2018
2022

1.

VAS 3009a

USING THE CARPENTER'S SQUARE

1. Testing the Steel Square
2. Identifying Parts of the Square
3. Laying Out Braces
4. Laying Out Stairs
5. Laying Out Rafters
6. Student Shop Projects

The square is one of the oldest tools known to man and one of the most useful ones. Since earliest recorded history, man has depended upon the square as one of his basic tools in construction. There are several types of squares that are used by builders and construction workers (Fig. 1). The carpenter's framing square is used for squaring boards, for squaring inside and outside corners, and for measuring and marking angles used for braces, rafters, and stairs. It is probably the most accurate member of the common square family.

The try square, the try-and-miter square, and the combination square are used for marking the edges of boards, for squaring small pieces, and for lay-out work. All squares are alike in the fundamental characteristic that they have two parts or legs which intersect at an angle of 90 degrees.

Good quality squares are made of steel that is capable of holding its shape. They are plated with non-corrosive material so they will not rust. They are marked so the inch graduations, tables and figures may be read easily.

When selecting a square, choose one that can be read easily where it will be used. If a square is to be used outdoors, a bright finish will make it hard to read on a sunny day.

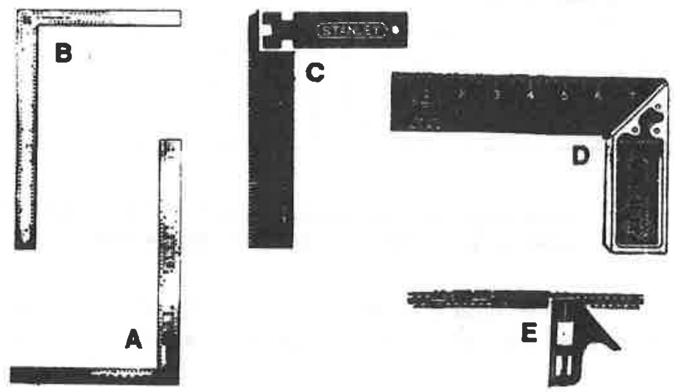


Fig. 1. Common types of squares include: (A) carpenter's framing square; (B) metric square; (C) try square; (D) try and miter square; (E) combination square.

Try squares and try-and-miter squares may have handles of hardwood or steel. The squares with steel handles wear longer and may retain their accuracy better than those with wooden handles. Squares with wooden handles should not be used to align steel for welding.

1. TESTING THE STEEL SQUARE

Since a square is a precision instrument that is used as a standard for construction, it is important that a square be accurate. Small squares can be tested for accuracy by comparing them with a carpenter's framing square. Squares are subject to rough usage on the job so their accuracy should be tested frequently. The framing square can be tested as follows. Select a wide, straight board or plank such as a 1"x12" or a 2"x12". The straightness can be determined by sighting along the edge. Place the square on the board as in Fig. 2 and mark a line with a sharp pencil. Reverse the square and observe whether the edge of the square coincides with the original line. If it does, the square is true. If it is not true, note whether the included angle is more or less than 90°.

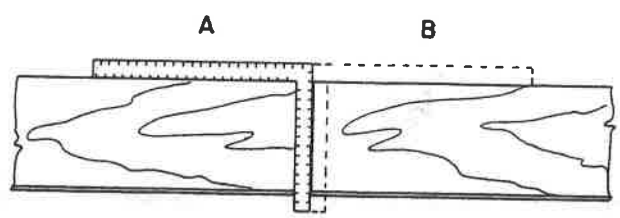


Fig. 2. Use a wide, straight board to test a square. Mark line with square in position A; then reverse square and re-mark in position B. Lines should coincide.

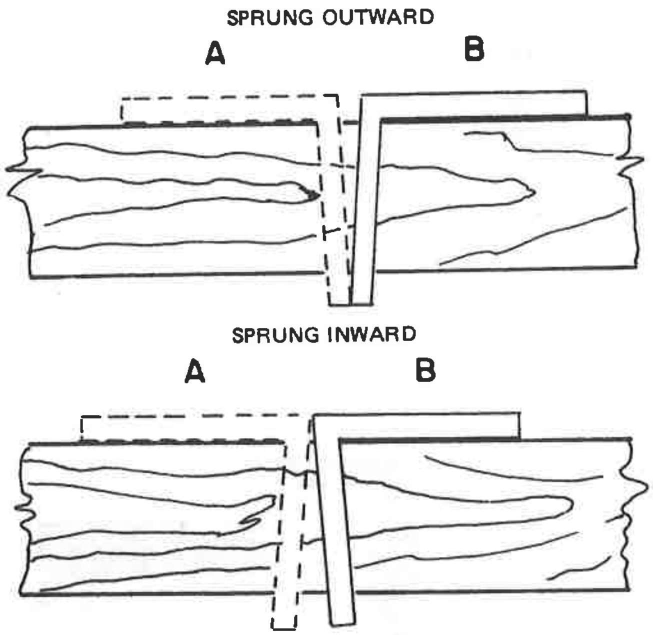


Fig. 3. If the included angle is greater than 90°, the square is sprung outward. If it is less than 90°, it is sprung inward.

If the square is not true (Fig. 3), it may sometimes be corrected by placing it on an anvil (Fig. 4)

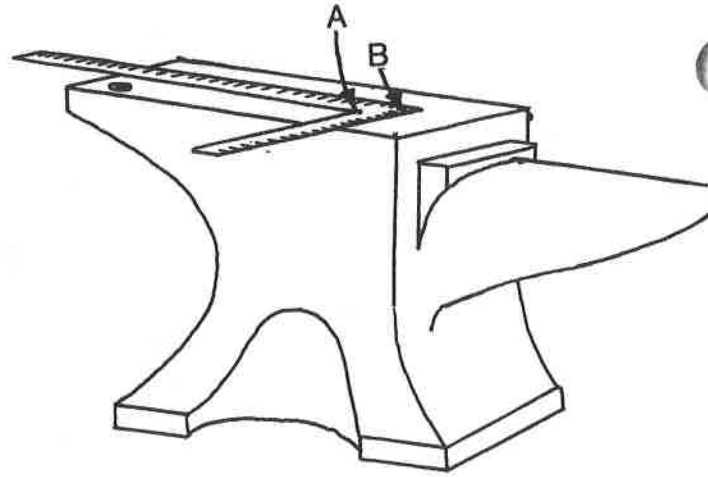


Fig. 4. To correct a square that is not true, lay it on an anvil and strike with ball-peen hammer at A to increase the size of the included angle; at B to decrease it.

and striking it several sharp blows with a ball-peen hammer at point A if the included angle is less than 90° (sprung inward) or at point B if the angle is greater than 90° (sprung outward). After correction, recheck the square by the method previously described and repeat the operation if necessary.

2. IDENTIFYING PARTS OF THE SQUARE

Parts of the square

The framing square has two legs. The longer leg is called the **blade**, while the shorter leg is called the **tongue** (Fig. 5). The blade of a standard framing square is 2 inches wide and 24 inches long. The tongue is 1½ inches wide and 16 inches long.

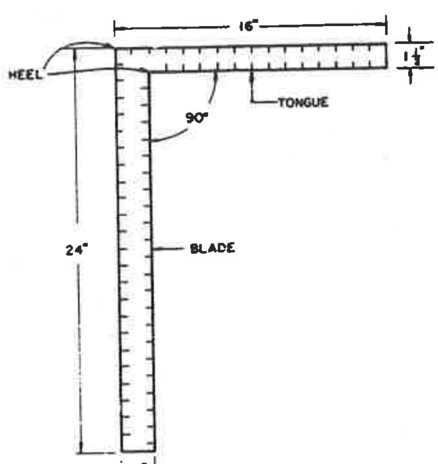


Fig. 5. The framing square has a tongue which is 1½" by 16", and a blade that is 2" by 24".

The side of the square on which the trademark is located is called the **face** or **front** of the square. The opposite side is called the **back**.

Graduations of measure

Although the square is not primarily a measuring instrument, it is often convenient to use it for that purpose, especially if unusual fractions of an inch are desired. There are six scales on the standard framing square. The outer edges of both the tongue and blade on the face side of the square are graduated in 16ths of an inch (Fig. 6a). The inner edges of the tongue and blade on this same side are graduated in 8ths. The outer edges of both the tongue and blade on the back side are graduated in 12ths (Fig. 6b). The inner edge of the blade on this side is marked in 32nds, while the inner edge of the tongue is marked in 10ths. Somewhere on the square, usually on the back near the intersection of the blade and tongue, is the sixth scale--a single inch marked off in 100ths. To use this scale accurately, it is usually necessary to set a pair of sharp dividers and transfer the measurement to your work.

