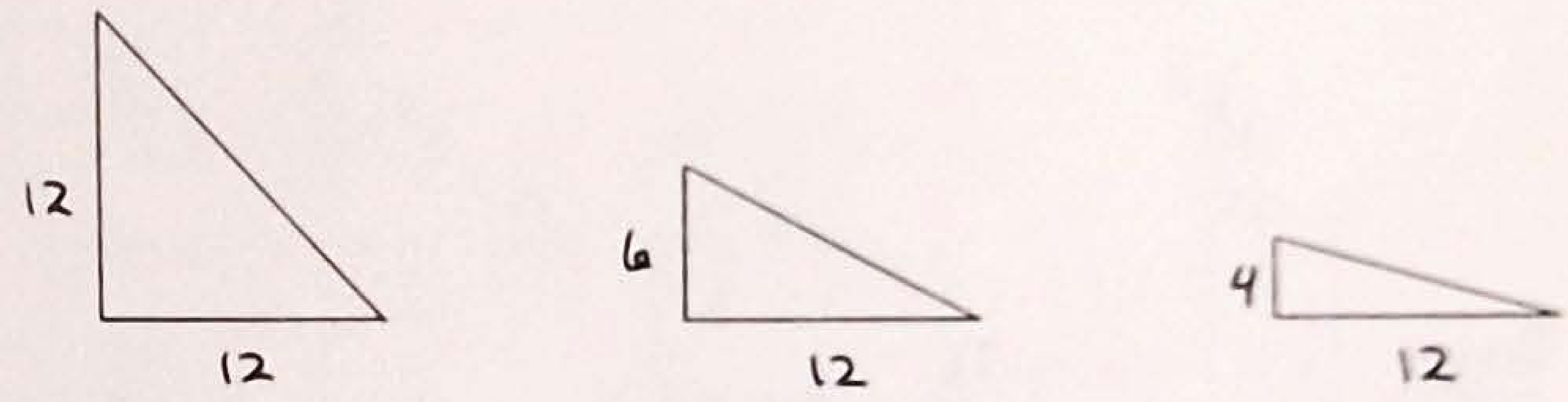


Fig. 5 - Three Roof Pitches

The Framing Square

A roof cannot be built without a framing square--it is probably the most useful tool ever developed. It can be used to find the length of any rafter and it is used to layout the angles of the cuts at the ridge board and top plate. Fig. 6. There are several models of squares but the one that is needed for roofs has rafter tables on the blade of the square. It is best to get a steel square (instead of aluminum) because steel holds its shape better. It's a tough choice though, because aluminum is lighter and easier to use.

There are hundreds of things you can do with the framing square--including, say the old timers, figure out your wages. The little booklet that comes with the square explains all its scales and uses, so I will simply cover its uses concerning

Common rafter

Framing square

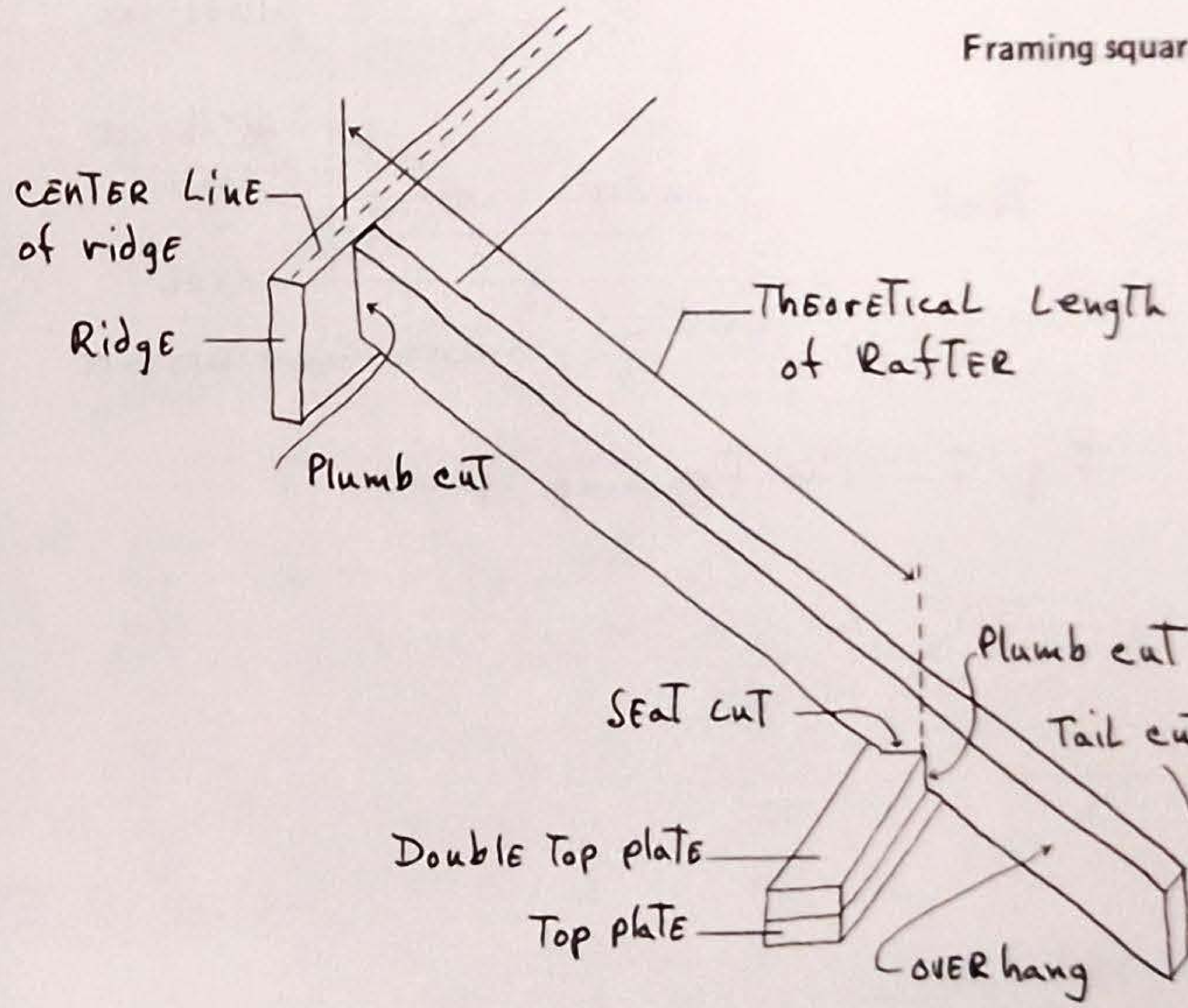


Fig. 6 - The Parts of a Rafter

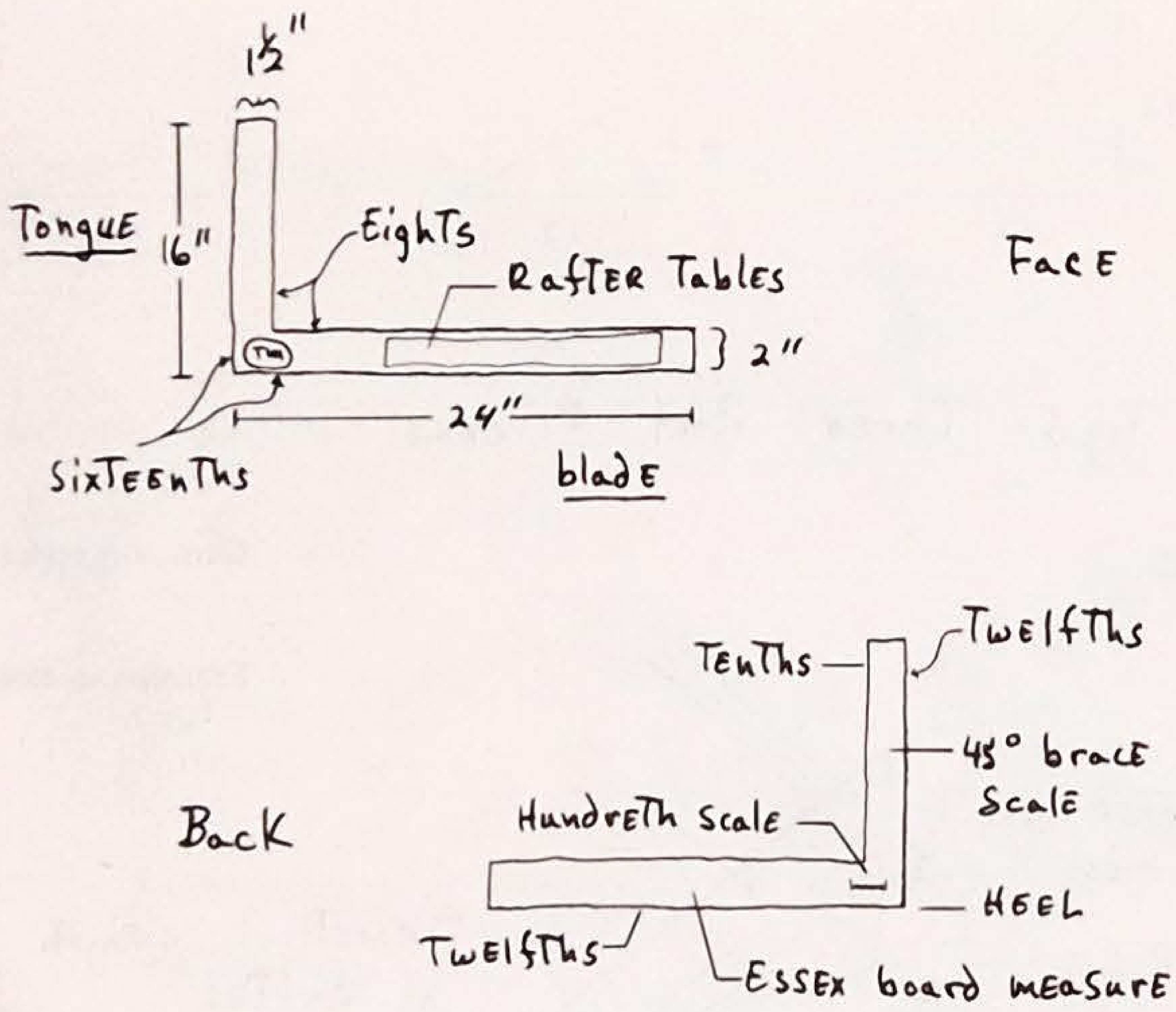


Fig. 7 - The Framing Square

rafters.

To find the theoretical length of the rafter in our building with a total run of 12' and a total rise of 6', first compute the unit rise and run. In this case it's 6" of rise in 12" of run.

> *To compute unit rise, change the total rise into inches and divide this figure by the number of feet in the total run. If the total run is uneven, e.g., 8'8", you would divide the rise by 8.66 .*

Now look at the rafter tables on the blade of the trademark side of the framing square. Fig. 8. The numbers run horizontally along the blade in 6 categories. We are concerned with the first line: Length of Common Rafters per foot of Run. The others all relate to hip roofs--a more complex roof that I do not cover in this book. The numbers are also arranged in vertical columns under the whole numbers of inches marked on the ruler along the outside of the blade. When reading the rafter scale, these whole numbers of inches represent the different units of rise per foot of run.

To find the length of the common rafter in a roof that has 6" of rise per foot of run, look under 6 on the ruler on the outside of the blade. Fig. 8. The number given in the first line is 13.42. This number means that for a little triangle with a base of 12" and an altitude of 6", the hypotenuse is 13.42". Fig. 9.

To find the total length of the rafter, multiply 13.42 by the number of feet in the run, which in this case is 12:

13.42 x 12" =	161.04"	Finding the rafter length
161.04" ÷ 12 =	13.42'	Changing inches to feet
13' 5 1/16" =	13.42'	Theoretical length of rafter

These calculations give the length of the rafter from the center of the ridge to the outside of the double top plate--the theoretical length of the rafter.

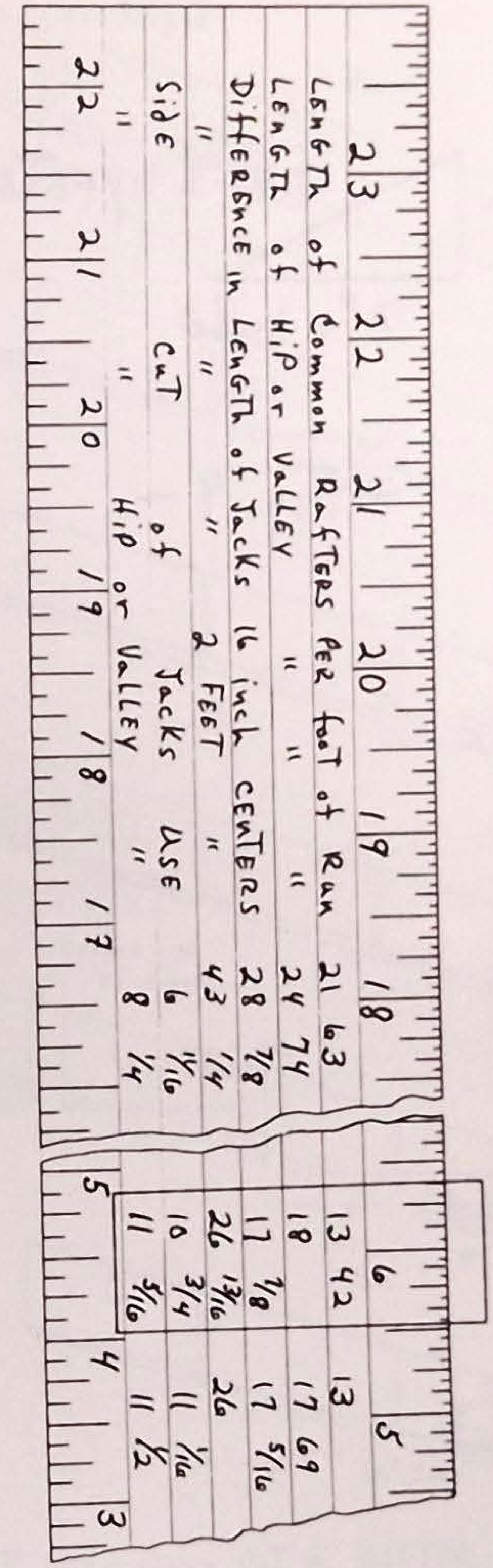
THE STEP-OFF METHOD FOR LAYING OUT A RAFTER

It stands to reason that if we measure off the unit measure of 13.42" twelve times (once for each foot of run) along the 2x6 or 2x8 that is to become the rafter, we will arrive at the same total figure 13' 4 15/16" that we arrived at using the Pythagorean theorem. This is the best way to lay out a rafter; it is called the step-off method and the tool used is the framing square.

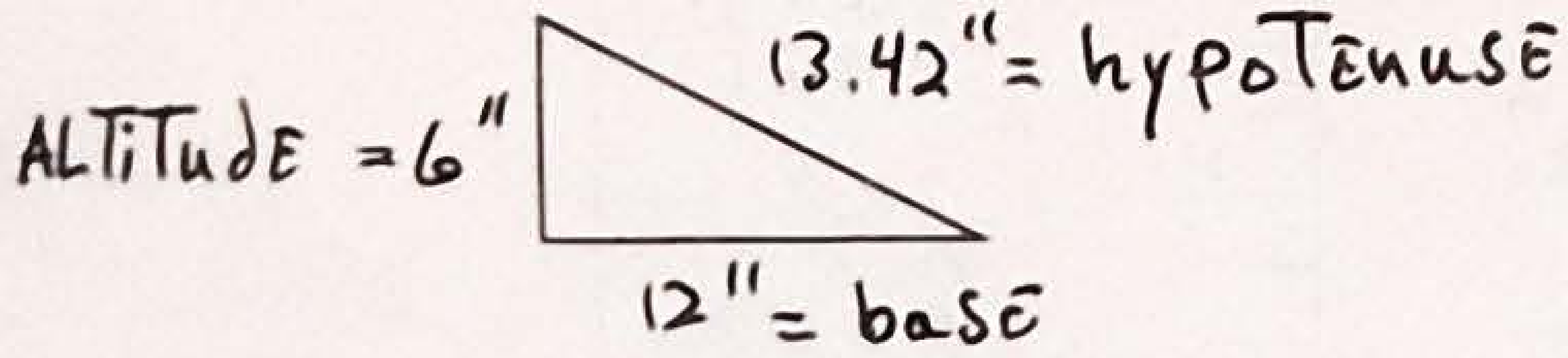
To illustrate the step-off method let's pick a different sized structure so that we can deal with all three of the possibilities found in laying out a rafter: laying out the rafter itself, laying out an odd increment (a segment of run smaller than 12"), and laying out an overhang. For the sake of illustration our new structure will have a total run of 2'8", a slope of 5" in 12", and an overhang of 1'. Fig. 10.

When you lay out a rafter with the framing square and hold the same slope throughout, lines drawn along the tongue will always be plumb lines (vertical) and lines drawn along the blade will always be level lines (parallel with the horizon). As at Fig. 10A, lay the framing square on top of

Fig. - 8 The Rafter Tables on The Framing Square



Tongue and blade–See This Chapt.: Fig. 7



— Fig. 9 —

Crow's foot--See Tools: Fig. 7

the 2x-- and near one end. Move the square until 5" on the outside of the tongue (the unit rise) and 12" on the outside of the blade are both aligned with the bottom edge of the 2x--. Draw a line along the tongue near the end of the 2x--. This is the top end of the theoretical length of the rafter, i.e., the center line of the ridge. Now make a mark on the edge of the 2x-- directly under the 12" measurement on the blade of the framing square.

> *Since the edge of the 2x-- is rounded and awkward to make an accurate mark on, it is easier to mark on the face of the 2x-- using the corresponding number across from 12 on the inside of the blade--in this case 10 1/2. The mark should be made with a very sharp pencil or knife in the form of a crow's foot, V, with the point on the correct measurement.*

Fig. 10B shows the second foot of run being stepped off. The framing square is moved down the 2x6 so that the outside of the tongue is directly over the mark indicating the end of the first step off.

The framing square can either be picked up and set down on each step or, by holding the framing square with the thumb and first finger over the 5 on the tongue and 12 on the blade, the square can be slid down the 2x6 keeping the same 5" in 12" slope in relation to the rafter.

When the square is in place, draw a line along the tongue through the crow's foot and make another mark over the $10\frac{1}{2}$" on the inside of the blade or 12" on the outside. This last mark is the end of the second foot of run of the rafter.

Fig. 10C shows the stepping-off of the last 8" increment of the run of the rafter. Slide the square down the 2x-- as before and place it over the last crow's foot made. Draw the plumb line along the outside of the tongue as before but this time, since you are stepping off the last odd increment in the total run of the rafter, which in this case is 8", the crow's foot is made under the 8" mark on the blade of the square. Since the 8 is out in midair in this instance, use the corresponding measurement on the inside of the blade--here it is $6\frac{1}{2}$. If the odd unit is very small, like 4", neither the inside nor the outside of the blade will be over the 2x--. When this occurs, take a smaller square like a try square and lay it over the 4, square across the gap and mark along the blade of the small square which is on the wood. Fig. 11.

Fig. 10D depicts the stepping-off of the overhang. It is done just as in A and B, and if there is an odd increment in the overhang, it is done as in C. The line that is drawn along the tongue at D delineates the building line. After the overhang has been stepped off, slide the framing square down the 2x-- one more time so that a line can be drawn along the tongue through the crow's foot that marks the end of the overhang and also the end of the rafter. The rafter is cut along this plumb line; this is the tail cut. Fig. 3.

Laying Out The Bird's Mouth

Fig. 10E shows the laying out of the "bird's mouth," the part of the rafter which is notched

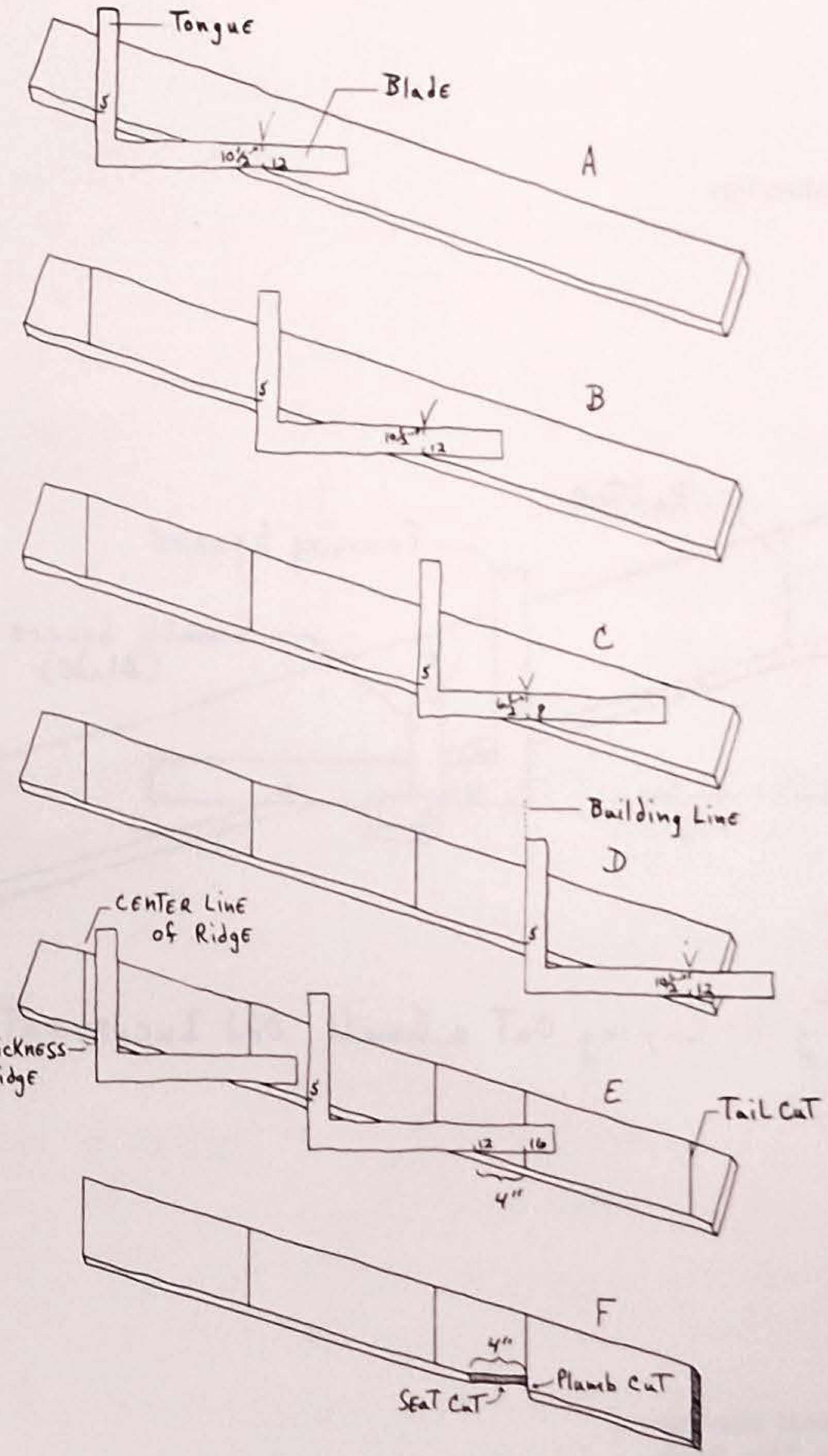


Fig. 10 - Laying Out A Rafter

Building line

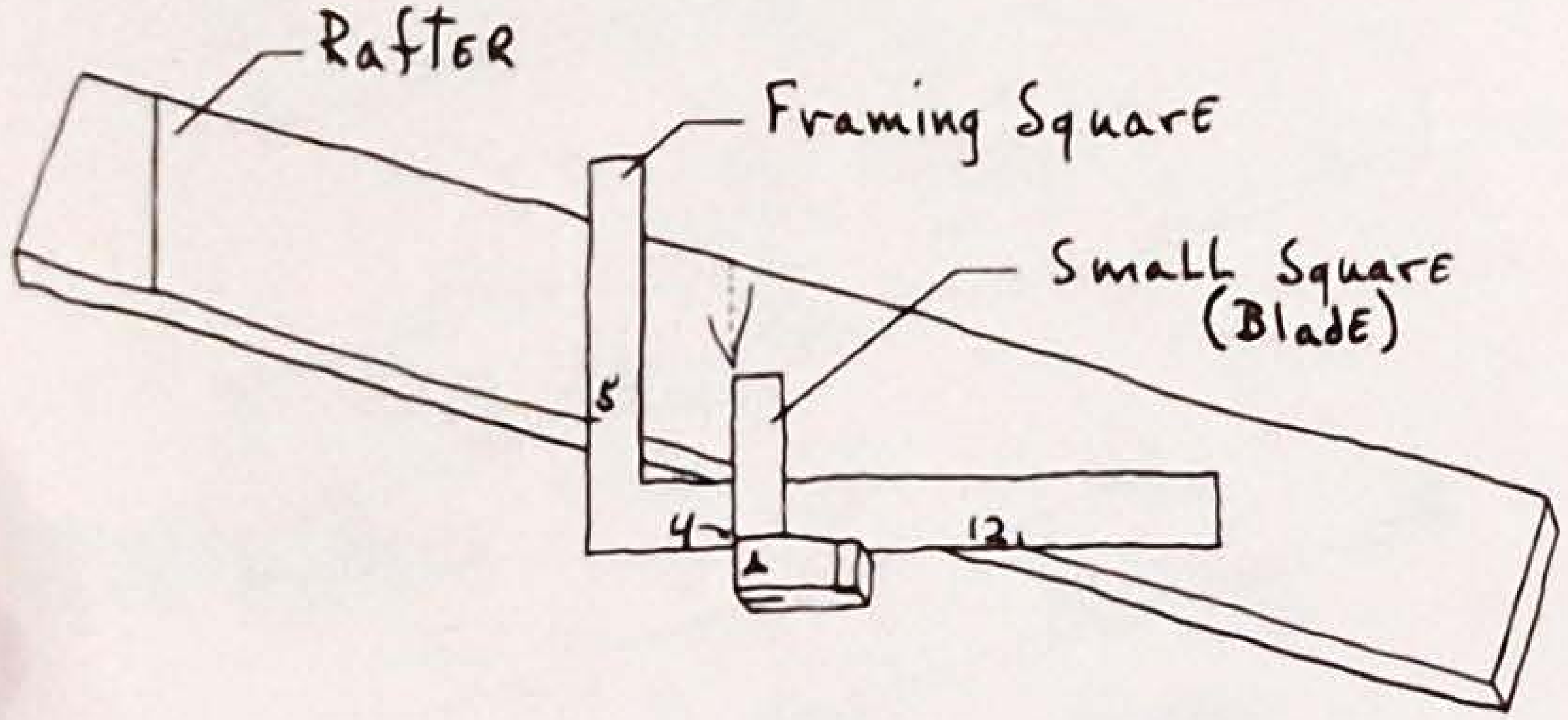


Fig. 11- Laying Out a Small Odd Increment

Nominal size-See Using This Book

out in order to fit over the double top plate. Fig. 3. The bird's mouth is really two cuts: the seat cut that rests on the double top plate, and the plumb cut which coincides with the building line. Fig. 5. Since the building line is already marked on the rafter, only one more line needs to be laid out--the seat cut line. The length of the seat cut can differ from one building to another or from one blueprint to another. If the building line designates the edge of the plates and studs, the seat cut is 3½" long. But if the building line is placed at the outside of the sheathing, then the seat cut is the thickness of the stud wall (3½") plus the thickness of the sheathing (usually ½"). Let's assume that in this case the building line is the outside of the sheathing, so the seat cut is 4" long. Slide the square along the edge of the 2x-- still (as always) holding the same slope (5 in 12) until the 16" mark on the outside of the blade is aligned with the building line and 5 and 12 with the edge of the 2x--. Draw a line along the blade from the 12 to the 16. This is the 4" long seat cut line.

Deduction For Width Of The Ridge Board

Fig. 10E also shows the deduction for the width of the ridge board. The first plumb line which was made in Fig. 10A shows the theoretical length of the rafter--that is, the length of the rafter if there were no ridge board. Since most roofs do have ridge boards, which add strength and rigidity to the roof, half the thickness of the ridge board must be deducted from the top of the rafter. Ridge boards are made of 2x-- material and are one nominal size wider than the rafter. If the rafters in this building are 2x6's, the ridge will be a 2x8. The actual thickness of a 2x8 is 1½". Half of 1½" is 3/4". Make a mark 3/4" from the plumb line that delineates the top end of the theoretical length of the rafter--measure along a line perpendicular to the plumb line. Holding 5 and 12 on the framing square, slide the square until the tongue is over the new mark. Draw a line along the tongue through the mark. This new line is the top end of the actual length of the rafter. The top plumb cut is made along this line.

Fig. 10F shows the rafter with all cuts completed.

Testing The Rafter Pattern

The first rafter to be laid out will be the pattern for cutting the other rafters so the layout and cuts should be done carefully. The tail cut and top plumb cut can be done with a power saw, but the bird's mouth cuts, though they can be started with a power saw, must be finished with a hand saw.

Lay the pattern rafter on another piece of rafter material. Trace the top plumb cut, tail cut and bird's mouth on the second rafter and make these cuts. Take the two rafters to the structure; place the bird's mouths over the double top plates--one on each side of the building--so the tops of the rafters meet as they will when the roof is completed. If there is to be a ridge board, hold a piece of ridge material between the rafters at the top. (This testing operation will take about three women.) In this way you can see, before you cut a lot of rafters to the pattern, whether a gross mistake has been made. If everything is as you desire, use the pattern rafter to

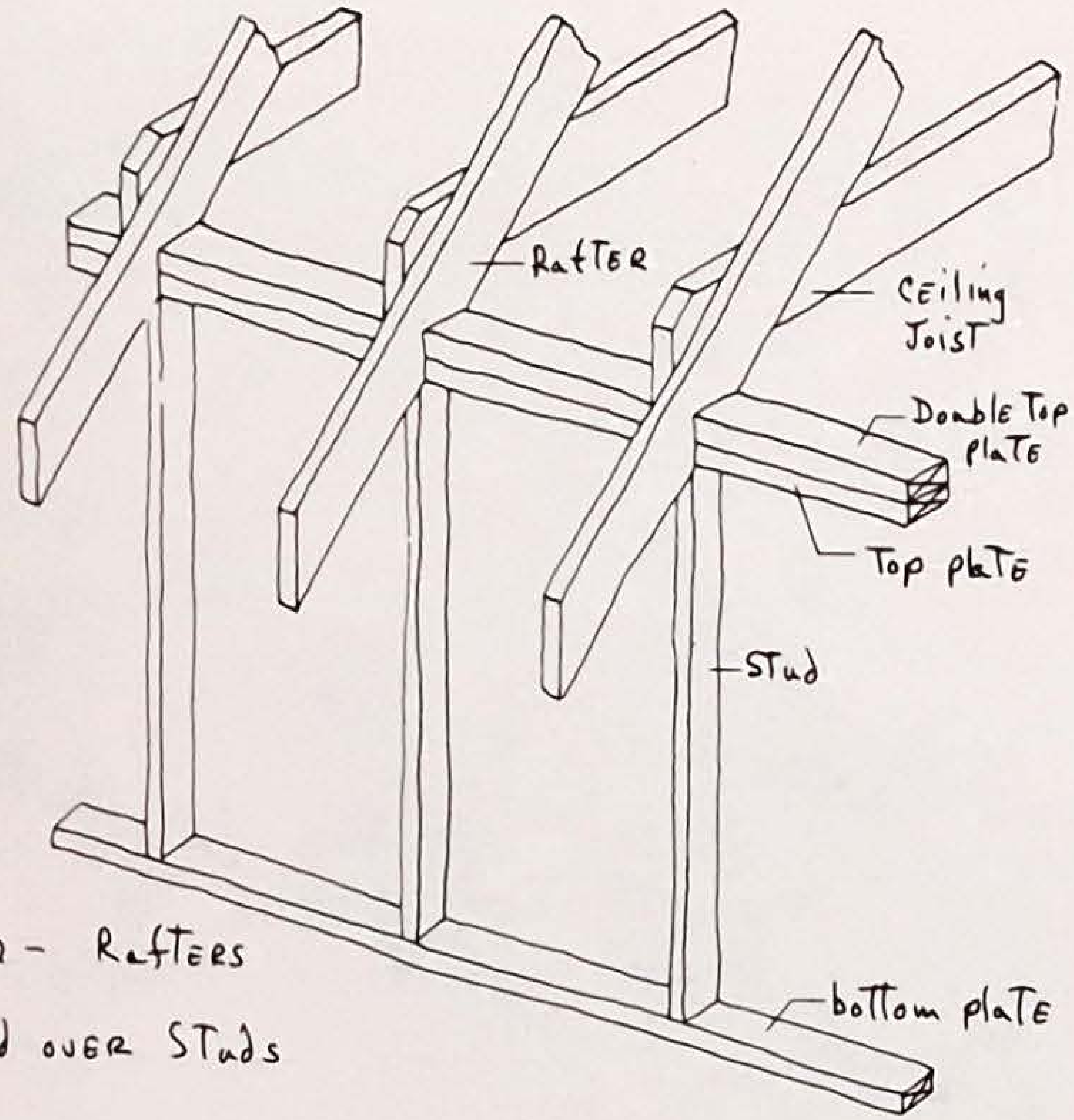


Fig. 12 - RafTERS Placed over STuds

Laying out plates--
See Walls: Layout

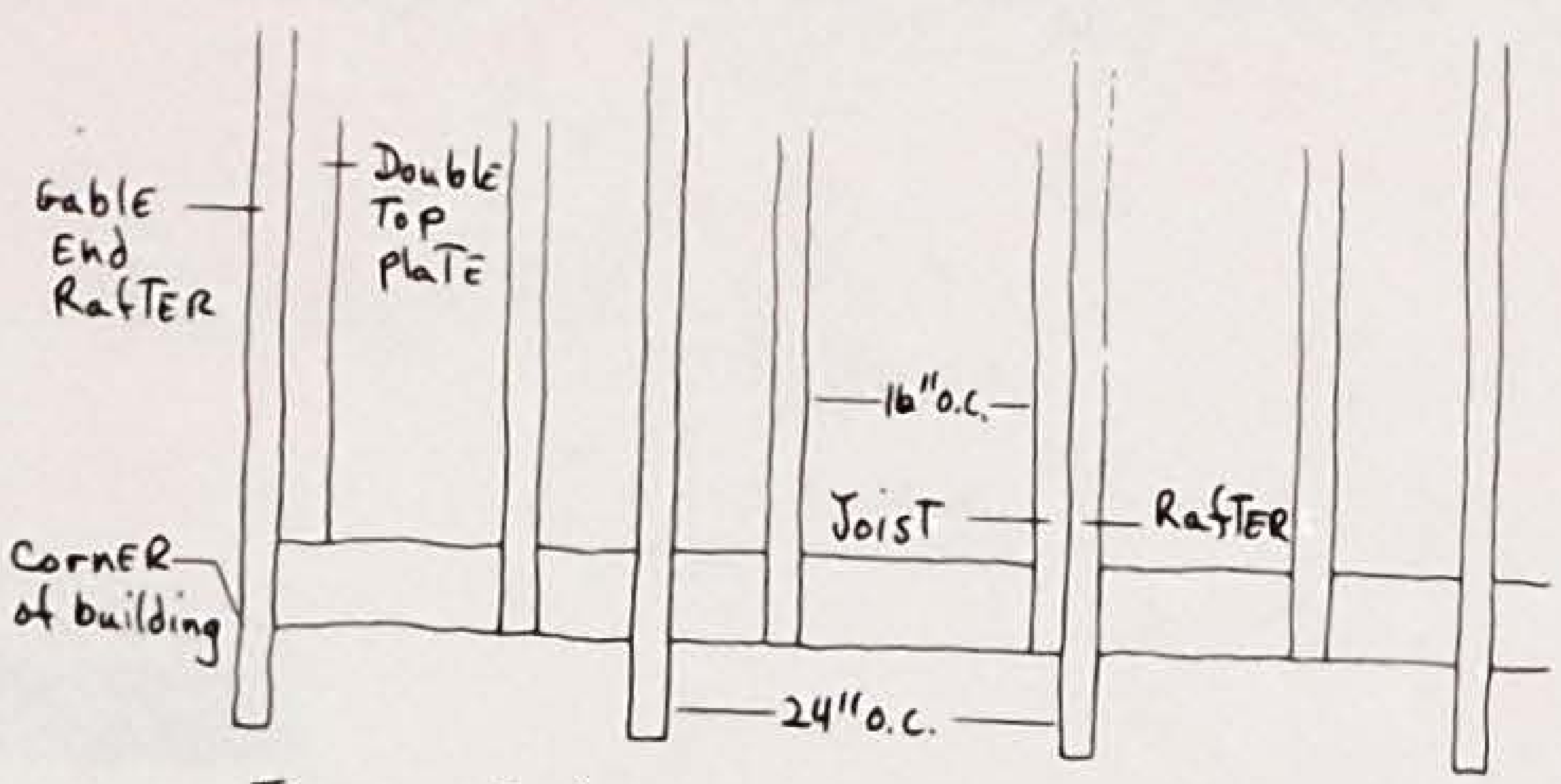


Fig. 13 - RafTER and JoisT Spacing

lay out as many rafters as will be needed.