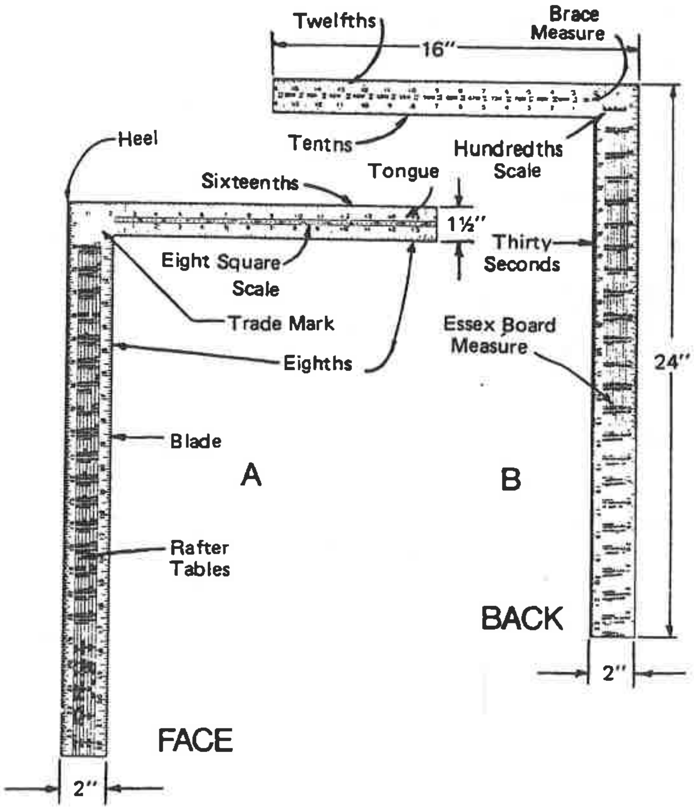


Fig. 6. The standard framing square has six scales for measurements.

Tables on the square

There are several patterns of framing squares in use, and they differ somewhat in the number and kinds of tables printed on them. The most common pattern has the four tables described below.

The **Essex board measure table** (Fig. 7) is found on the back of the blade. It can be used to determine the number of board feet in a board of any common width and length. The inch graduations along the outer edge of the blade can be taken as lengths of the board in feet. The column of numbers under the **12 inch** graduation can be taken as widths of the board in inches. **To use the table, first** find the width of the piece in the column under 12. Not all widths are given. The most common widths of boards are 4, 6, 8, 10, and 12 inches. Of these only 8 and 10 are given. If the board is 4 inches wide, take half the value given for an 8-inch piece. Six- and 12-inch boards can be figured rather easily without the table. Having found the width of the piece, move along the square to the column under the inch mark representing the length of the piece in feet. The answer will be found in the same relative position in this column and is given in board feet and **12ths**.

Example: How many board feet are there in a 1"x10"x14'?

Procedure: Find the number 10 (width) in the 12 column. Follow this line out to the 14 column (length). The answer is 11 8 which is 11 8/12 board feet or 11 2/3 board feet.

For 2-inch lumber, multiply the answer found for 1-inch lumber by two. If the piece used in the example above were a 2"x10"x14', the answer would be 11 2/3 x 2 or 23 1/3 board feet. If the piece were a 2"x4", it would be figured as a 1"x8" and read directly off the square.

The **brace table** (Fig. 8) is found on the back of the tongue. It is used to determine the length of common braces. All but one of the figures given in this table are for braces whose rise and run are the same. The rise of a brace (Fig. 9) is the vertical distance AB, spanned by the brace. The run is the horizontal distance, AC. The two small numbers, one above the other, are the rise and run of the brace in inches. The large number is the length of the brace in inches and 100ths. To determine the length of a brace whose rise and run are 5 feet, find the figure 60 inches on the brace table. It reads $\frac{60}{60}$ 84 $\underline{85}$. This means that the brace is 84.85 inches long from B to C.

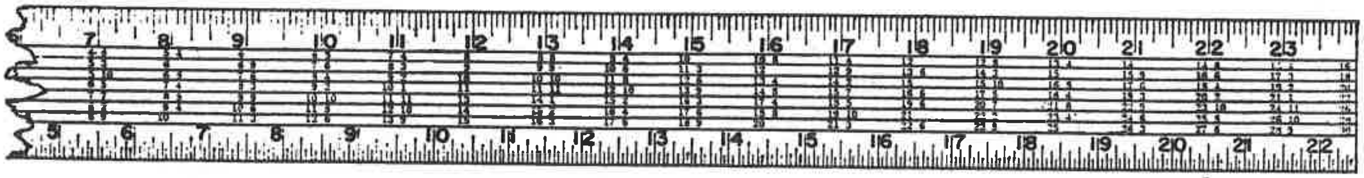


Fig. 7. Essex board measure table.

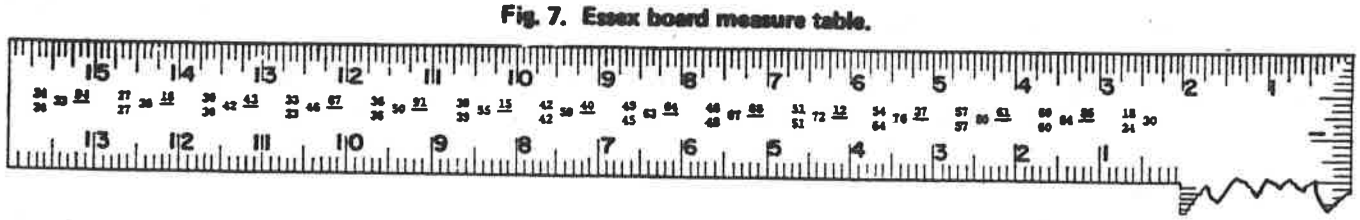


Fig. 8. Brace table.

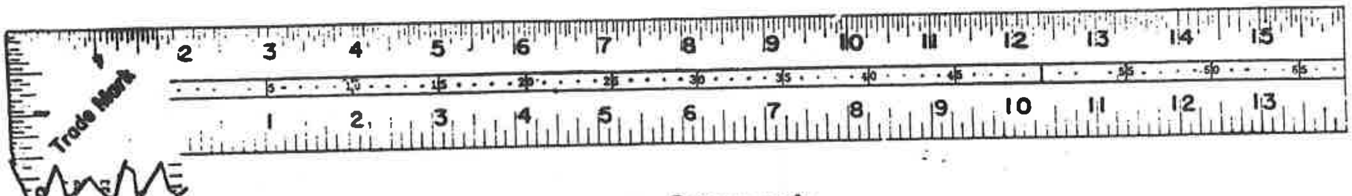


Fig. 10. Octagon scale.

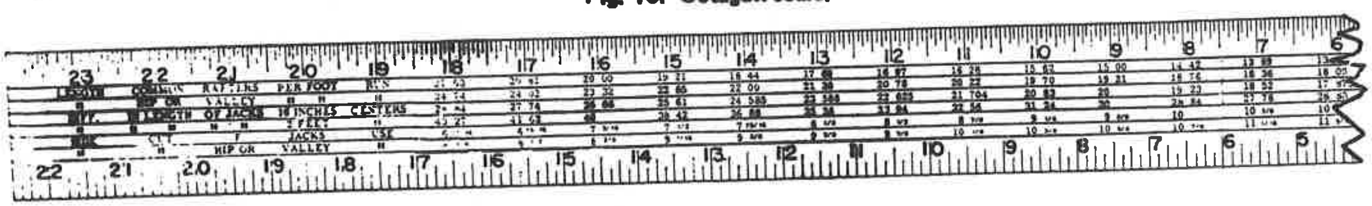


Fig. 12. Rafter table.