LAYING OUT THE DOUBLE TOP PLATE

The layout for the rafters and ceiling joists is marked on the double top plate after the walls have been erected. When marking the layout for the rafters and joists on the double top plate, remember that the rafters should be located directly over the studs because they carry more weight than the joists. If both the rafters and joists are to be 16" O.C., the rafters are placed over the studs and the joists are placed next to the rafters. Fig. 12.

If the rafter layout is 24" O.C., which is common in garages, and the joists layout is 16" O.C., which is always common, a joist is nailed to every other rafter. Fig. 13.

The double top plate is laid out in the same way as the bottom plate in a wall. Once the layout of the double top plate has been completed, the ridge board should be laid next to the double top plate and the rafter layout markings transferred to the ridge board. Then, after the ceiling joists have been toenailed to the double top plate, the ridge boards (which are as straight and true as possible) are placed on top of the ceiling joists, near the middle of the building, where they will be handy when it is time to nail them to the rafters.

1x6's running the length of the building can be temporarily nailed to the top of and perpendicular to the joists to keep the joists upright, so that women can safely walk on them as the roof is raised.

RAISING THE ROOF

The raising of a roof takes at least two women and preferably three. The pair of rafters at each end of the building (the gable end rafters) should be especially straight. The other rafters should be installed with their crown (the curve or warp along the edge of the rafter) up so that the weight of the roof and snow will bring the crown down. Fig. 14.

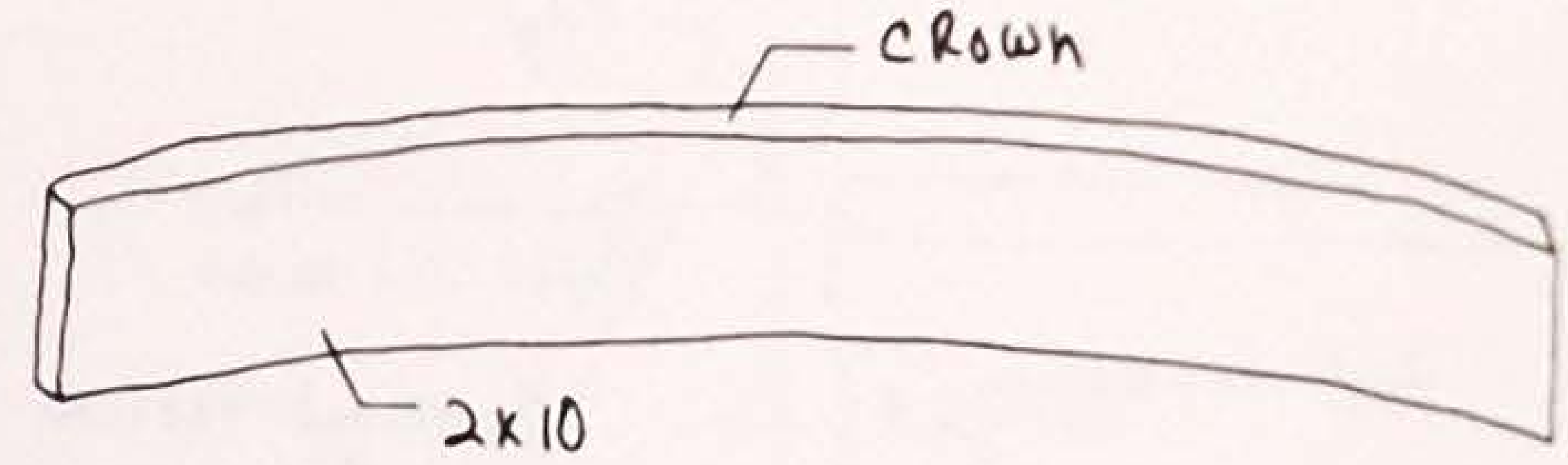


Fig. 14 - A Crown in a Rafter

Crown

Nailing The Rafters

The rafters are toenailed to the double top plate with two 10d common nails. If a rafter is next to a ceiling joist at the double top plate, it is facenailed to the joist with four 16d nails. Fig. 15. The first rafter of a pair is nailed to the ridge board with three 16d nails end nailed through the ridge board and into the end of the rafter. The second rafter of a pair can be toenailed to the ridge board with four 16d nails. The second rafter of a pair can also be nailed to the ridge by nailing from the side of the ridge that is connected to the first rafter. End nail at a slight angle from either side of the first rafter into the second rafter with four 16d nails. Fig. 16.

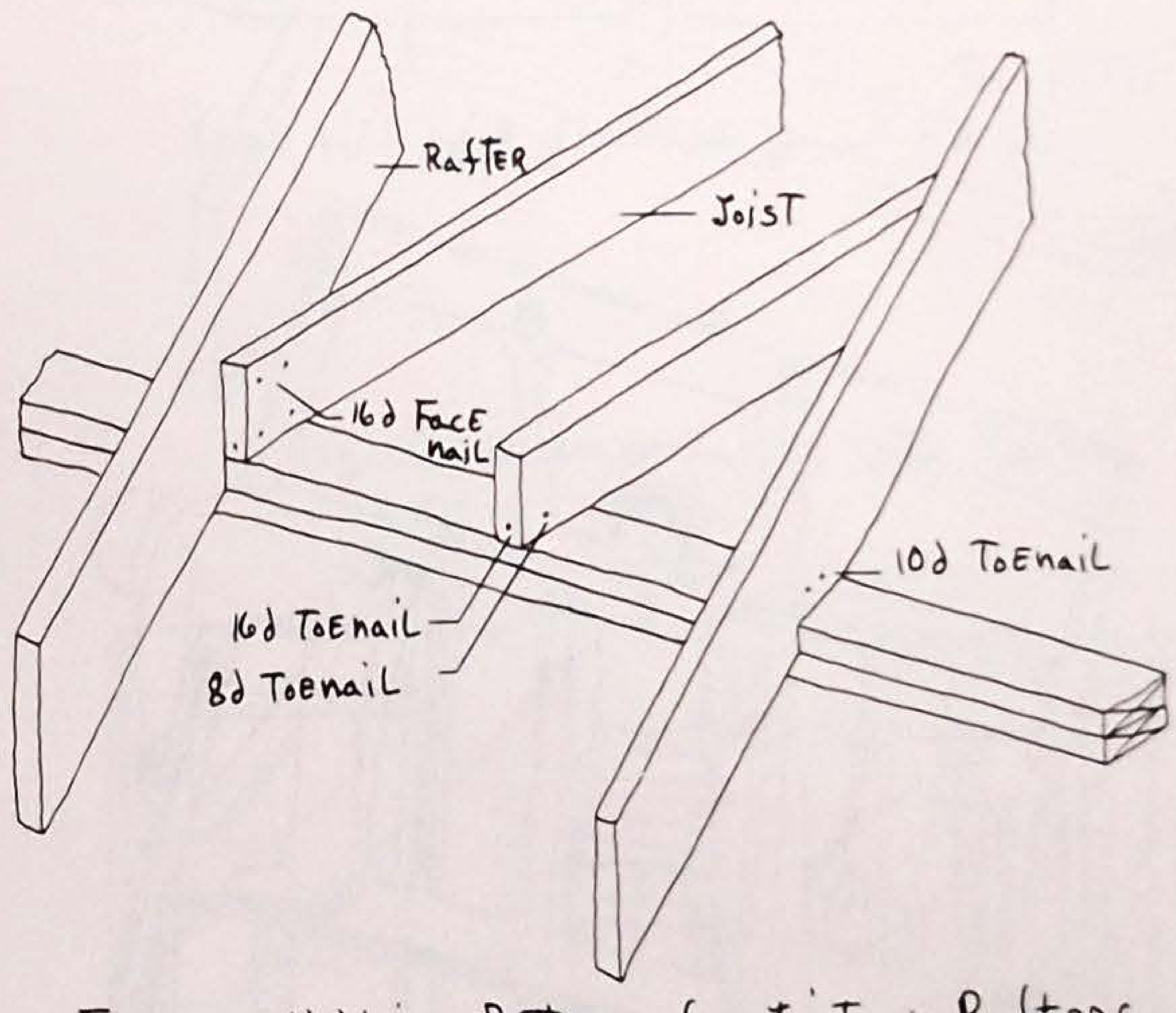


Fig. 15 - Nailing Patterns for Joists & Rafters

RAISING THE RAFTERS

If the roof is small and the ridge is in one piece, nail two gable end rafters to either end of and on only one side of the ridge board. Fig. 17. They should be nailed to the gable end rafter layout marks on either end of the ridge board. Nail

Gable end rafter

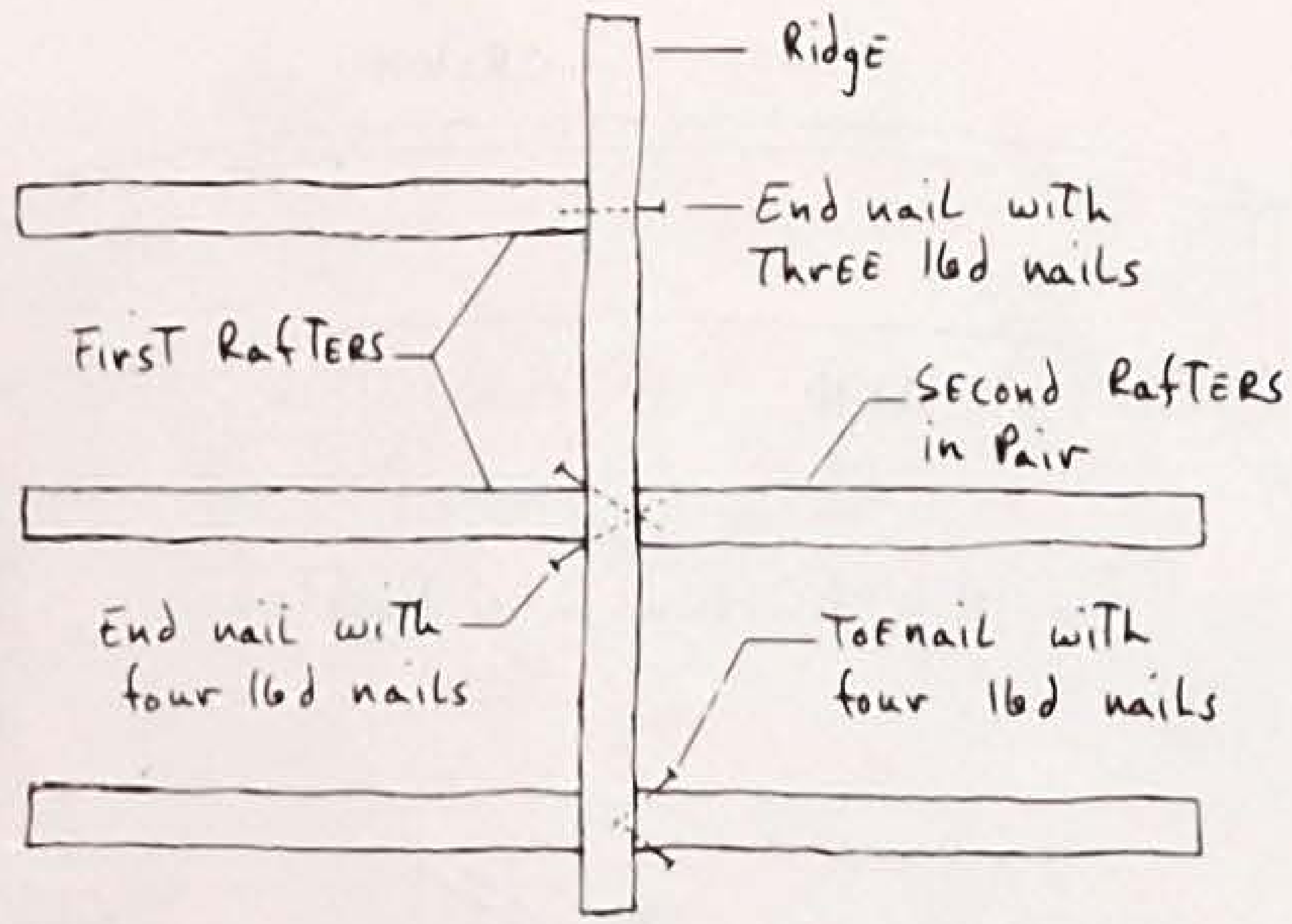


Fig. 16 - Nailing Rafters To Ridge (Top View)

Fig. 17 - Raising The Rafters

one more rafter in the middle between the two gable end rafters.

While one or two women nail these two rafters to one plate, another woman supports the weight of the assembly at the ridge. The woman holding up the ridge can either stand on the ceiling joists or if there aren't any, as is common in small structures, she can stand on a ladder placed on the floor below. Now nail the two remaining gable end rafters to the other side of the ridge so that the assembly is self-supporting.

If the structure is longer and the ridge is made up of more than one piece, the pieces of ridge material must break on a rafter. Raise the ridge one piece at a time as described above; proceeding from one end of the building to the other, nail three rafters to the first piece of ridge board: one at the gable end, one in the middle, and one at the other end. When this section is raised and the corresponding rafters installed on the other side of the ridge, the next section of the ridge can be raised in similar fashion. The roof should be braced as shown in Fig. 20 whereever needed.

The roof at this point is very resistent to forces pushing down on it, but has a tendency to sway from side to side horizontally before the sheathing is nailed on. To prevent this lateral motion, temporary bracing should be installed. But before bracing, the roof parts should be checked for square. Hold the blade of the framing square against the double top plate and place the edge of the tongue against the inside width dimension of the gable end rafter. Fig. 18. The woman at the ridge should push the ridge board toward either gable end until the full width dimension of the gable end rafter is in contact with the framing square. This indicates that the rafter is square with the plates and all rafters are parallel with each other.

While the rafters are thus held square with the plates, the temporary bracing is nailed in place. Nail a piece of 1x6" to the underside of the middle rafter near the ridge and nail the other end to the underside of one gable end rafter down near the plate.

Bracing along the diagonal is the strongest way to hold two parallel members in position or to hold the members of a flat rectangular structure in the proper relation to each other. Fig. 19.

Now brace the roof the other way by nailing another 1x6" to the middle rafter near the ridge and the other end of the brace to the other gable end rafter near the plate. Fig. 20.

This bracing will ensure that when the rest of the rafters are nailed to the double top plate and to their corresponding layout marks on the ridge board, the rafters will be square with the ridge and plates. The temporary bracing can be removed after the roof has been sheathed because the sheathing acts as bracing in the same way.

Sight down the ridge to see if it is straight and level. If it isn't, install the rafters that come into the ridge at the unlevel or unstraight point. The rafters when put up correctly should tend to straighten the ridge.

Raise the intervening rafters, nailing them

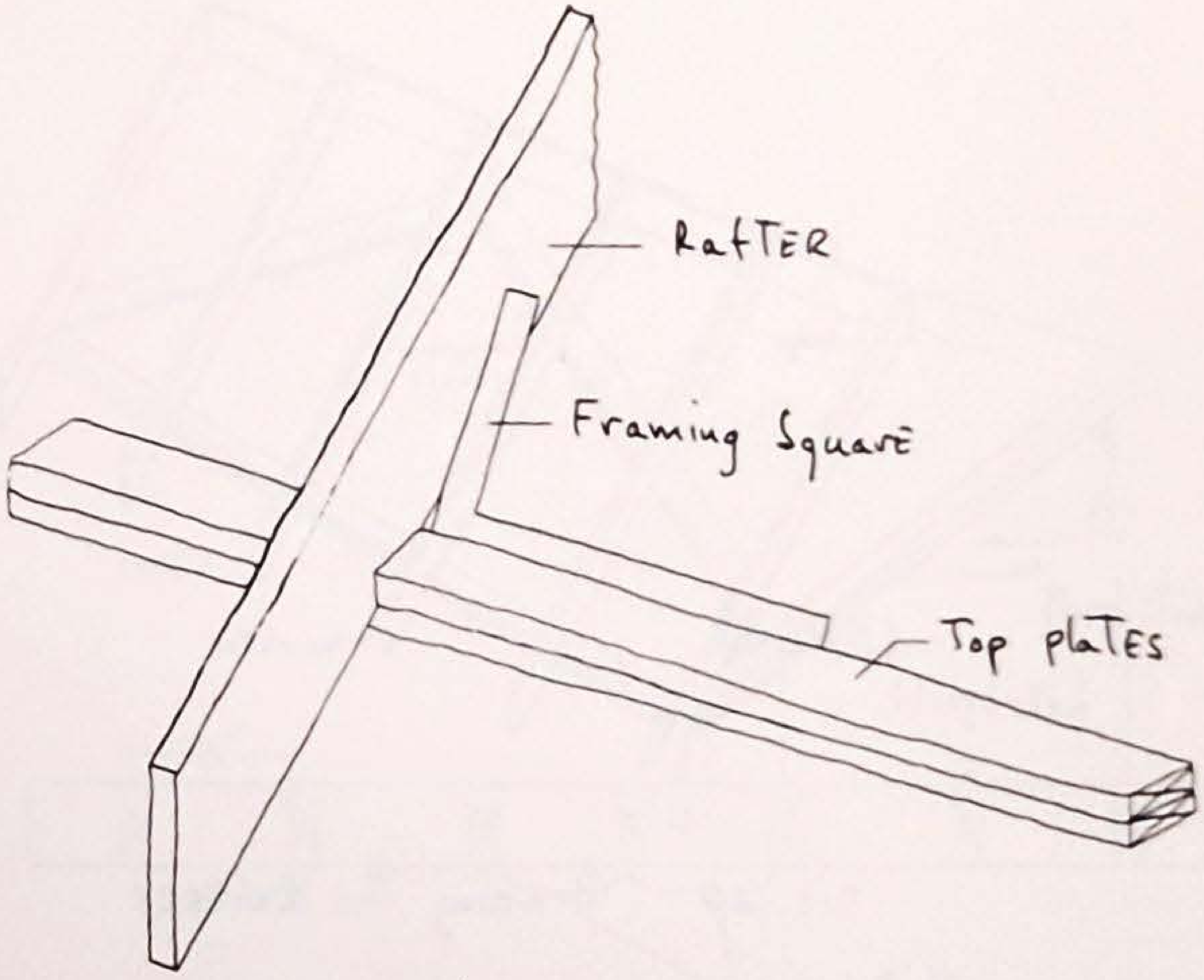


Fig. 18- Squaring RafTER with PlaTES

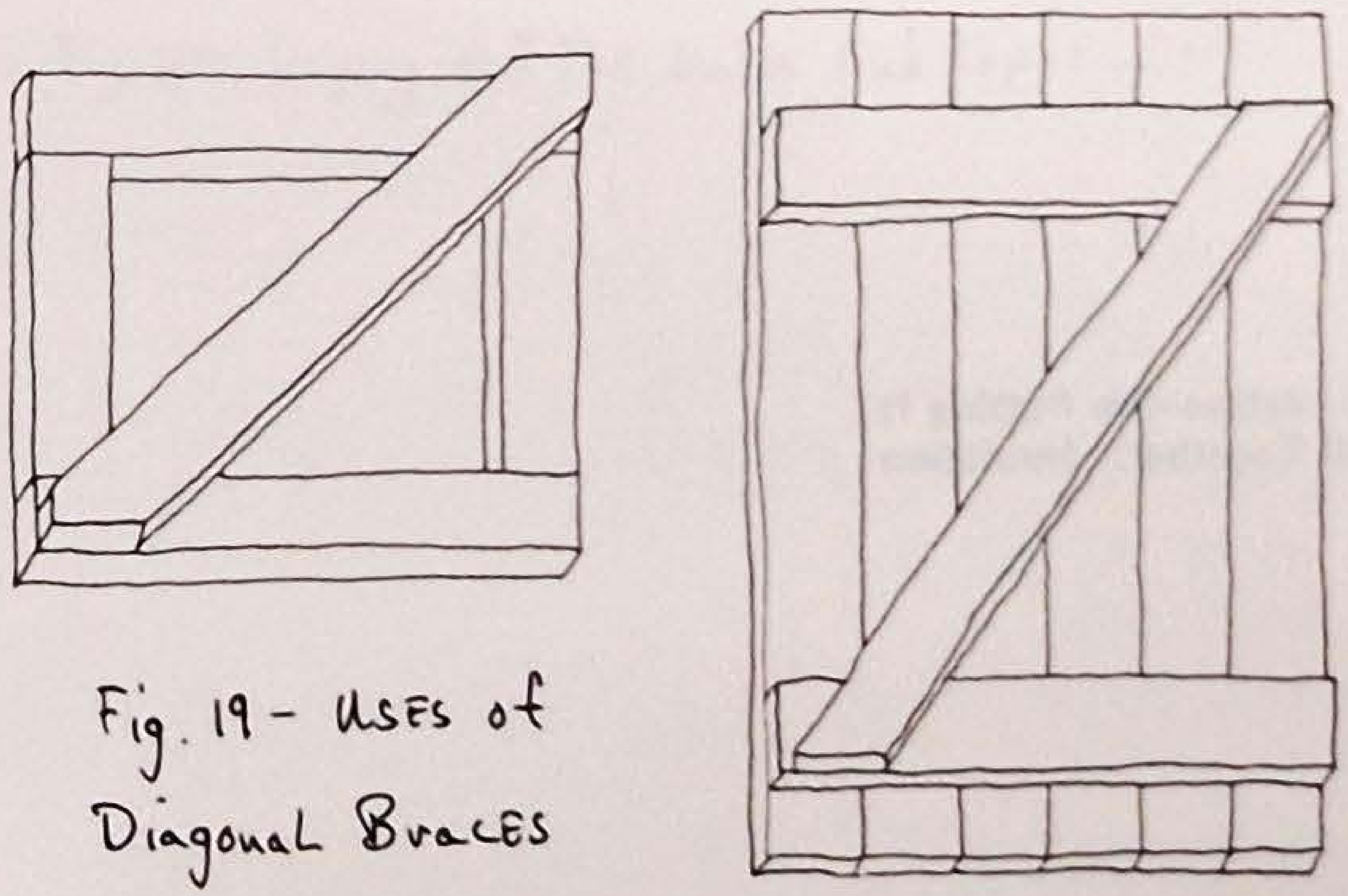


Fig. 19 - USES of Diagonal Braces

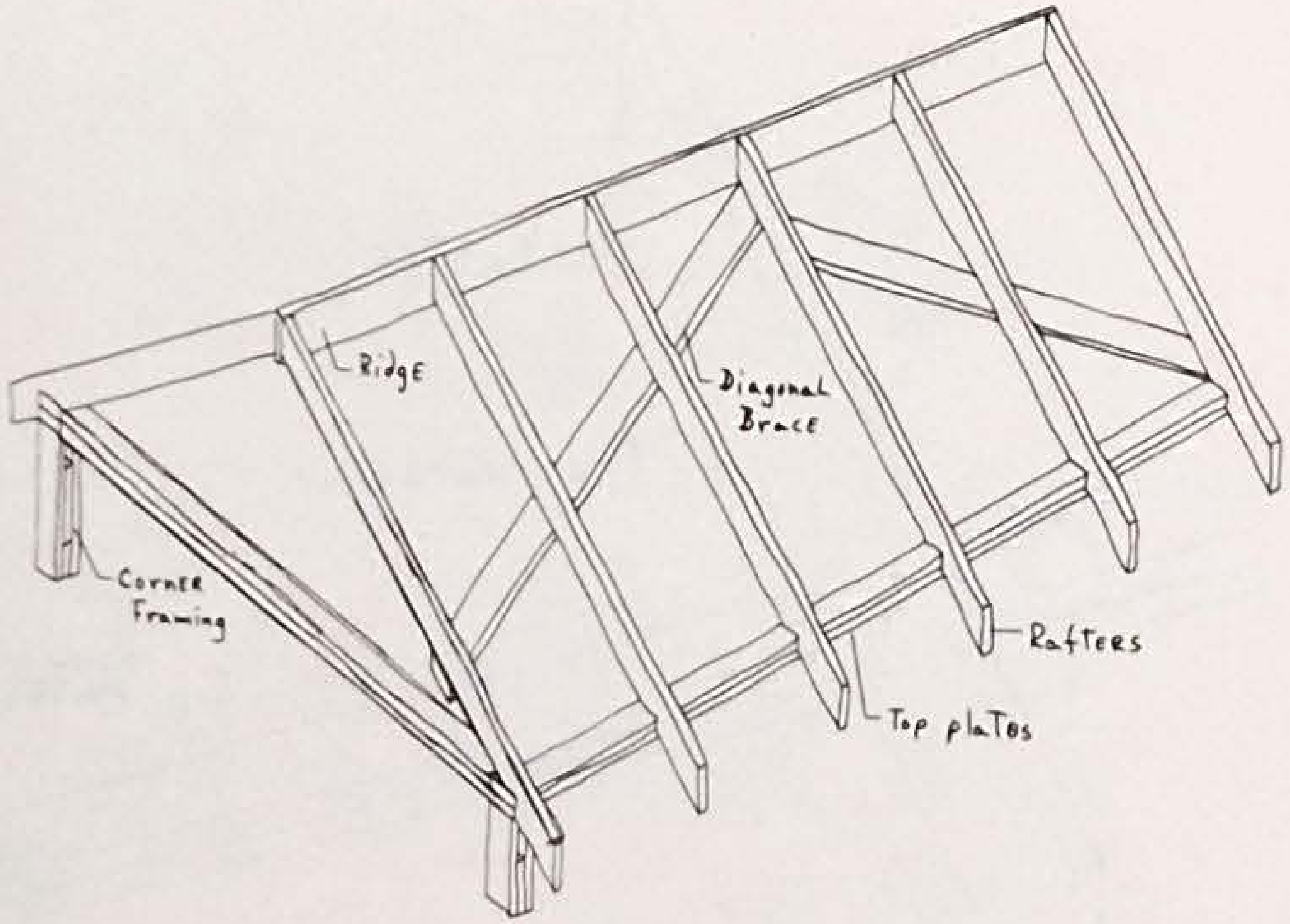


Fig. 20 - Bracing The Rafters

louvers

Cornice

Insulation-See Putting It All Together: Insulation

first at the plate and then at the ridge as previously described.

THE IMPORTANCE OF ATTIC INSULATION AND VENTILATION

Roofs must breathe (have good ventilation) or moisture will build up and cause damage to wood and paint.

For this reason there is usually a ventilator or louvers in the gable ends or built into the overhang of the rafters if it is enclosed in a cornice. If there isn't enough insulation in the attic floor or ventilation in the attic space under low pitched roofs (4" of rise in 12" of run and under), a problem can arise that will have lasting repercussions. Heat escaping through the roof causes the snow to melt and run down the roof. It then freezes when it reaches the overhang which, because it is not over a heated space, is colder than the rest of the roof. An ice ledge can be built up that traps the water running down the roof and forces it to back up under the shingles and leak into the building. Without adequate ventilation this moisture can rot the wood. Therefore, vents should be put in the center of both gable ends of the roof.

GABLE END FRAMING

Notice in Fig. 13 that there is no joist next to the gable end rafters. This allows for the gable end framing--studs running vertically from the double top plate to the gable end rafters.

Laying Out The Double Top Plate For The Gable End Studs

The first step in laying out for these studs is to plumb down from the center of the ridge to the corresponding point on the double top plate. Hold the string of the plumb line at the center of the ridge board and let the plumb bob swing freely just above the plate. When it has stopped, make a mark on the plate directly under the point of the plumb bob. This is the center of the plate. Square a line across the plate through this point and measure one-half the width of the rough opening for the vent on each side of the line--these lines represent the insides of the first studs. Lay out the rest of the studs from these two marks at 16" centers. Fig. 21.

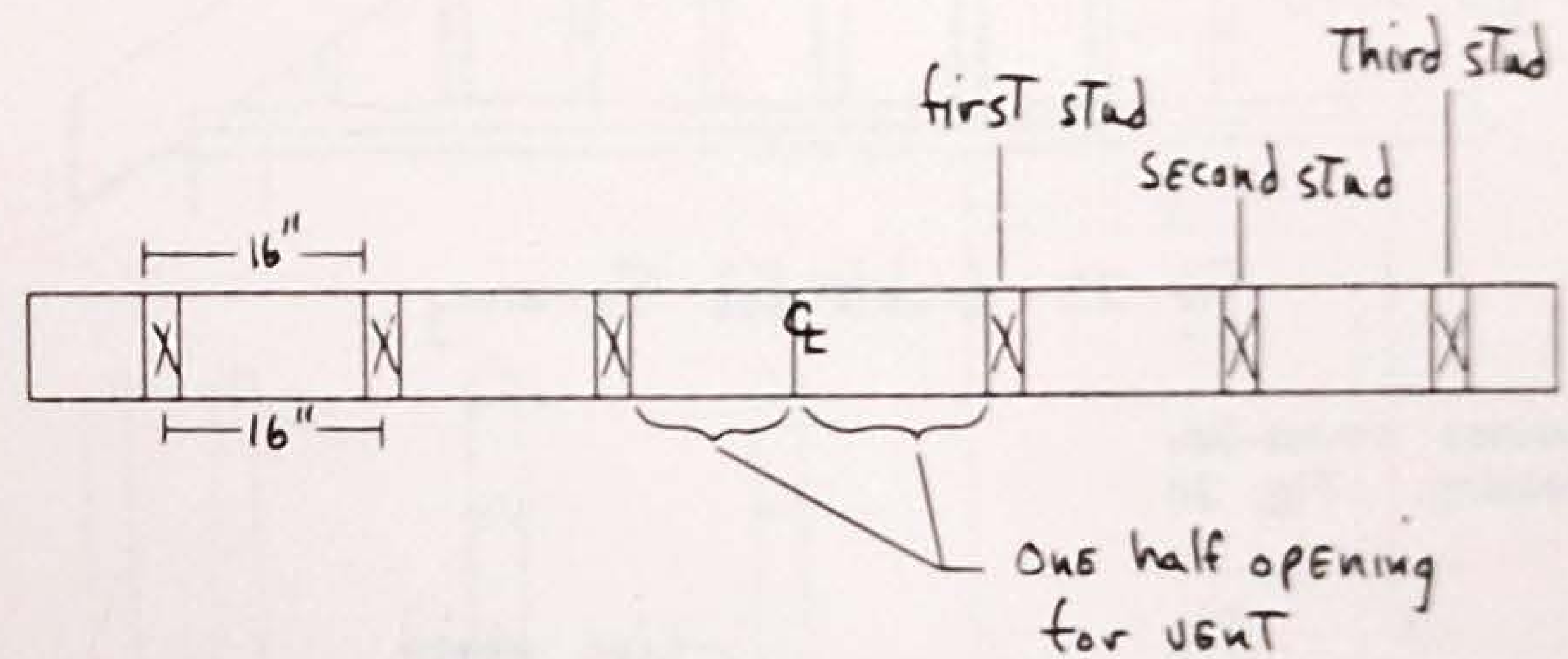


Fig. 21 - Laying out The Gable End Top Plate

Finding The Common Difference In Gable End Stud Lengths

Plumb a 2x4" up in the first stud space and mark across the edge of the stud at the underside of the gable end rafter. Now move this stud down to where the second stud will go, plumb it with a level, and mark in the same way the distance from plate to underside of rafter. The distance between the two marks is the common difference in stud lengths. Each stud will differ in length