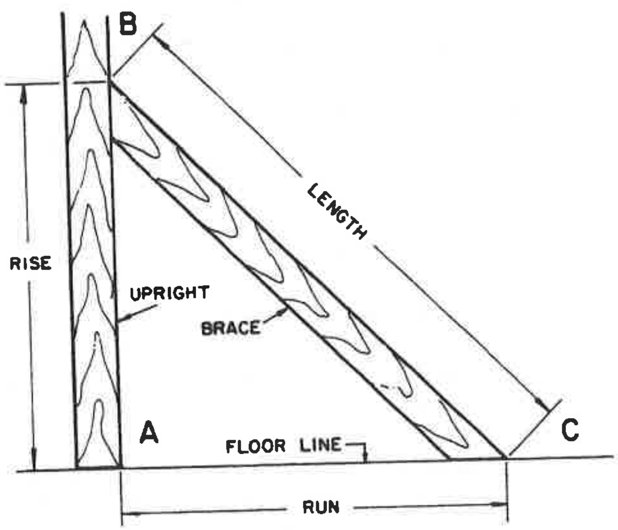


Fig. 9. The rise of a brace is the vertical distance AB; its run is the horizontal distance AC; while its length is BC.

If the length of the brace desired is not found in the table, any even multiple of this length can be used. For example, a brace with a rise and run of 12 feet would be 3 times the length given for a brace 48 inches by 48 inches.

The one brace dimension that does not have an equal rise and run is that given as $\frac{18}{24}$ 30. This is the familiar 3-4-5 triangle which is commonly used in squaring such things as building foundations and fence intersections. Any triangle that is constructed with one side equal to 3 units, another side 4 units, and the third side 5 units, is a right triangle, or the large angle is equal to 90°.

The **octagon scale** (Fig. 10) is found on the face of the tongue of many squares. It can be used to construct an octagon or 8-sided figure. (Fig. 11) shows how the octagon is constructed. First locate points A, B, C, and D in the center of each side of the square figure. Then set a pair of dividers with one point on the first dot on the octagon scale and the other point on the dot which is numbered the same as the number of inches along one side of the square. Set the dividers at point A and mark points A_1 and A_2. Mark points B_1, B_2, C_1, C_2, D_1, and D_2 in a like manner. When you connect these points as shown in Fig. 11, you have a perfect octagon.

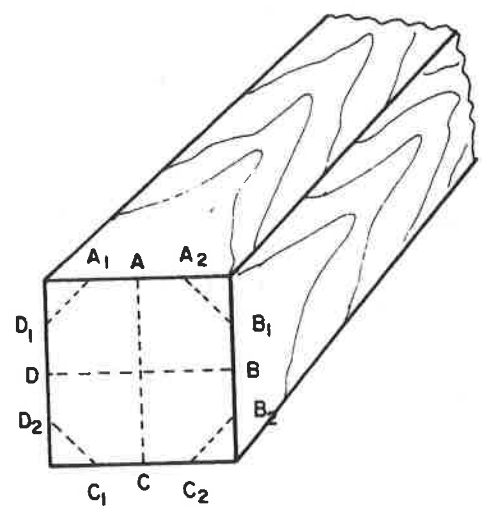


Fig. 11. An 8-sided member can be laid out using the octagon scale.

The **rafter table** (Fig. 12) is one of the most useful tables on the framing square. It can be used in laying out all kinds of rafters, braces, and other building members which require angle cuts. The first row of figures gives the length of common rafters per foot of run. The numbers along the face of the blade from 2 to 18 represent the inches of rise per foot of run. The first figure under each number is the length of the common rafter for each foot of run. In effect, it is the length of the hypotenuse of a right triangle, one leg of which is 12 inches, the other leg represented by the inches of rise per foot of run. For example, if the two legs of the triangle are 12 and 8 inches, the hypotenuse is 14.42 inches.

The other parts of the rafter table are length of hip or valley rafters per foot of run, difference in length of jack rafters on 16- and 24-inch centers, and side cuts for jack rafters, hip rafters, and valley rafters. In each case, the column of figures used is that under the inch mark representing inches of rise per foot of run of the common rafter.

Detailed information for the use of these tables will be presented in the section on rafter cutting. There are many different makes of framing squares and the scales and tables vary with the cost and manufacturer. If you find tables that you cannot understand, the manufacturer will provide you with an information booklet on the square.

3. LAYING OUT BRACES

Many times in building construction diagonal members are used to brace the frame. The principle involved is that of dividing rectangles into triangles. A rectangle is free to move in its joints except for the strength of the nails or other fasteners used at the joints. A triangle, on the other hand, is rigid even if fastened at the joints with a single bolt or pin.

With some types of construction, there are no fixed points for the brace to begin and end. Then, it is usually satisfactory to cut 45° angles on both ends which means that the run and rise will be equal. To mark a 45° angle, select two equal numbers on the square and line them with the edge of the piece (Fig. 13). It is necessary, however, that both numbers be either on the outer edge or on the inner edge of the square.

You can determine the length from the brace table and measure it on either edge of the brace as desired. Then mark out a second 45° angle at the other end of the brace.

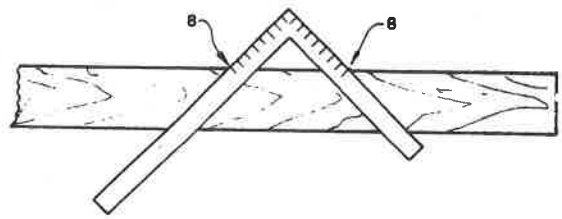


Fig. 13. To mark a 45° angle, apply the square so that two equal numbers, as 8 and 8, are aligned with the edge of the piece.

If there are fixed points into which the brace should fit, three things must be determined: (1) What is the total rise or vertical distance covered by the brace? (2) What is the total run or horizontal distance covered by the brace? (3) What is the total length of the brace? The rise and run can usually be accurately measured. For a brace such as that illustrated in Fig. 9, the length can also be measured. Note that the length, BC, must be measured from the same points that the rise, AB, and the run, AC, are measured.

Three ways to lay out this brace are shown in Fig. 14. In A, all measuring and marking is done

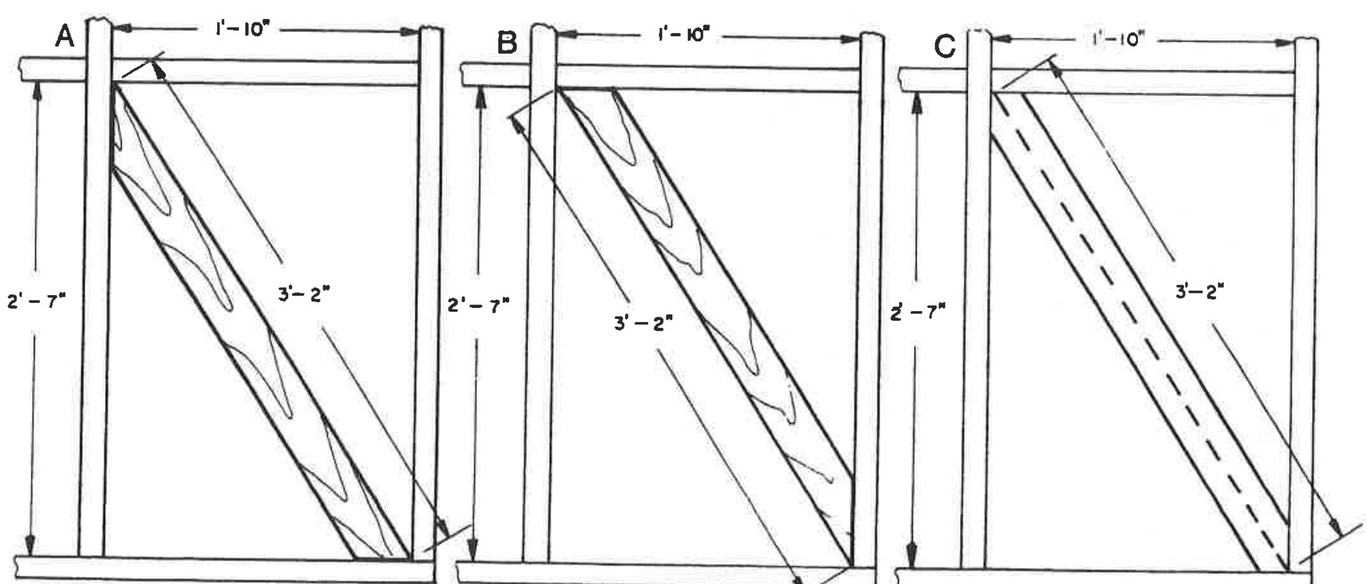


Fig. 14. Braces may be measured and marked from: (A) upper edge; (B) lower edge; or (C) center line.

from the top edge of the brace; in B, from the lower edge of the brace; and in C from a line drawn down the center of the brace. Method C is generally considered to be the best way to fit a brace.

To mark a brace this way, use the square to find the center of the board. Since most boards are of uneven width, place the heel of the square on one edge and any even inch mark (example: 10-inch mark) on the other edge (Fig. 15). Then place a dot at the center (5-inch mark). Repeat this procedure at another location and then connect the dots and you have a line down the center of the board.

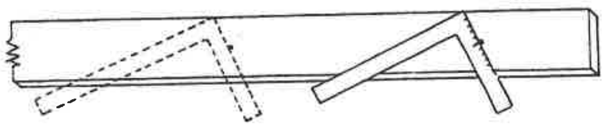


Fig. 15. Mark dots in the center of the board by placing the square as shown. Connect the dots to mark the center line of the board.

Mark the length of the brace first on the piece from which it is to be made. Mark this length (3'2") either on the top edge, bottom edge, or center line, as the case may be. Then mark the angles by using two numbers on the square that are in the same proportion as the length of rise and run of the braces. This may be done as follows. On the 12ths scale, find the number of inches and 12ths represented by the rise and run in feet and inches, or 2 7/12" on the blade and 1 10/12" on the tongue. These figures are so close to the corner of the square that it is more convenient to multiply each by some common number such as 2, 4 or 6 in order to get them large enough to handle. If we multiply each by 6, we have 15 6/12" and 11", or 15 1/2" and 11". Place these numbers on the marking edge as in Fig. 16 and mark the vertical lines along the blade and horizontal lines along the tongue.

In laying out a brace using a center line, it is necessary to mark both a horizontal and vertical cut at each end. Unless the brace is to be cut from a long piece of lumber, it is necessary to rotate the square as shown in Fig. 17. This is an important fact to remember. You can rotate a square and still mark horizontal lines along the tongue and vertical lines along the blade, so long as you do not turn the square over.

Laying out a brace for a door, as shown in Fig. 18 presents a special problem but one that can easily be accomplished with the framing square. Measure the rise and run and the diagonal distance AC. Lay out a line equal in length to AC on the board running from one side to the other as in Fig. 19. Place the square on this line using 10" and 12" numbers that are in proportion to the rise and run measurements, and mark the angle cuts on the brace.

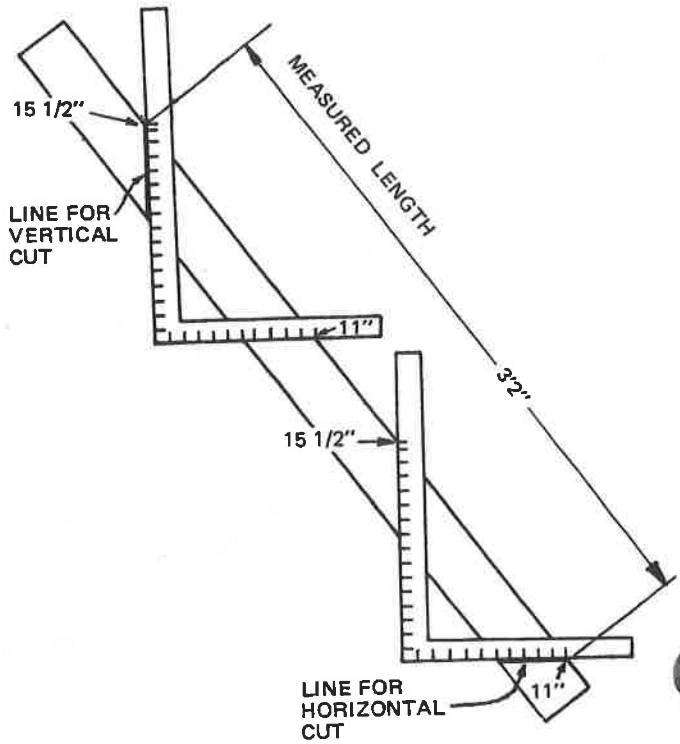


Fig. 16. Measure and mark the length of the brace. Then apply the square, using two numbers in proportion to the rise and run of the brace.

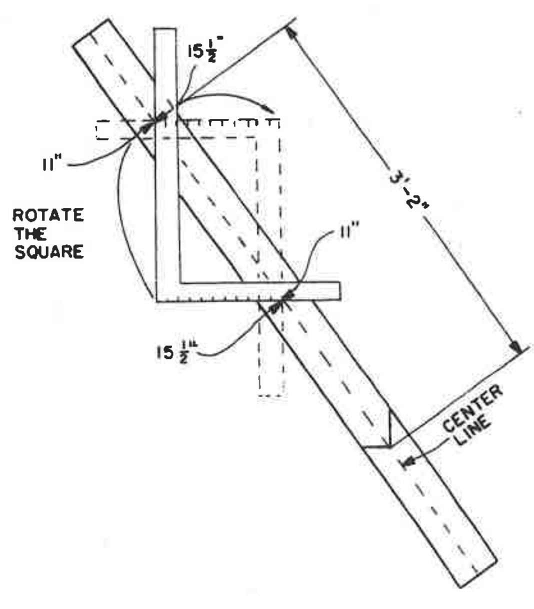


Fig. 17. If a brace is marked from the center line, mark the length, apply the square and rotate it to mark both a horizontal and vertical line at each end.

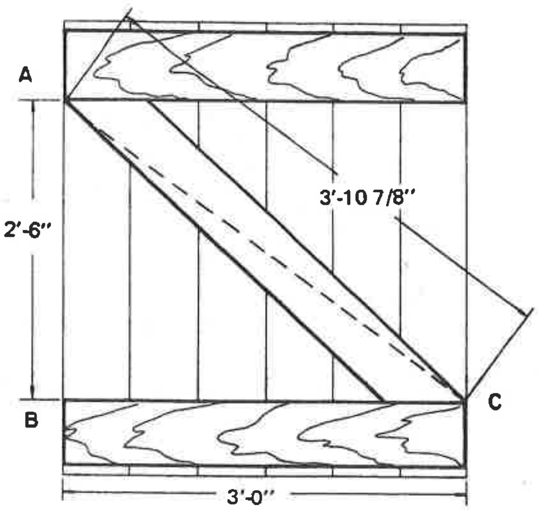


Fig. 18. To lay out a door brace, it is necessary to measure lines AB, BC, and AC.

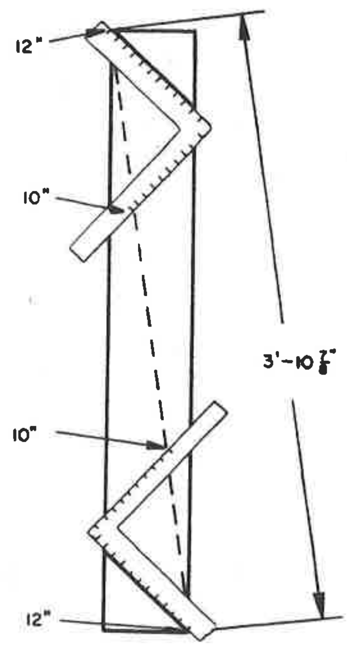


Fig. 19. Mark diagonal line across the board for the brace equal in length to line AC. Using proportional numbers on the square, lay out angle cuts from this diagonal line.

4. LAYING OUT STAIRS

Although there are many ways to build stairways, only one method is discussed here to illustrate the principles involved. A staircase has a total rise and run, since it travels both horizontally and vertically, but it is also divided into a series of steps, each of which has a rise and run. The width of each tread is its run and the height of each riser makes up the rise of each step.

Determining the width of treads and height of risers

The "magic number" in stair building is 17. This is because the width of the tread and the height of the riser should add together to form 17 inches, or approximately this amount. (Some stair builders try to stay between 16½ and 17½ inches.) Any great departure from 10-inch treads and 7-inch risers is uncomfortable for the average person and may even be dangerous.

In laying out a stairway, the total rise is usually a fixed figure and it is important to divide this distance into a number of steps of equal rise. The procedure usually followed is first to determine total rise in inches and divide this distance by 7 in order to determine how many steps there should be. This answer is determined only to the closest whole number. Then divide the total rise by this number and work it out to the closest 1/16 of an inch.