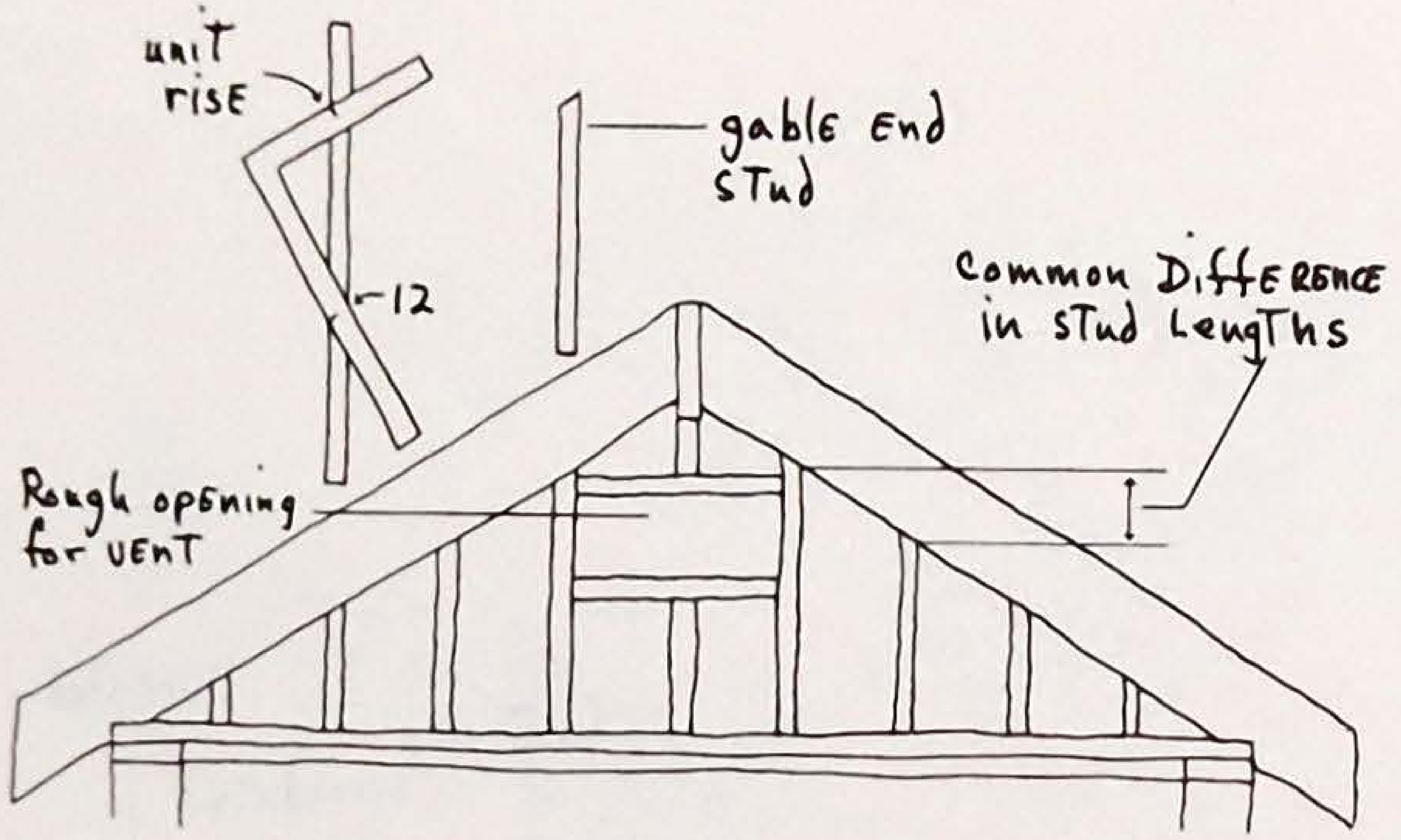


Fig. 22 - Gable End Framing

Square across--See
Joining: Fig. 26

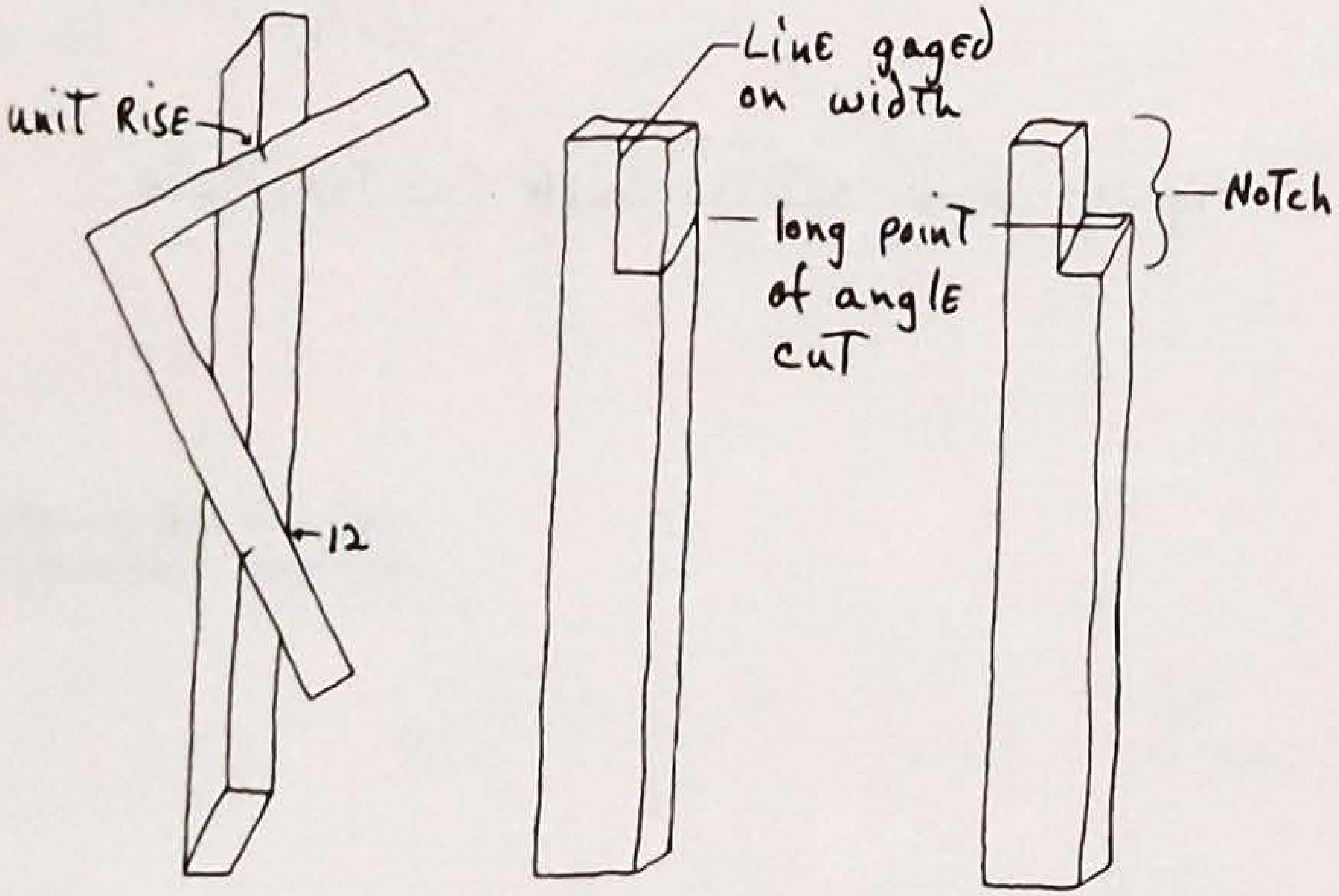


Fig. 23 - Laying out a Gable End Stud

from an adjacent stud by exactly this amount. Fig. 22.

There are a couple of different ways the gable end studs can be measured and cut. The way that is simplest, but takes a lot of climbing up and down, is to plumb a 2x4" up in each stud space marked on the gable end double top plate and mark on the edge of the stud along the underside of the rafter. This gives both the length and the angle cut under the rafter of each gable end stud.

Another method is to use the "common difference in stud length" to figure out the length of each stud and use the framing square to lay out the angle cut under the rafter:

1. Measure the lengths of the first and second studs on one side of the center line. (The lengths should be the same for the corresponding studs on the other side of the center line.) Make all measurements to the short point of the stud. Figure the common difference in stud lengths by subtracting the length of the shorter stud from the longer stud.

2. Measure off the length of the first stud on the edge of a 2x4" of appropriate length. Square the mark across the edge with a small square.

3. Lay the framing square on the edge of the stud and align the unit rise of the roof slope on the tongue with the point where the line squared across intersects the edge. Align the 12" on the blade with the same side of the stud edge. When all points are aligned, draw a line along the tongue. This line is the angle cut under the rafter. Fig. 23.

4. Cut the 2x4" off 3" or 4" above the long point of the angle cut layout. Measure along the width of the 2x4", in from the edge that has been laid out for the angle cut, the distance equal to

the thickness of the rafter (approximately 1½"). Gauge (draw) this line along the width of the stud from the top end down to the angle cut lay out. Fig. 23.

5. The next step is to cut the notch out of the gable end stud. Saw down through the edge of the stud following the angle cut layout until the saw kerf intersects the line gauged along the width of the stud. Finish cutting out the notch by sawing along the line on the width of the stud until the saw kerf reaches the angle cut.

Saw kerf–See Tools: Fig. 6

6. This is the first gable end stud on one side of the center line. It can be used as a pattern to make the other studs. Subtract the common difference in stud length from the first stud length, and the result is the length of the second stud. Subtract the common difference from the length of the second stud, and the result is the length of the third stud. And so on. Lay out and cut the gable end studs in pairs. The angle cut layout will be opposite on two studs in a pair. The tongue of the framing square will be held in the left hand for one angle cut layout and in the right hand for the other.

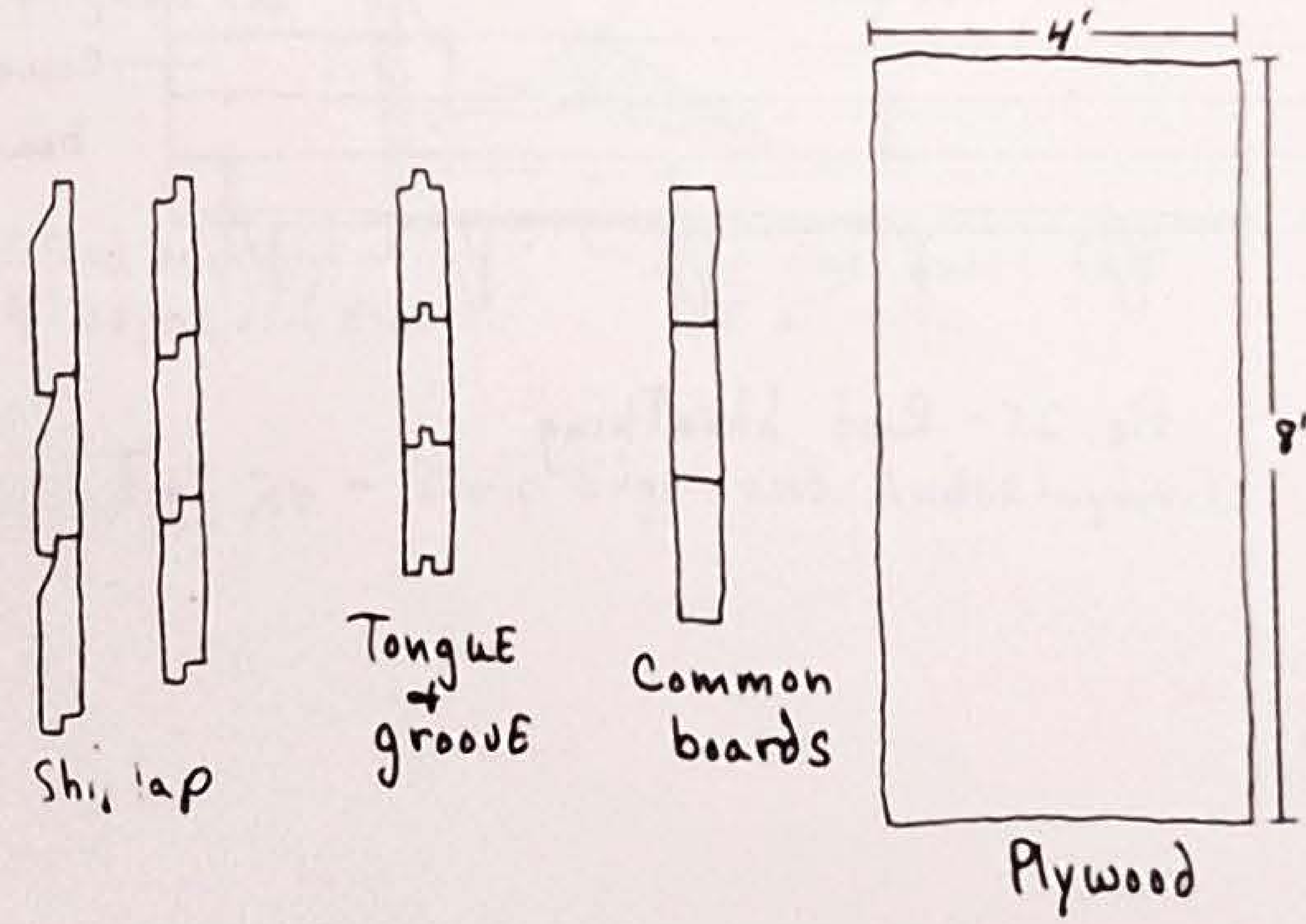


Fig. 24- Sheathing Materials

ROOF SHEATHING

The sheathing on a roof (the boards that go over the rafters) adds rigidity, strength and provides the nailing base for the shingles or roof covering. Shiplap, tongue and groove, common lumber or plywood can be used as sheathing. Fig. 24.

Shiplap lumber

Common boards

Tongue and groove lumber

Shiplap, common, and tongue and groove boards are nailed to each rafter with two 8d nails with joints located over the center of a rafter. The

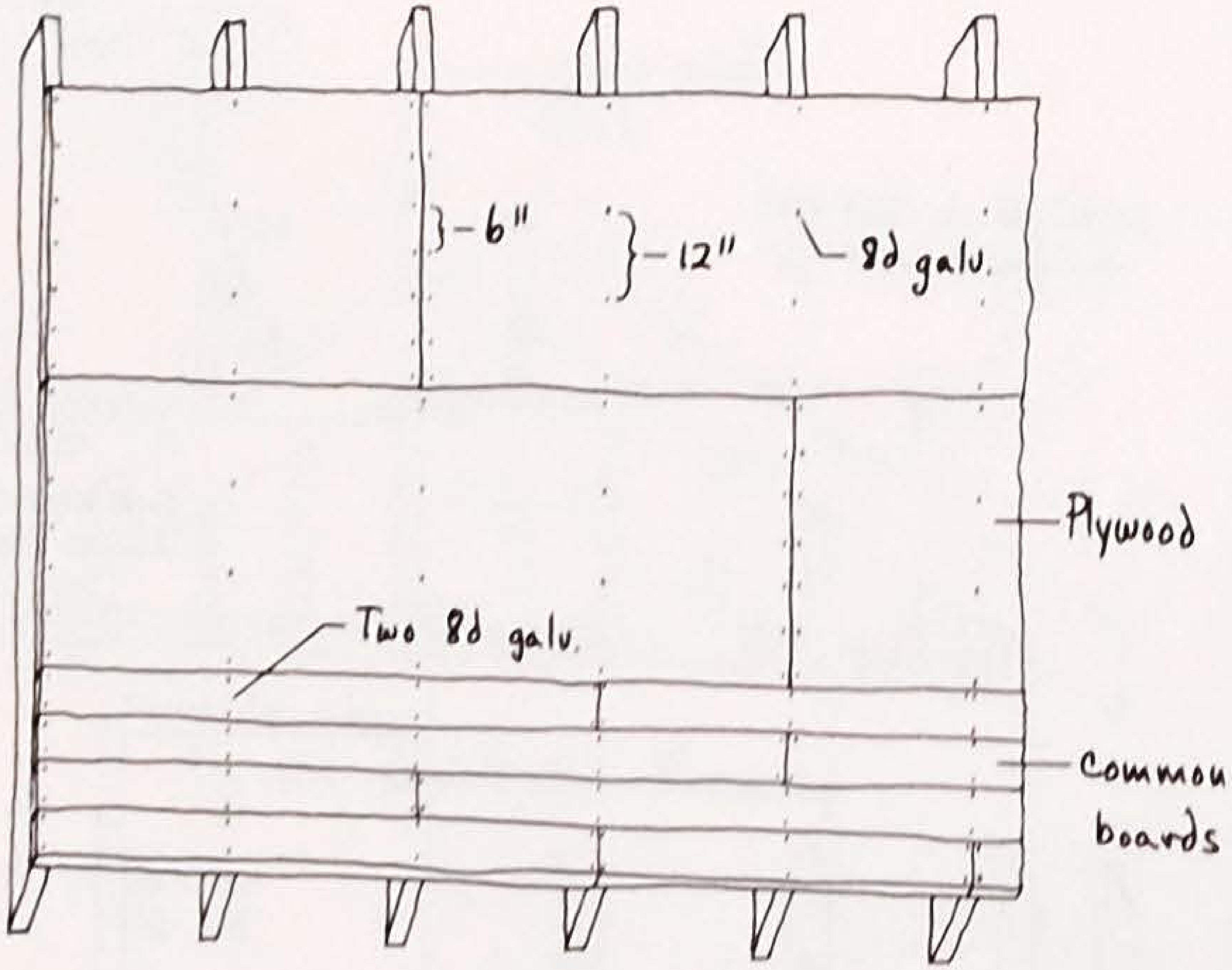


Fig. 25- Roof Sheathing

boards should be staggered so that they don't all begin and end on the same rafters. Small lengths can be used, but they must cover at least two rafter spaces. Fig. 25.

Plywood makes excellent sheathing. It is installed similarly to shiplap and common board sheathing in that the sheets are staggered, break over a rafter, and partial pieces must cover two rafter spaces. Plywood is laid with its face grain (the direction of the grain on its surface plys) perpendicular to the rafters. On most roofs half-inch plywood is used over rafter spaced 24" O.C. If the roof is to carry an unusually heavy load like a tile roof, then half-inch plywood is used over rafters spaced 16" O.C. Nail the plywood with 8d galvanized, ring shank or rosin coated nails every 12" along intermediate rafters and every 6" along joints between sheets.

If there is a chimney coming out of the roof, the sheathing should stop at least 1/2" from it and the framing members should be 2" from it--to protect the wood from the heat.

MAKING THE ROOF WATERPROOF

A drip edge made of 26 gauge galvanized steel should be installed over the sheathing along all roof edges. It should extend back from the edge 3" and should be bent down over the edge and hang below the sheathing so that water will drip to the ground and not work its way back under the roof material by capillary action. Fig. 26.

The first step in waterproofing a roof is to cover the roof with 15 lb. roofing felt. This is dry felt impregnated with coal tar or asphalt. It comes in rolls 36" wide and 72' or 144' long. It is not waterproof and waterproof felts that might act as a vapor barrier should not be used because they will allow moisture to accumulate between the roof covering and the roof sheathing, thereby causing the sheathing to rot.

15 lb. felt is used with most kinds of roof coverings but requirements may vary. It is laid down only when the roof deck is dry. The felt protects the roof deck from moisture until the shingles are laid and provides protection against the wind driven elements.

The important rule in applying any layer of roof covering is that no seam should be vulnerable to the weather. The courses (or rows) are started at the eaves and each succeeding course overlaps the one before and down-roof of it. Fig. 32.

The requirements for laying 15 lb. felt are that it have at least 2" lap between courses at the top and 6" side lap. It should be tacked down with roofing nails or square headed nails--just enough to hold it in place. Fig. 26.

Types Of Roofing

Roofs can be covered with asphalt shingles, clay tile or wooden shingles. The most common kinds of roofing are asphalt shingles and mineral surfaced roll roofing. Both of these are each made by impregnating heavy felt with water resistant asphalt and sprinkling mineral granules over the surface.