Example: Total rise is 54 inches.
$\frac{54}{7}$ = 7 5/7 or 8 (probable number of steps).
$\frac{54''}{8}$ = 6 6/8, or 6 3/4" (height of each riser)
Width of tread should be 17" - 6 3/4" = 10 1/4"
(Can vary from 9 3/4" to 10 3/4")

Laying out the horses

The side members which support the treads are called "horses". There is usually one less tread than the number of risers as figured above. It may be desirable to draw a sketch and number the risers in order to avoid making an error in laying out the stair horses. Such a sketch is shown in Fig. 20.

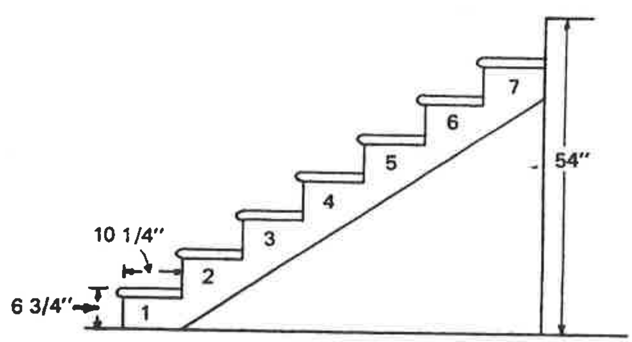


Fig. 20. After calculating the number of steps and the height of each riser, draw a sketch and number the risers.

Place the square along the 2"x10" with the amount of rise on the tongue and the width of tread on the blade of the square. It is more convenient to use clips or a wooden fence to avoid the necessity of reading the square each time it is applied (Fig. 21).

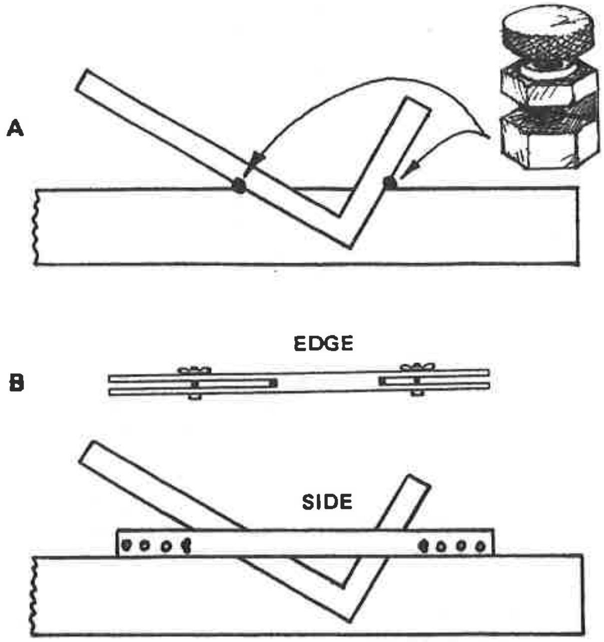


Fig. 21. Metal clips called angle or stair gauges are shown (A). Wooden fence (B) can be used as shown here to lay out a series of similar angles as on stair horses.

The metal clips are available from a large retail and mail order store and they are called angle or stair gauges, Dunlap No. 9-3956. They can be made from 5/8" length of 5/8" hexagonal brass stock, slotted 3/16" to receive the square and drilled and tapped for a 1/4" cap screw.

The fence may be made of oak 1/4"x1 1/2"x 24" slotted with a 9" saw kerf on both ends with holes for 1/4"x1" capscrews with wing nuts.

Detailed instructions for making these items are included at the end of this unit.

Mark lines as shown in Fig. 22 where the pieces are to be cut out of the horses. Finally, make a correction at the lower end to shorten the first riser by an amount equal to the thickness of the tread. This amount is usually 1 1/2" or 1 1/16" depending upon whether nominal 2" or 1 1/4" lumber is used. The one correction at the lower end takes care of the top step also as it lowers the entire horse by one tread thickness.

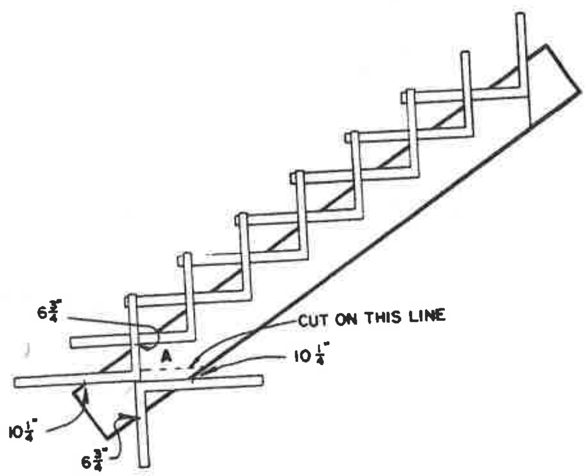


Fig. 22. Lay out the stair horses with the square, making correction at A for the thickness of the stair treads.

5. LAYING OUT RAFTERS

There are several types of roofs commonly used in farm construction (Fig. 23). Of these, the shed roof, gable roof, and hip roof are the most common types.

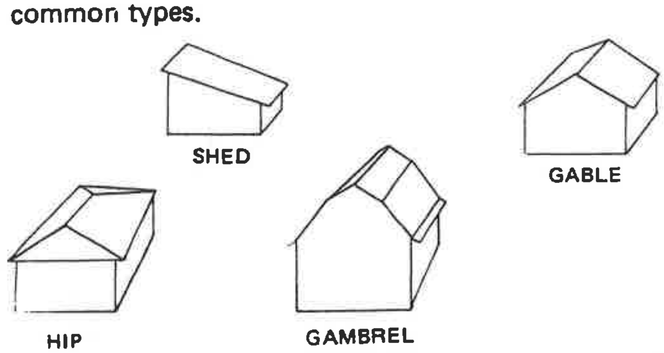


Fig. 23. Common roof types include shed, gable, hip, and gambrel.

Roof slope or pitch may be expressed in two ways. In former years, it was common to define pitch as $\frac{rise}{span}$ and to express it as a fraction, as 1/4 pitch, 1/3 pitch, or 1/2 pitch. Modern plans usually show roof slope in inches of rise per foot of run. The small triangle in Fig. 24 means that the rafters rise 6 inches for each foot of run. This is sometimes expressed as 6/12 slope but should not be confused with 6/12 or 1/2 pitch. A 6/12 slope is actually 1/4 pitch by the old standard.

Carpenters continue to use pencils to mark lumber because ink from ball-point pens is hard to erase and tends to bleed through paint. In the work that follows the first mark is not the final mark for cutting. Develop the habit of using a well-sharpened

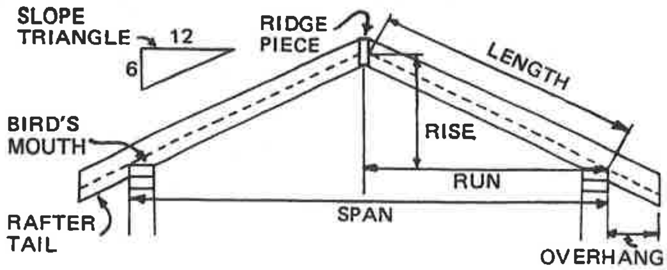


Fig. 24. Standard terms are applied to gable roof buildings and rafters.

pencil to mark lumber. The width of a pencil mark is not important in framing cuts but in finish work a fine pencil line or a knife mark may be necessary to get a precise fit.

Laying out a shed-roof rafter

A shed-roof rafter rests on two fixed points, the rear plate and the front plate (Fig. 25). Since these two points are fixed, the shed-roof rafter is laid out in a manner much like that used for a brace. Measure the total rise and run of the rafter. The rise is the difference in height of the rear and front plates. Note that the run is measured horizontally from the rear edge of the rear plate to the rear edge of the front plate. Thus, although the roof slopes in one direction only, the span and run of the rafters are not the same quantities.

If the rafter is to be notched where it rests on the two plates, draw a marking line on the rafter. This can be done by drawing along the blade of the square which is held even with the top side of the rafter, if it is a 2"x4". Place the square along the bottom side of the rafter if it is a 2"x6" or wider member.

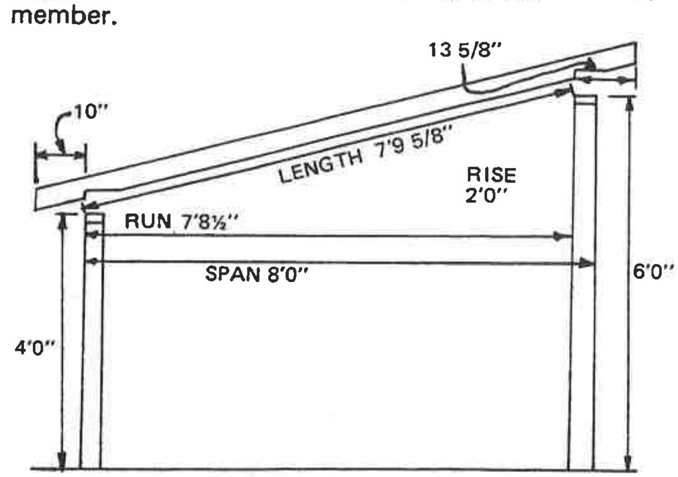


Fig. 25. The rise, run, and length for a shed-roof rafter are determined by direct measurement.

Select two numbers that are in the same proportion to each other as the rise and run of the rafter. If you use the two edges of the square that are marked off in 12ths of an inch, you can use a scale of 1" = 1' very conveniently. By this scale, each inch mark is equal to one foot and each 1/12 inch represents 1 inch. For the building shown in Fig. 25 select 2" on the tongue of the square and 7-$\frac{8\frac{1}{2}}{12}$ on the blade. The $\frac{1}{12}$ is estimated. If you triple each of these figures as shown in Fig. 26, they become 6" and 23 $\frac{1\frac{1}{2}}{12}$"+, and are easier to handle.

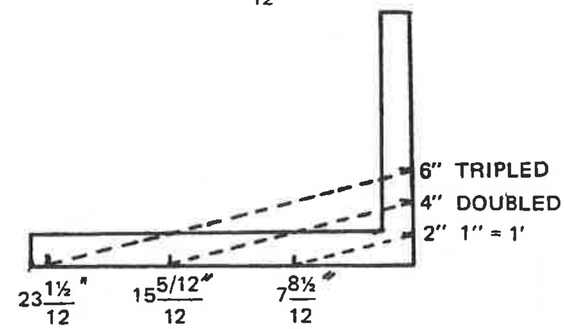


Fig. 26. Select two numbers on the square that are in proportion to the rise and run of the building. Doubling or tripling both numbers may make them easier to apply.

Use the numbers 6" and 23 1/12"+ to lay out the bird's mouth and rear overhang as shown in Fig. 27. Measure the distance from the rear corner of the lower plate to the rear corner of the upper plate with a steel tape. This distance (7'9 5/8") is the length of the rafter from one bird's mouth to the other. Mark this distance on the marking line at the upper end of the rafter and lay out the upper bird's mouth and front overhang (Fig. 28). This method of laying out a shed-roof rafter for a small building is easy and quite accurate.

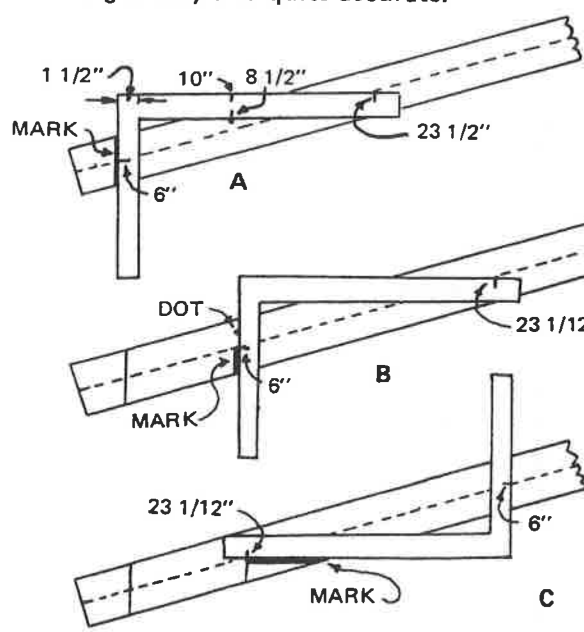
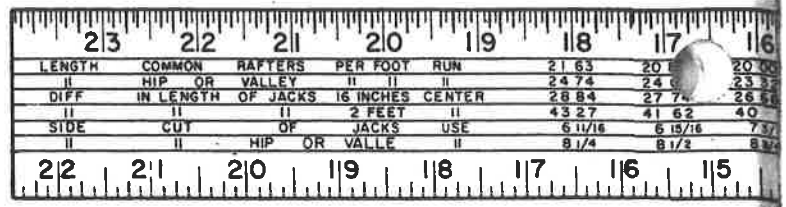
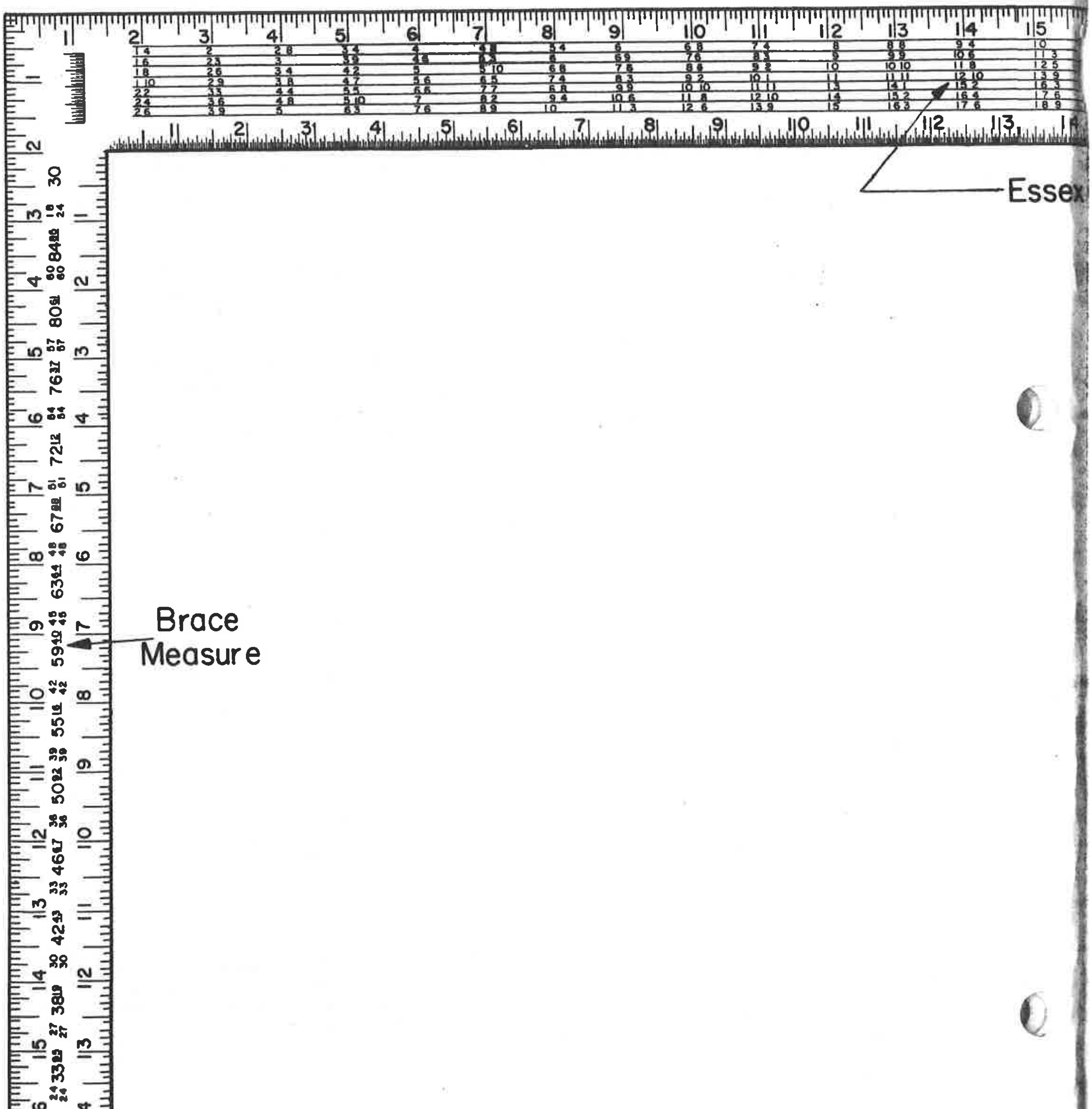
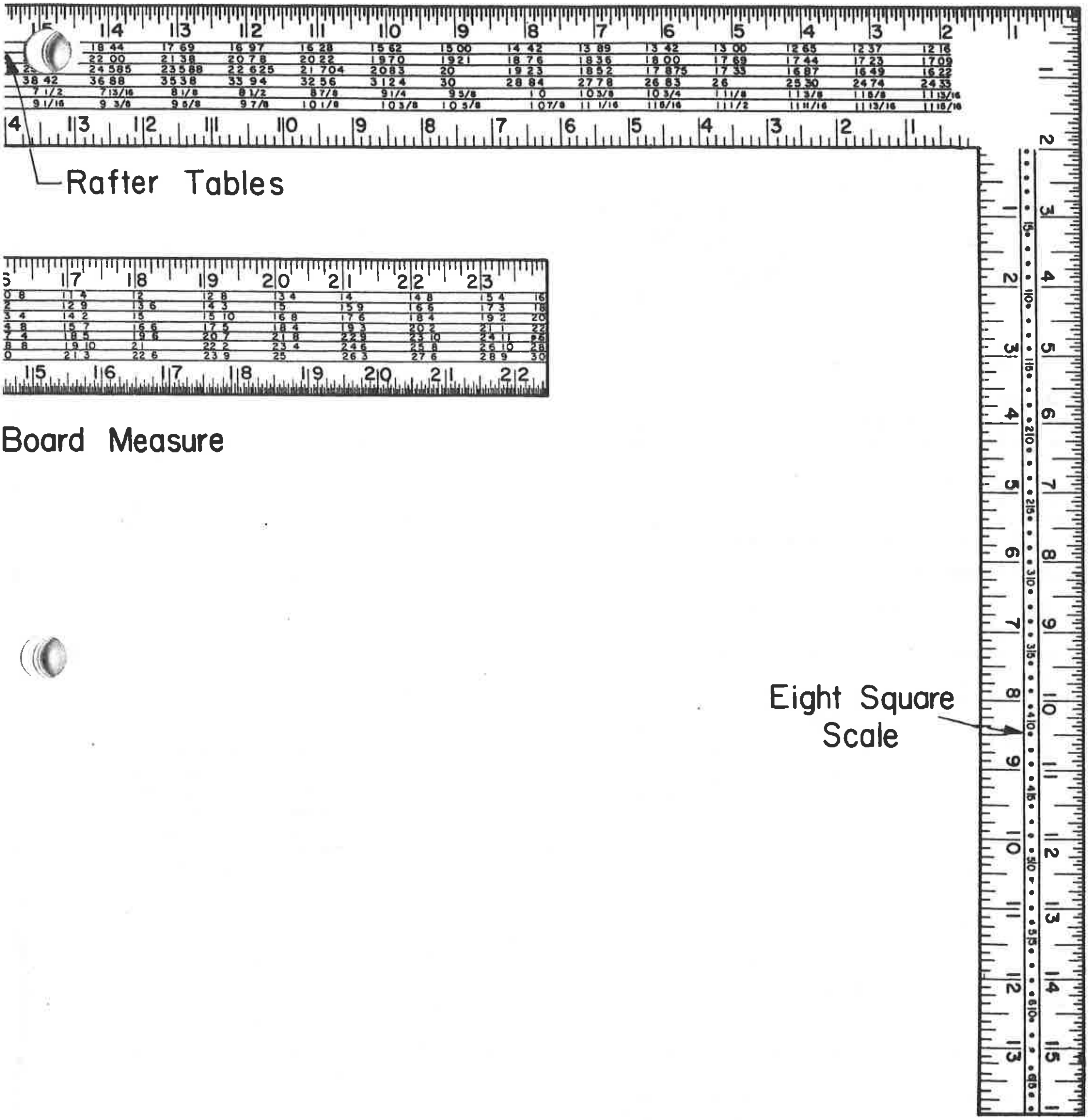