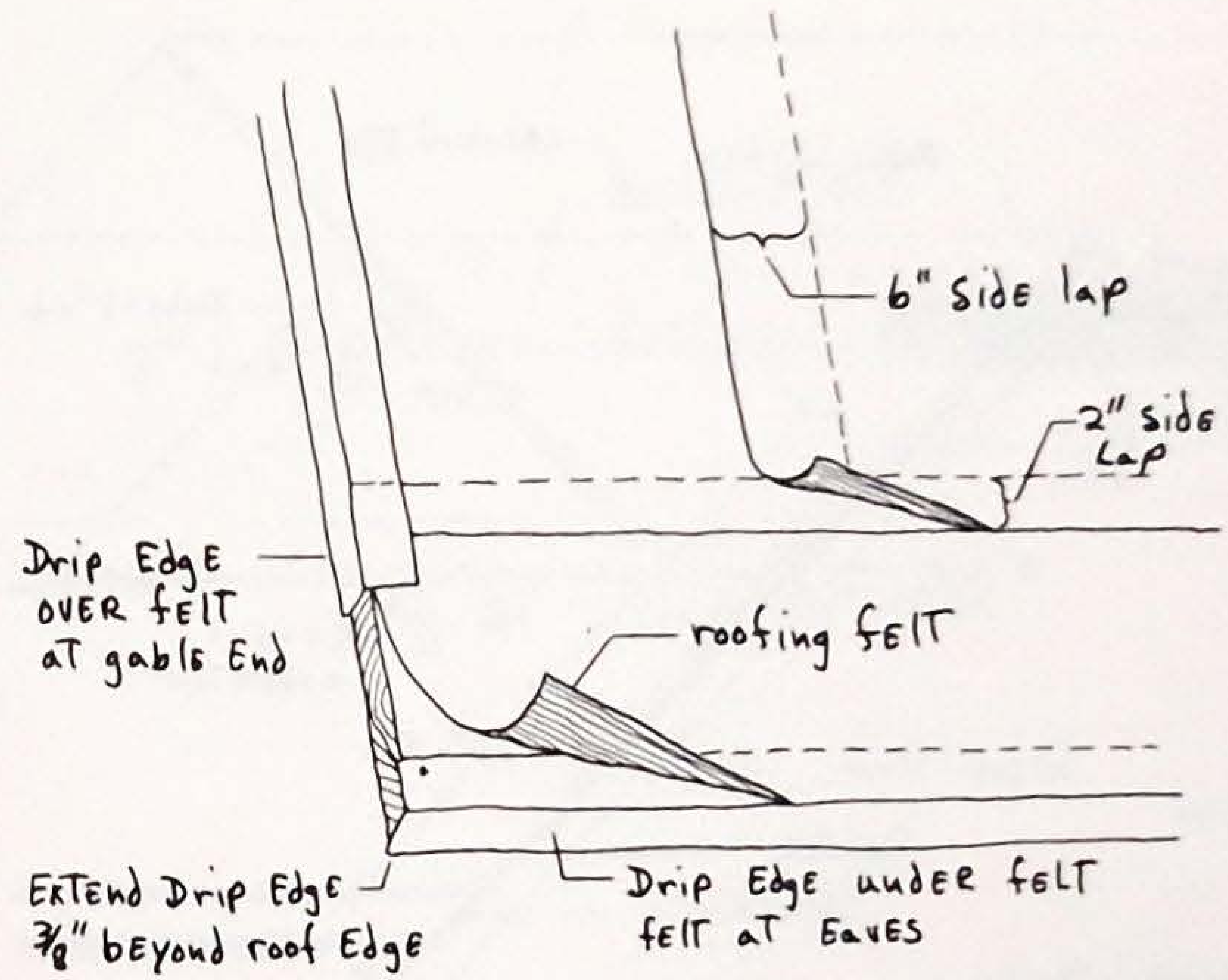


Fig. 26 - Drip Edge and Underlayment

Course

Deck

Eave

Roll roofing

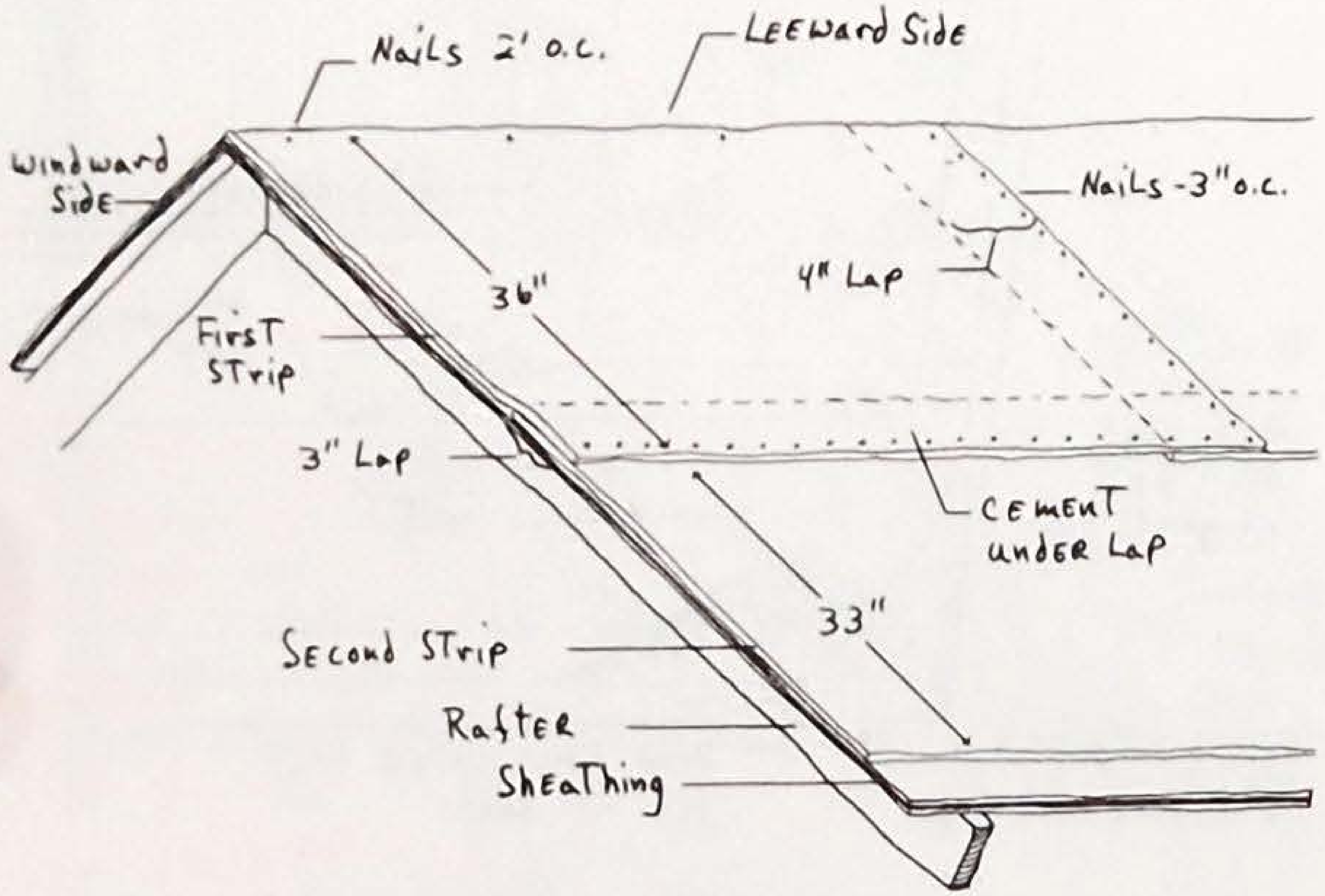


Fig. 27- Installing the First Strips of Roll Roofing

Leeward

Lap cement

Roofing cement

INSTALLING MINERAL SURFACED ROLL ROOFING

A roll of mineral surfaced roofing is 36" wide and 36' long and is laid over the felt underlayment with a 6" side lap and a 3" top lap. The width of each course that is exposed to the weather is 33". Fig. 27. Measure the roof from eave to gable. If from the measurement you realize that laying the courses of roll roofing 33" to the weather will yield a last course that is narrower than the rest, increase the lap to even up the courses.

1. Begin laying the strips or courses down the leeward side of the roof. Snap a chalk line parallel to the ridge and 36" below it. Roll the roofing out and nail it along the ridge (spacing the nails 2' apart) so that the bottom edge of the strip is on the chalk line. Allow 2" to hang over the edge of the sheathing at the eaves and gable ends.
2. Roll out another strip of roofing and snap a chalk line 3" from the top edge of the second strip. Paint this 3" strip with lap cement, being careful not to cover the chalk line. Lap cement is a thinner form of roofing cement. Roofing cement is a thick, gooey, tar-like substance that is used like caulking to waterproof the joints, nail heads and flashing of roofs.
3. Slip this 3" portion of the second strip of roll roofing under the first strip and align the chalk line on the second strip with the bottom edge of the first. Seat the top strip into the cement by walking on it. Fig. 27.
4. Nail the joints between strips with roofing nails spaced 3" apart and 1" in from the bottom edge of the top strip. Start the nailing in the middle of the roof and work to the gable ends so

that the joint will be smooth, even and free from buckles and pockets. After each joint between strips has been nailed, the seam should be painted with roofing cement. Fig. 28.

5. If a joint is made in the middle of a course, it should be perpendicular to the ridge and lapped 4". The joint should be cemented and nailed like the long joints between courses. Fig. 27.

6. When the leeward side of the roof is covered, begin laying strips of roll roofing on the windward side. The first strip on the windward side is laid along the ridge with 3" folded over the ridge to the leeward side and 33" exposed on the windward side. Fig. 29. This strip is nailed 1" from the edge of the 3" portion folded over the ridge. The top 3" of the first strip on the leeward side should be painted with roofing cement so that the portion of the first strip on the windward side that is folded over the ridge can be pressed into the cement and seated properly. The folded over portion is nailed 1" from the edge with nails spaced 3" apart.

7. The rest of the windward side of the roof is covered as previously described.

8. The most stress on roll roofing occurs at the eaves and along the gable ends where the wind constantly tears at the roof. There are two methods of anchoring the roll roofing at the eaves and gable ends that will increase the life of the roof. Fig. 30. In Fig. 30A the roofing is folded under the eaves and gable ends and held in place by pieces of 1x3". The 1x3" cleats run the length of the eave or gable end and are nailed from their underside into the sheathing. Fig. 30B shows a less durable method.