Fig. 27. Lay out the lower end of the shed-roof rafter in these steps: (A) Place the square so that 6" and 23 1/12" are on the marking line. Also place a dot opposite 8½" on the inside of the blade. This with the 1½" width of the tongue measures the 10" overhang. (B) Slide the square up the rafter and mark the plumb line for the bird's mouth even with the dot. (C) Rotate the square and draw the level line for the bird's mouth.


LENGTH COMMON RAFTERS PER FOOT RUN
HIP OR VALLEY
DIFF IN LENGTH OF JACKS 16 INCHES CENTER
2 FEET
SIDE CUT OF JACKS USE
HIP OR VALLE


Essex
Brace Measure


Rafter Tables
Board Measure
Eight Square Scale

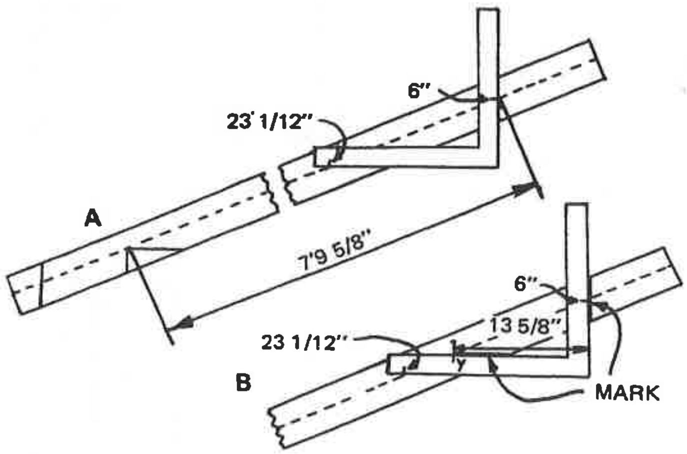


Fig. 28. Lay out the upper end of the shed-roof rafter as follows:
(A) Measure up the marking line from the corner of the lower bird's mouth and mark the length of the rafter. Mark the plumb line for the upper bird's mouth to intersect the marking line at this point.
(B) Measure the front overhang (13 5/8") along the square in a horizontal direction and mark the plumb cut at the upper end of the rafter. Also mark the level line for the bird's mouth at Y while the square is in this position.

Laying out a gable-roof rafter

Since gable rafters meet in midair, the height of the plate is the only fixed point and it is not necessary to determine the total rise. The only information needed is the total run and the slope, or inches of rise per foot of run. Total run is determined by measuring the span from plate to plate (Fig. 29) and dividing by two. Rate of rise is obtained from the slope triangle. In this case the total run is 11 feet and the slope is 6 inches of rise per foot of run.

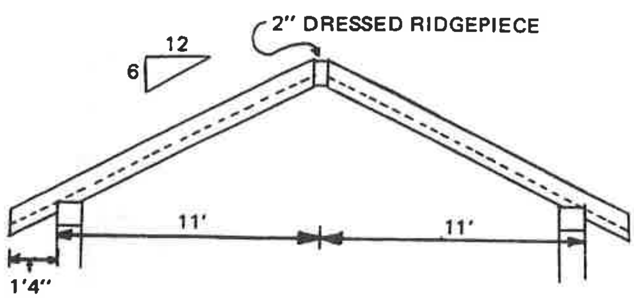


Fig. 29. Total run of a rafter for this building is $\frac{22'}{2}$ or 11'.

Put a marking line parallel to the edge of the rafter and 2" down from the top edge. Using 12" on the blade and the number of inches rise per foot of run (6" in this case) on the tongue, lay out the lower end of the rafter first (Fig. 30). Mark the lower plumb cut first and then measure with the square in position the desired amount of overhang as a horizontal distance and locate the corner of the bird's mouth on the marking line. Mark out the bird's mouth with a horizontal line where the rafter is to rest on top of the plate and a vertical line where it is to contact the edge of the plate.