9. A mineral surfaced roll roof will last only

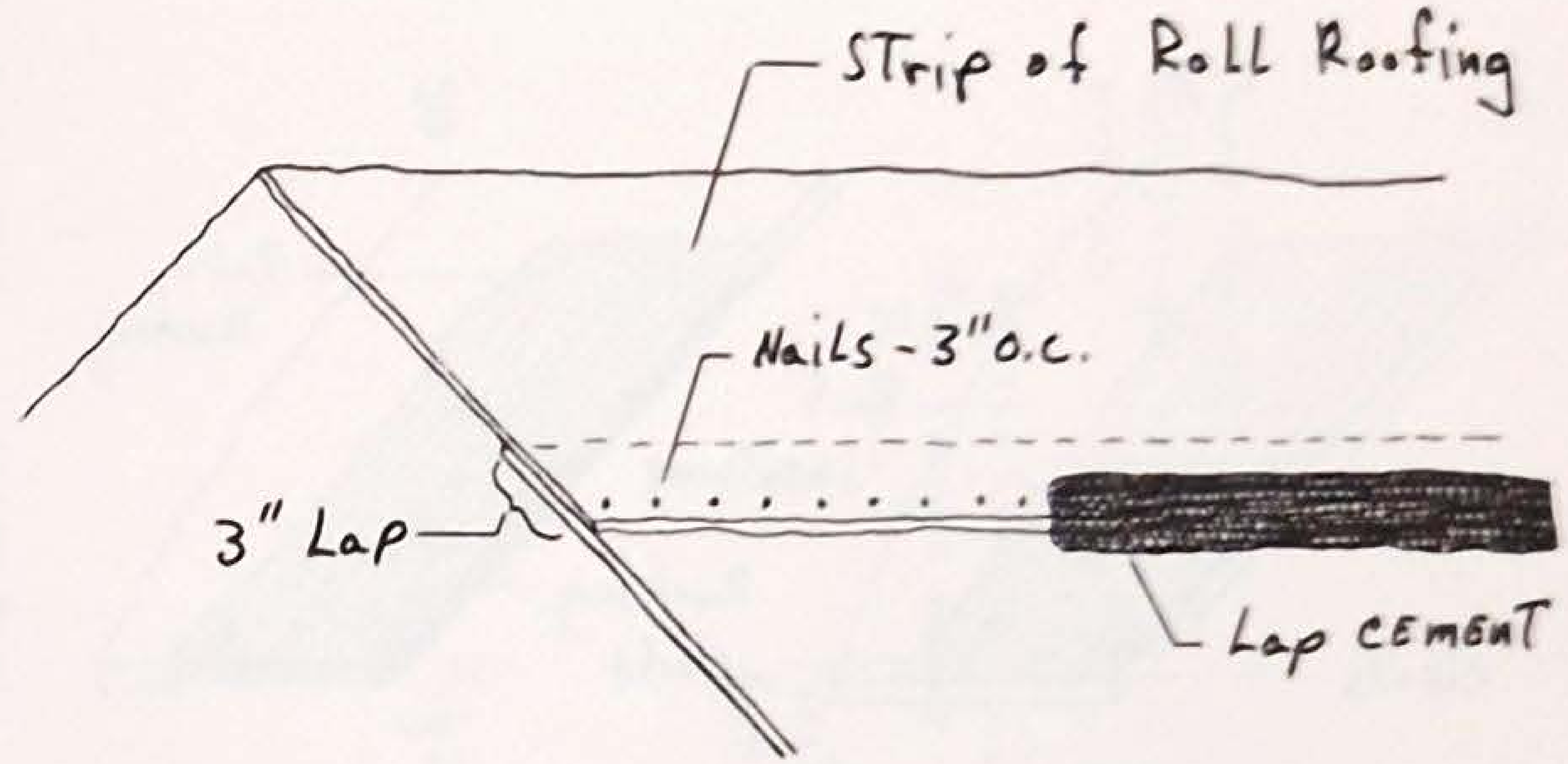


Fig. 28 - Lap Cement

Windward

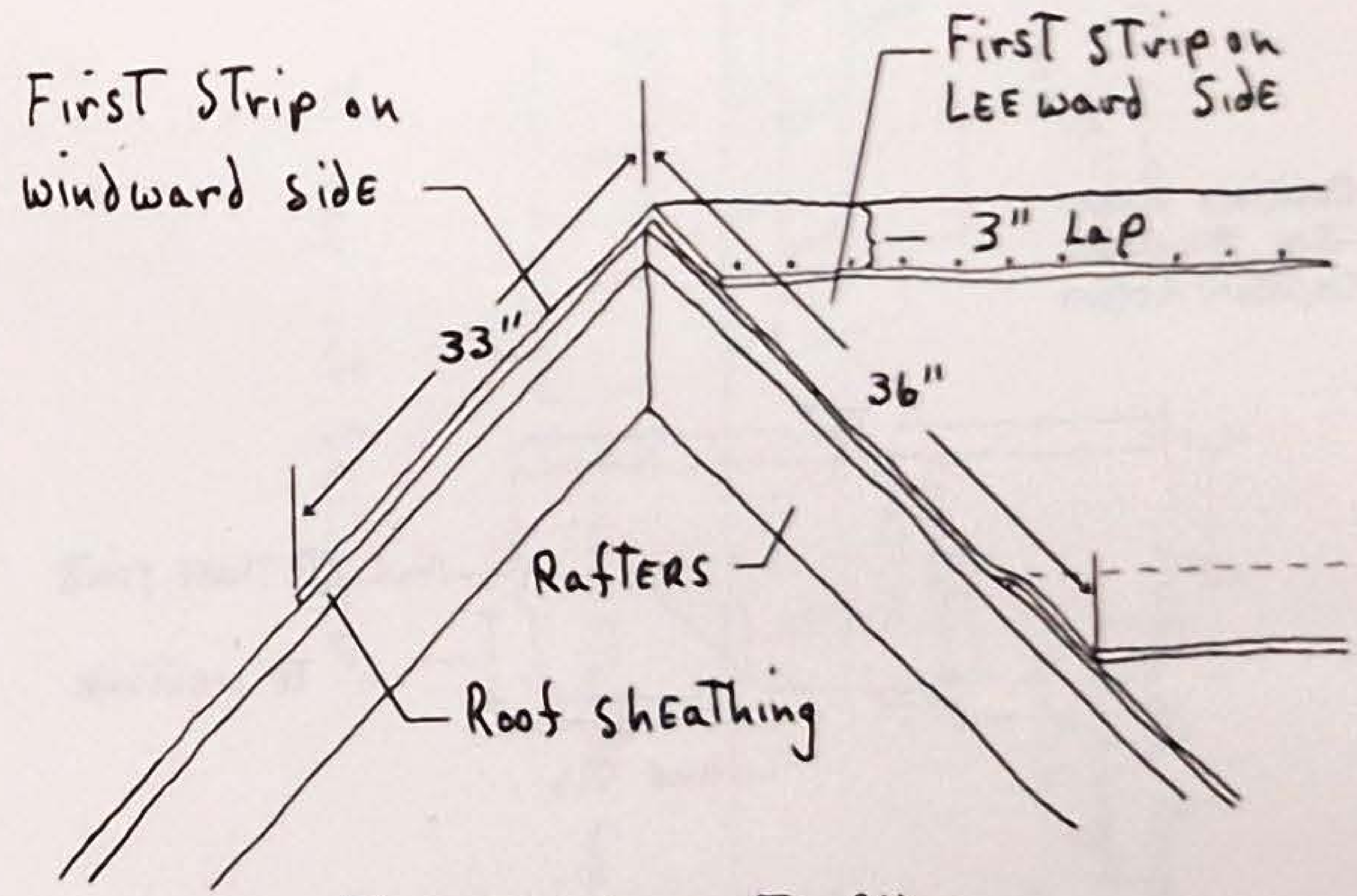


Fig. 29 - Lap at Ridge

Cleat

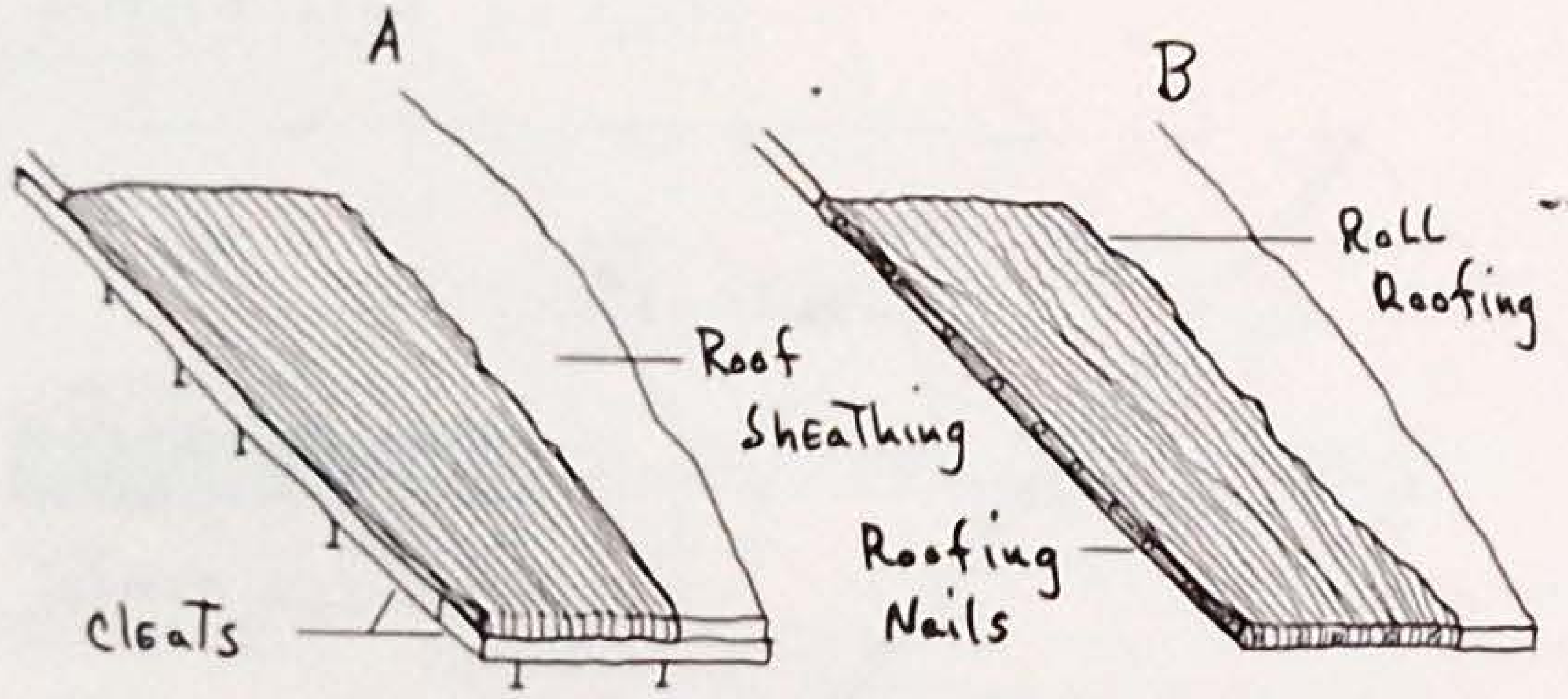


Fig. 30 – Securing The Roofing at the Eaves

Capillary action
--See Windows:
Capillary Action

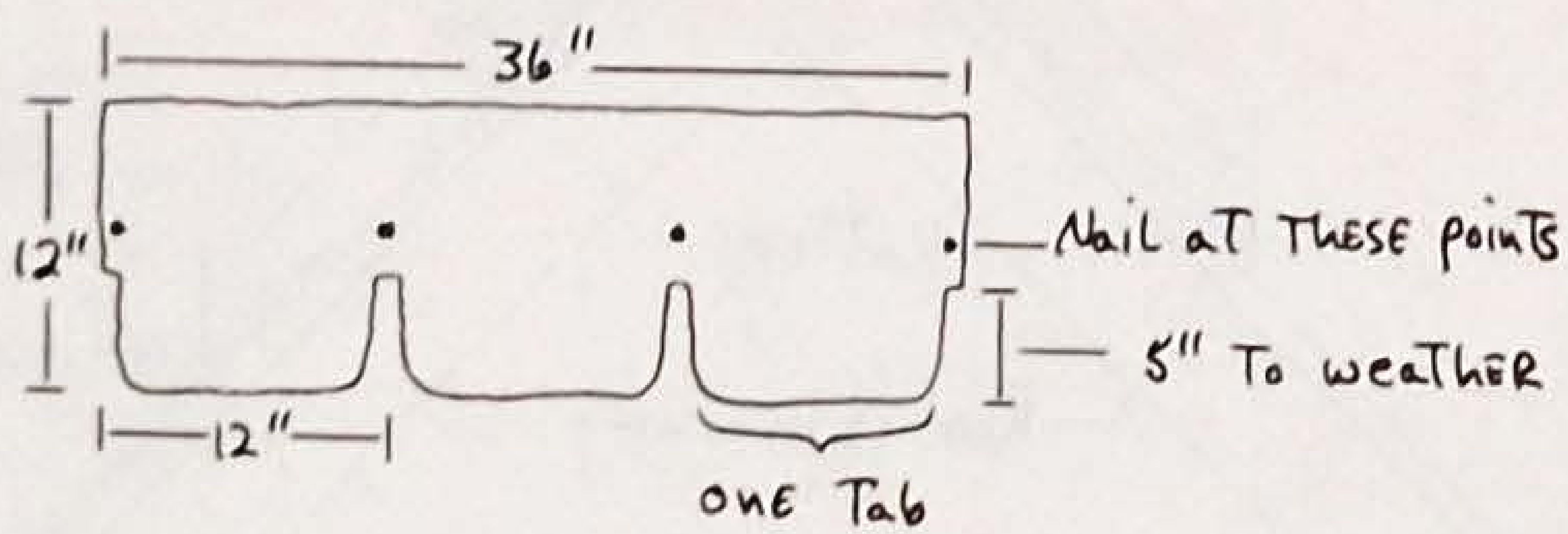


Fig. 31 - Asphalt Shingle

5-15 years. It is important to install it well to get the most out of the roof.

ASPHALT SHINGLES

Typical asphalt shingles are 12" wide by 36" long and have three tabs. Fig. 31. They come in quantities called bundles. Three bundles contain enough shingles to cover one square of roof surface. A square is 100 square feet.

Shingles are laid with different amounts of lap. The different laps are usually described with the words "5 inches to the weather, 4 inches to the weather, 6 inches to the weather, etc." When shingles on a roof are said to be laid 5" to the weather, it means that only 5" of the 12" width of the shingle is exposed to the air, sun and rain. All the rest of the shingle is covered by the shingle above it. The part of the shingle that is exposed to the weather is the part covered with mineral surfacing. Shingles must be lapped 6 or 7" so that wind and capillary action don't draw the water up under the shingle. Roofs with steep slopes can have an exposure to the weather of 5-6". Roofs with slopes of 4" in 12" or 5" in 12" should have an exposure to the weather of 4" so that there is more lap. Roofs like these with slopes that are much more horizontal than steeper roofs are susceptible to wind forcing moisture up under the shingles.

The starter course goes along the edge of the eave over the underlayment which has been laid over the drip edge. The starter course is a 9" row of mineral surfaced roofing or a row of shingles with their tabs laid toward the ridge and their mineral surface still towards the weather.

The purpose of this starter course is to fill in the space between the tabs of the first course. Therefore, the starter course should be offset by one tab from the first course so that the seams of the starter course don't fall under a notch. Fig. 32.

There are many layouts for shingles. In one of the most common, the first course begins with a full shingle at the gable end. Fig. 32. The shingles are nailed above the notches with wide head galvanized steel or aluminium nails. The next course, the second, is started with a full shingle minus half a tab and is placed over the first course so that 5" of the first course is exposed. The third course begins with a full shingle minus one whole tab, and the fourth begins with a full shingle minus one and one-half tabs. The fifth course begins with just one tab, and the 6th with half a tab. The seventh course begins again with a full shingle. It is helpful to chalk a line for every 6th course to keep the rows straight.

Shingles can be cut with a roofing ax. Cut the shingle from the non-mineral surface side. Fig. 33.

Nailing Shingles

Plain barbed galvanized nails are usually used for roofing, but ring shank or spiral threaded nails can be used. They should have large heads (3/8"--7/16" in diameter) and be 1¼" long for new roofs and 1 3/4" long for reroofing. The nails for reroofing need to be longer because the new shingles are put on over the old. Average shingles require 2¼ lbs. of the 1¼" nails or 2 3/4 lbs. of the 1 3/4" nails per 100 sq. ft. Use 4

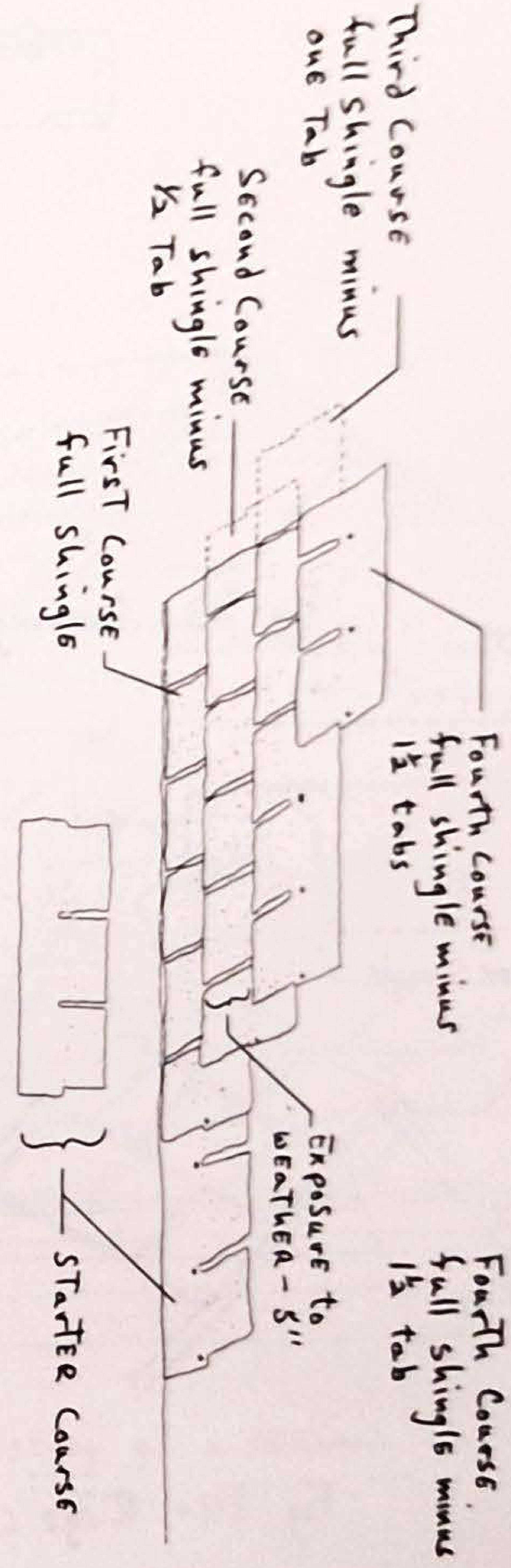


Fig. 32 - One Way To Lay out Shingles

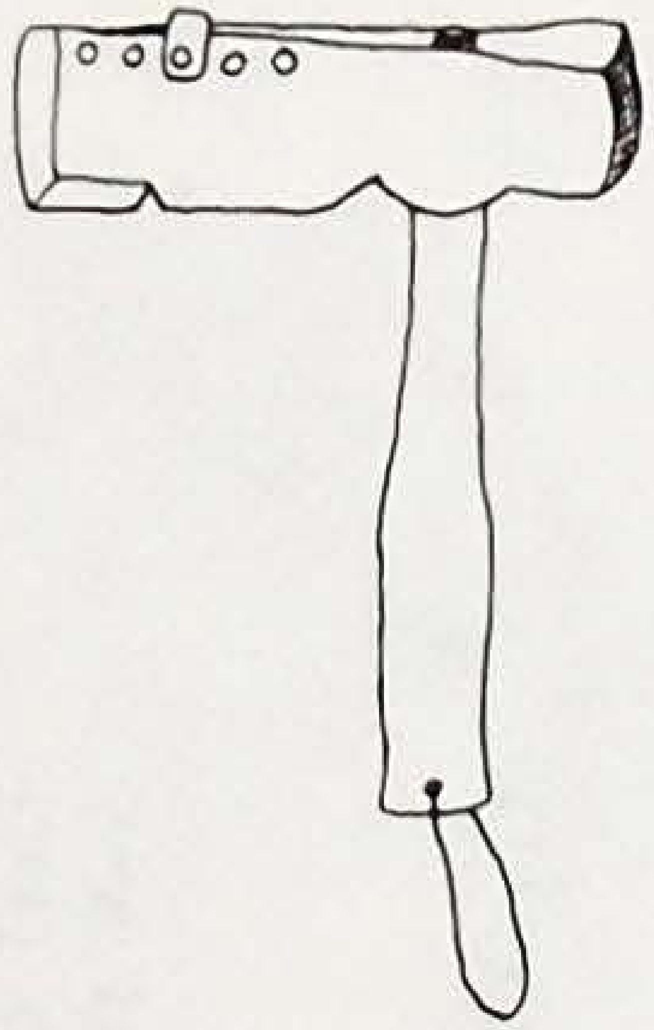


Fig. 33 - Roofing Ax

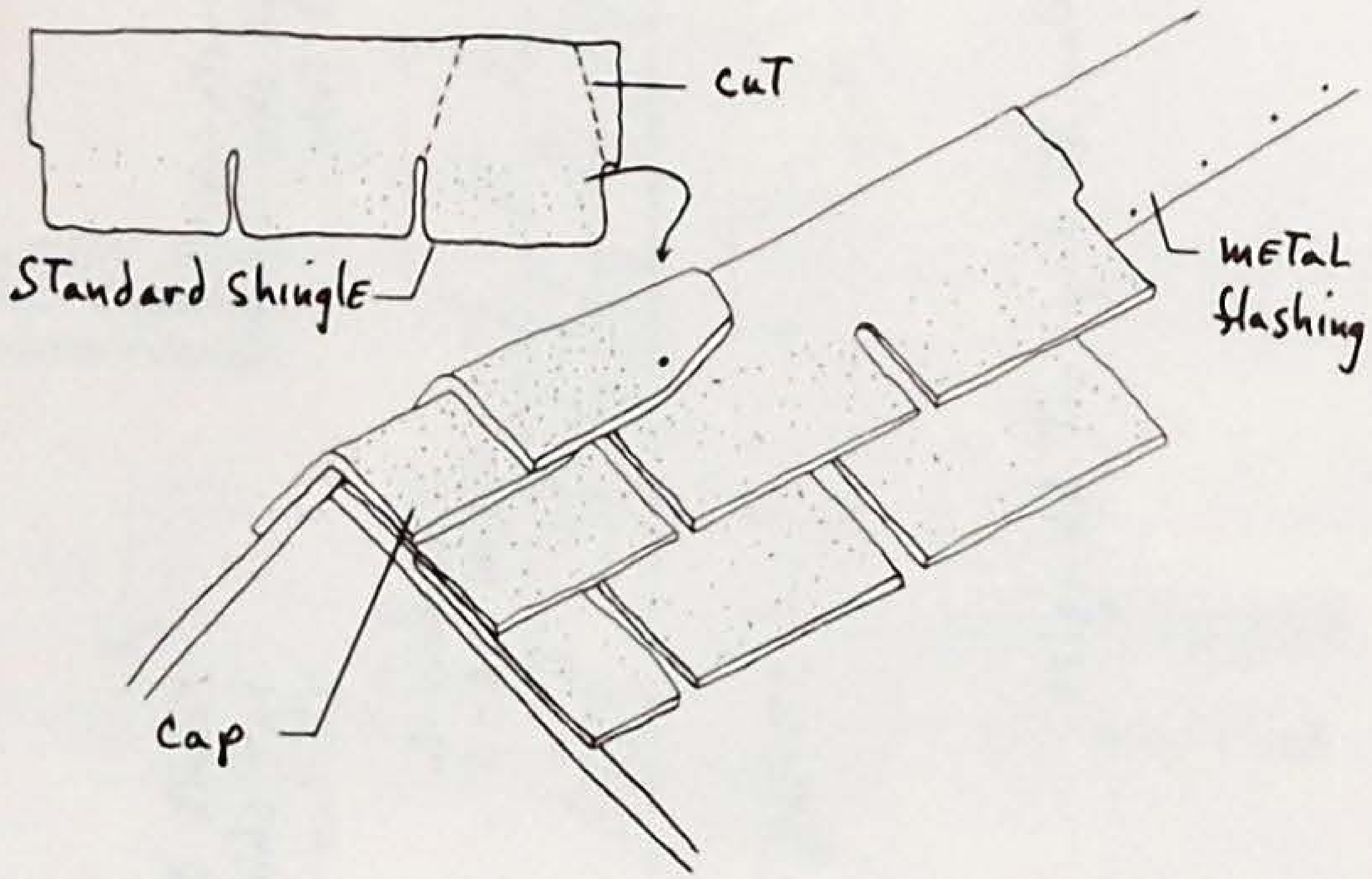


Fig. 34 - Ridge Cap

nails per each three tab shingle; begin the nailing with the edge next to the shingle just laid; and proceed across the shingle to prevent buckling. Drive the nails in straight so that the heads are flush but not indented into the surface. Be careful that the edges of the heads don't cut the surface of the shingle. Any cuts or breaks may admit water or moisture. If you have a large roof to shingle, it may be worth it to rent a pneumatic nailer or stapler for a day.

The Cap

The ridge of the roof is covered by a row of shingles called a cap. The cap is made up of shingles which are 9"x12" and extend down over each side of the gable roof approximately 4". The 9"x12" shingles can be cut from a roll of mineral surfaced roofing which matches the shingles already laid; or they can be made by cutting the three tabs of a regular shingle apart and tapering the end without mineral surface.

Bend the cap shingles along the center so that the bend is parallel to the 12" dimension. If you are working in winter and it's cold, warm the shingles before bending them, to prevent cracking the surface. Start at one end of the ridge and proceed to the other, laying the shingles 5" to the weather. The cap shingles should be nailed with 2 nails: one on either side of the ridge, 5½" back from the exposed end, and 1" in from the edges.

In areas where there are likely to be high winds, it is good idea to install metal flashing over the sheathing at the ridge (under the cap) for extra protection.

FLASHING

If there is a chimney or vent stack protruding from the roof, or if a sloping roof meets with a vertical wall, then flashing must be installed at the joints of the vertical and sloping surfaces in order to make them waterproof. Flashing can be tin, copper, aluminium, galvanized metal, asphalt shingles or roll roofing. The metals come in rolls of varying widths.

Step Flashing

When a sloping roof intersects a vertical wall, step flashing is used at the intersection to keep the joint waterproof. In step flashing, a piece of flashing is installed under each course (before each course is laid--not all at once). 2" of flashing extends under the shingle and 4" extends upwards along the wall. Each piece is 7" long and at least 2" wider than the portion of the shingle exposed to the weather. Fig. 35.

Except for the first piece, a piece of flashing is laid after each course of shingles is laid. After the lowest course of shingles is laid, the first piece of flashing is slipped under the shingle next to the vertical wall before it is completely nailed. When the last shingle in the lowest course is laid next to the vertical wall, a second piece of flashing is laid over this last shingle such that the bottom edge of the second piece of flashing laps the top edge of the first piece of flashing by 2". The last shingle in the second course is laid over this second piece of flashing. Then another piece of flashing is laid over the last shingle in the second course and so on. Each piece of flashing is held in place by one nail in

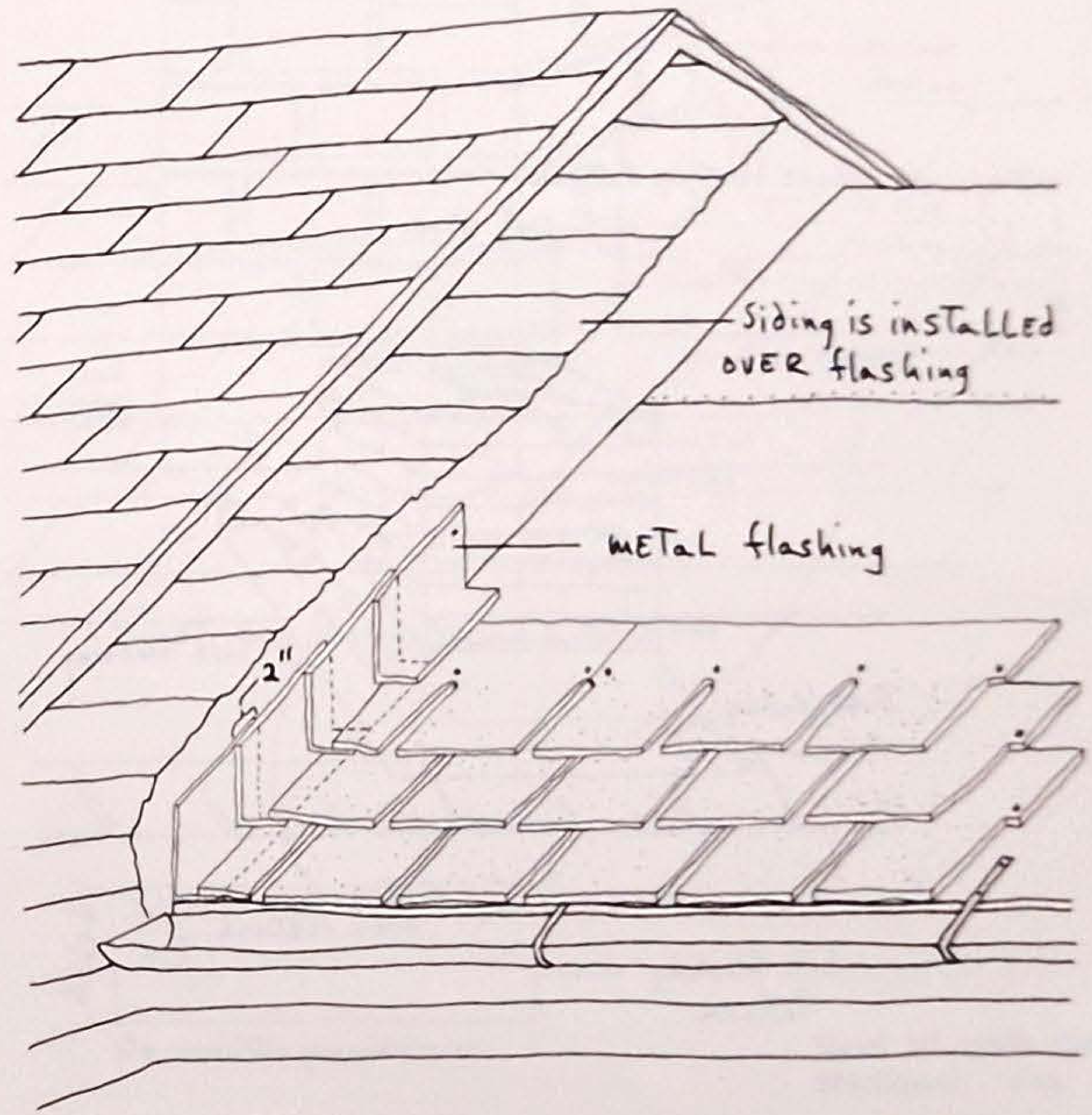


Fig. 35 – Flashing at a Vertical Wall

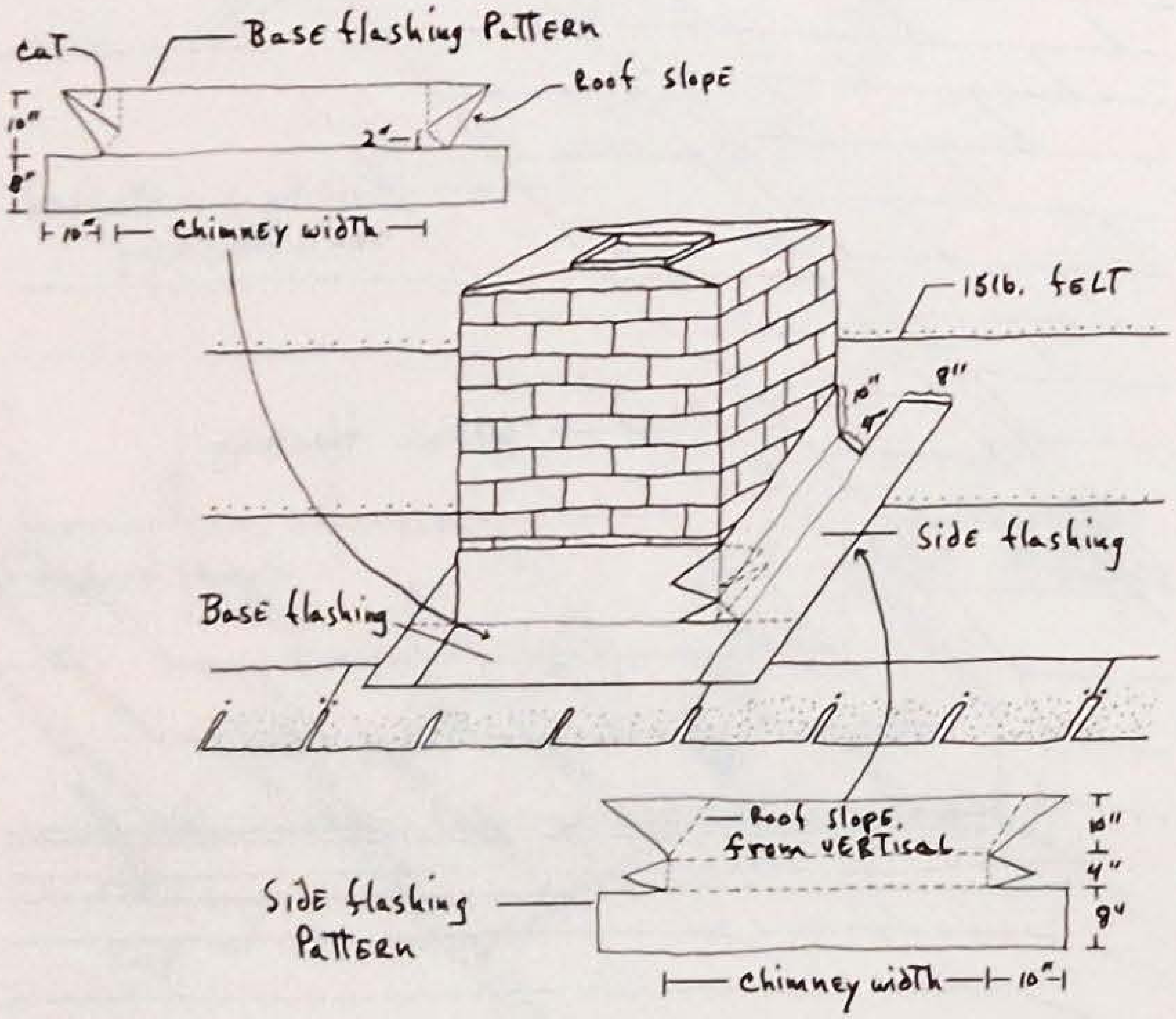


Fig. 36 - Base flashing Around a Chimney

the uppermost corner. Fig. 35.

Siding is installed over the vertical flashing completing the water proof joint. The siding should be kept 1/2" back from the shingles to prevent capillary action from drawing water up the length of the joint. If this type of joint occurs in an old house that is being reroofed, the siding or asphalt shingles on the vertical wall must be pried up and the vertical part of the flashing slipped under them. If a sloping roof meets a verticle brick wall, cap flashing is inserted into the mortar chimney flashing. The cap flashing covers the metal step flashing and completes the waterproof joint.

Chimney Flashing

The flashing around chimneys is made up of 2 parts: the base flashing, which is attached to the roof; and the cap flashing or counter flashing, which overlaps the base flashing and is attached to the chimney. The two groups of flashing are not attached to each other to allow for settling or shrinkage of the building frame. The shingles are laid up to the low edge of the chimney and the base flashing along the low side of the chimney is laid over the shingles and cemented in place with roofing cement. The base flashing is made of 90 lb. mineral surfaced roofing. The lowest piece is applied first and wrapped around the chimney. Some wedge shaped cuts are necessary to make a smooth corner. Then two side pieces are applied and wrapped over the corners of the lowest piece. The uppermost piece, similar in shape to the lowest piece, is cemented in place last and overlaps the corners.

The cap flashing is imbedded in the mortar joints of the chimney and folded down and over the base flashing. The cap flashing is made out of metal and is imbedded in the mortar joints of the chimney to a depth of 1/2". If the house is old and the mortar joints have already hardened, chisel out 1/2" of mortar from the appropriate mortar joints with a hammer and cold chisel. Cement the flashing into the hollowed out space in the mortar joint. Lead wedges can also be driven into the joint above the flashing to hold it in place. Caulk the joint between the chimney and flashing after the flashing is firmly in place.

Bending Metal Flashing

When flashing must be bent, it should not be hit directly with a hammer. This can cause dents and weak spots that might leak.

After a piece of flashing has been cut off the roll to the needed length, a board as long as the flashing is laid over the metal, along the line at which the flashing must be bent. The metal is bent using this long board as a corner to bend around. Another long board is placed on the other side of the flashing so that it is sandwiched between the two boards. The second board can be pounded on with a hammer to make the angle of bend more abrupt and sharp.

Patching

If a leak develops along some flashing in an existing roof, more flashing, like tar and caulk, can be used to fix it. If the siding or the existing roofing cannot be pulled up to allow the flashing to be properly pushed under and overlapped, then the flashing should be embedded in tar and the joint between the flashing and the

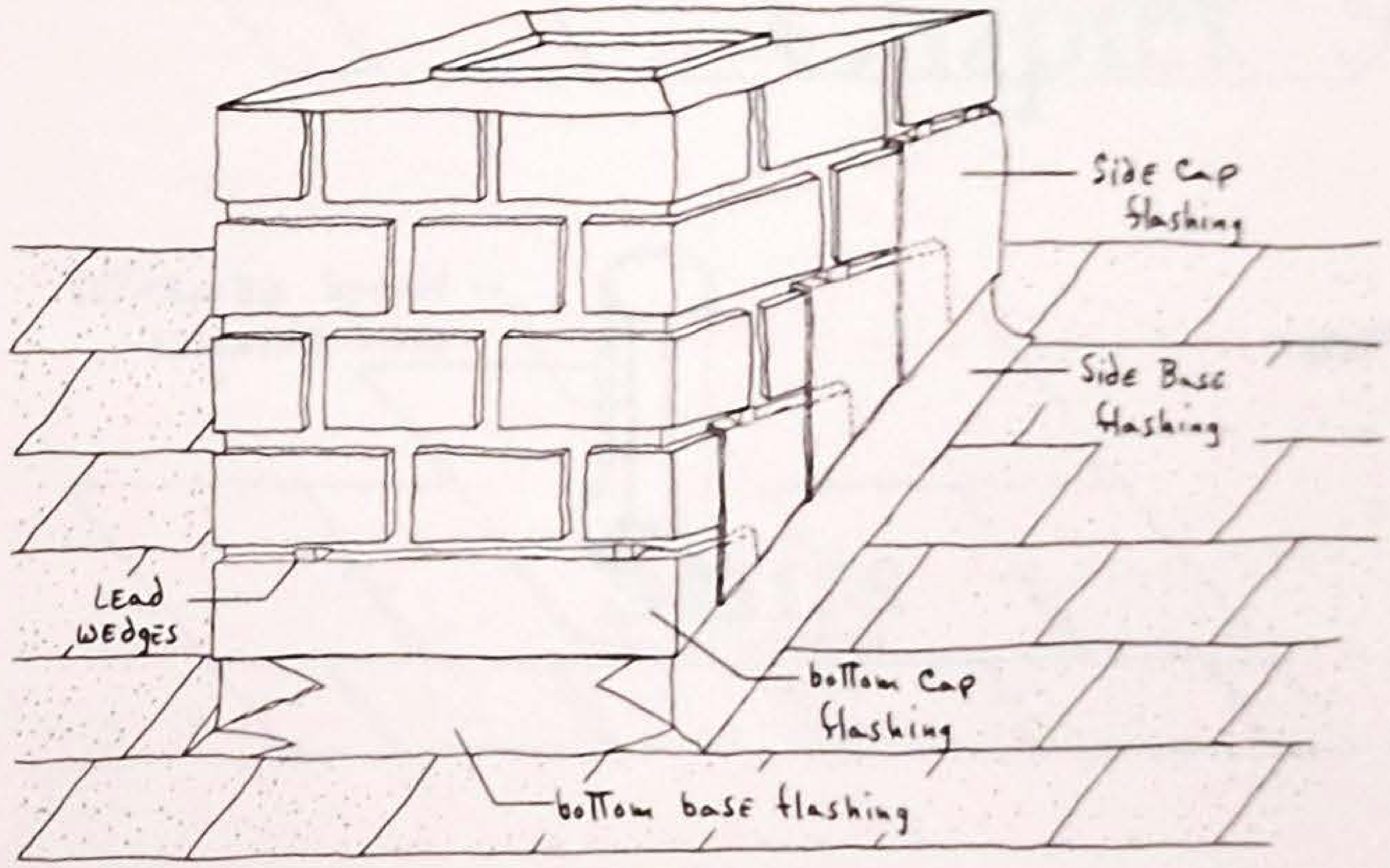


Fig. 37- Cap flashing Around A Chimney

Bead of caulk-See Windows: Fig. 3

Flanges

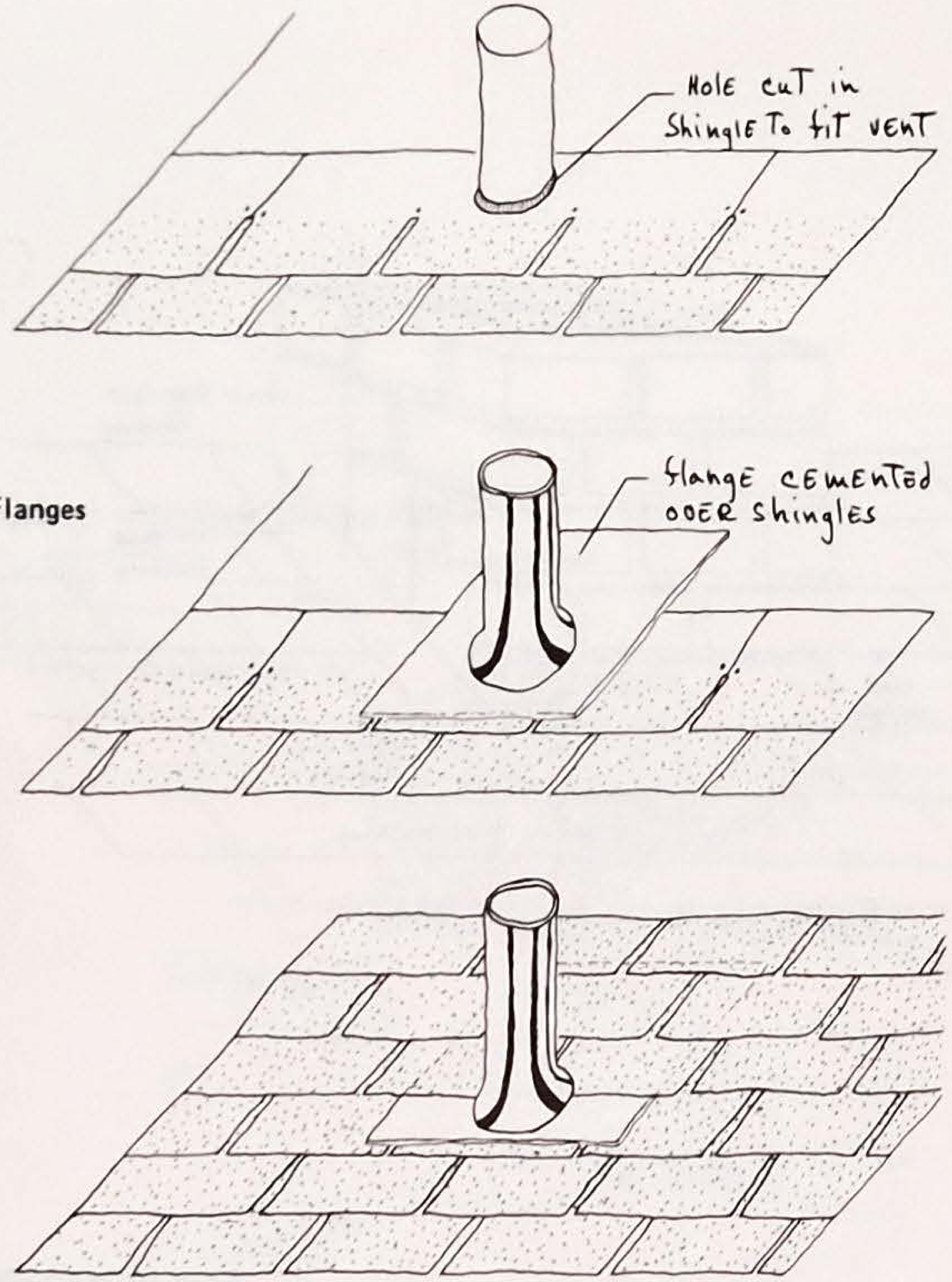


Fig. 38- Vent Stack flashing

roof or wall surface should be caulked. Smear a lot of tar on the surface over which the flashing will go. Push the flashing into the tar, seating it well. Take the caulk gun and caulk a bead all around the perimeter of the piece of flashing where the edge meets the surface of the roof or vertical wall.

Vent Flashing

When pipes or vents are protruding through the roof, prefabricated flanges are available.

Lay the shingles up to the vent stack, place the prefabricated flange over the stack, and cement it in place with roofing cement. It should extend at least 4" below, 8" above, and 4" on either side of the stack. The roof shingles are now laid over the flange with a hole cut out for the stack. Fig. 38.