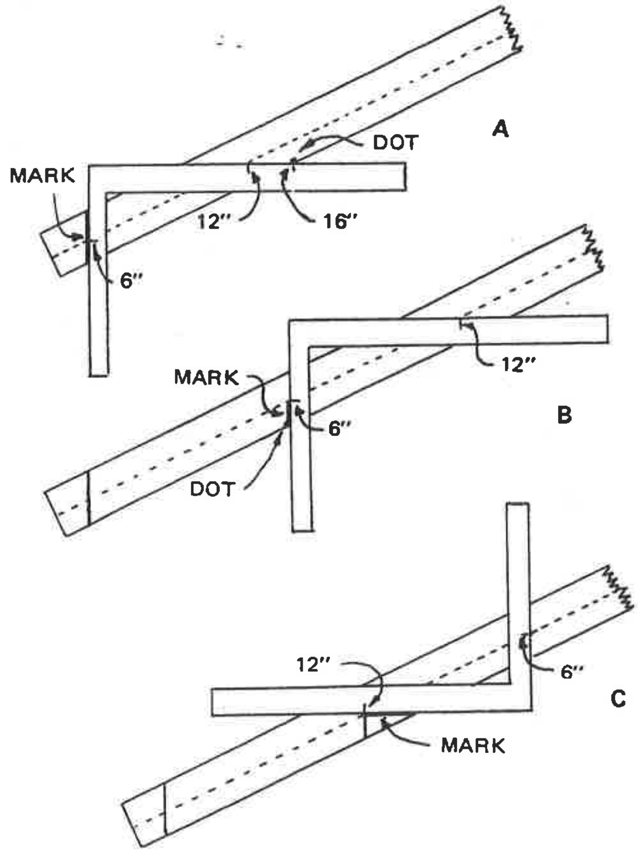


Fig. 30. Lay out lower end of gable rafter as follows:
(A) Place the square so that 6" and 12" are on the marking line. Mark lower plumb cut and place a dot opposite 16" on the blade of the square to indicate length of overhang.
(B) Slide the square up the rafter and mark the plumb line for the bird's mouth even with the dot.
(C) Rotate the square and mark the level line for the bird's mouth.

Calculate the length of the rafter as follows: Find the rafter table on the square and under the 6" mark, since the slope is 6" rise per foot of run, find the figure opposite "Length of Common Rafters per Foot of Run." This figure is 13.42, which means that for each foot of run, the rafter is 13.42" long. Calculate the length for the number of feet of run as follows:

Calculation: 13.42" x 11 = 147.62 inches
$\frac{147.62''}{12}$ = 12' 3.62" or
12' 3 5/8" (.625 = 5/8")

Measure out 12' 3 5/8" with a steel tape from the corner of the bird's mouth to a point on the marking line near where the upper plumb cut is to be made. Place the square with the numbers 6 and 12 on the marking line, with the number 12 even with the length mark (Fig. 31). Then measure back along the square a distance equal to half the thickness of the ridge piece. This is 3/4" for a standard-dressed 2" ridge piece, or 3/8"+ for a 1" ridge piece. Draw the line for the plumb cut through this corrected length mark and the rafter is ready to cut. If no ridge piece is used, the upper plumb cut is made to intersect the marking line at the full measured length.

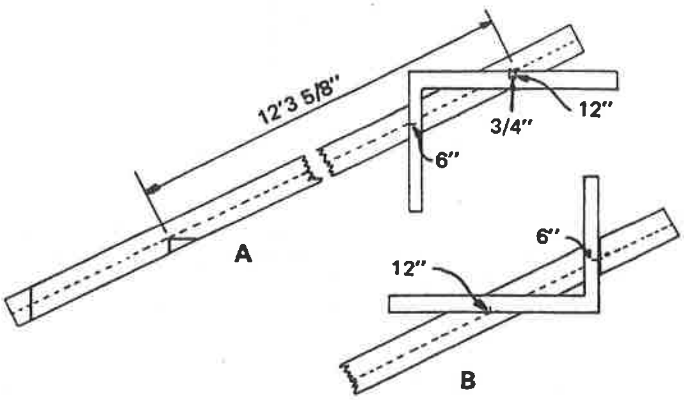


Fig. 31. Lay out upper end of gable rafter as follows:
(A) Measure the calculated length (12' 3 5/8") along the marking line from the corner of the lower bird's mouth and make a dot. Place the square with 6" and 12" on the marking line and with the 12" mark even with the dot. Measure back along the blade of the square a distance of 3/4" and make a second dot.
(B) Rotate the square and draw a plumb line through the second dot.

Laying out a hip rafter

In building a hip roof, it is customary to place the first pair of common rafters at a distance from the corner of the building equal to half the span of the building. In Fig. 32, this distance is 12 feet. A common rafter, B, is also placed in the center of the end of the building. The hip rafter, C, has the same total rise as the common rafters but its run is equal to the diagonal of a 12 foot square. The hip rafter is thus longer than the common rafters and its rise per foot of run is less than that of the common rafters. It is customary to make the hip rafters from heavier members than the common rafters. For buildings with 2"x4" common rafters, the hip rafters are usually 2"x6" or sometimes 2"x8". The marking line must be placed the same distance from the top of the hip rafter as it was from the top of the common rafters.

In order to mark horizontal and plumb cuts on the hip rafter, the two numbers used on the square are: (1) the number representing the inches of rise per foot of run of the **common rafter**, and (2) 17. For the building illustrated in Fig. 32, the numbers are 6" and 17". The number 17 is used because the diagonal of a 12" square is 16.97", or 17". Since the common rafters for the example building rise 6" per foot of run, the hip rafters rise 6" per 17" of run.

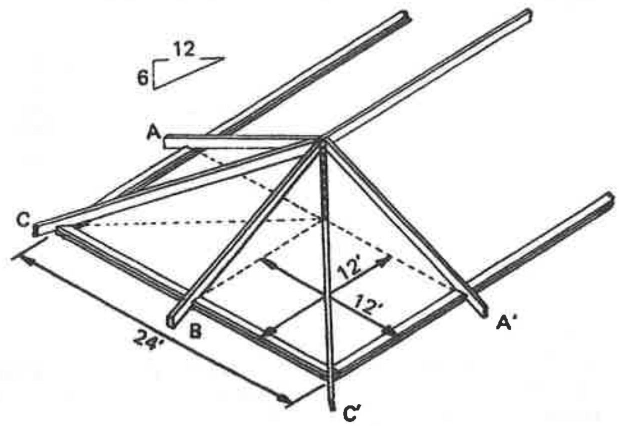


Fig. 32. On a hip roof the first pair of common rafters, A and A', are located at a distance from the corners equal to half the roof span. Common rafter B is located in the center of the end. Hip rafters C and C' run diagonally from the corners to the ridge.

Lay out a temporary bird's mouth. Use the numbers 6 and 17 on the marking line and mark out the bird's mouth, leaving plenty of length for the overhang (Fig. 33). This bird's mouth is temporary because at least one and perhaps two corrections will be made before the rafter is cut.

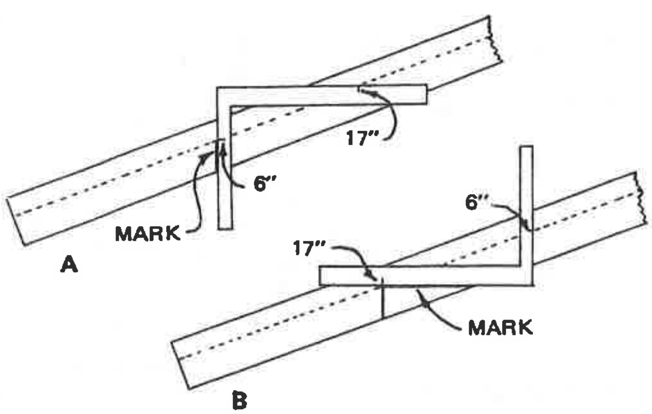


Fig. 33. To lay out the bird's mouth for a hip rafter, use the numbers 6" and 17" on the marking line. Mark the plumb line as in A; rotate the square and mark the level line as in B.

Calculate the length of the hip rafter. Use the second line of the rafter table on the square—"Length of Hip or Valley Rafters Per Foot of Run". On this line under the number 6 (6" rise per foot of run for the common rafters), the figure 18.00 is given. This means that for every foot of run of the common rafter, the hip rafter is 18" long.

Calculation: 12 x 18" = 216"

$\frac{216}{12}$ = 18 feet

Lay out the upper end of the hip rafter. Measure with a steel tape from the corner of the bird's mouth along the marking line and make a mark at 18 feet. Draw a temporary plumb line (with 6" and 17") through this mark (Fig. 34).

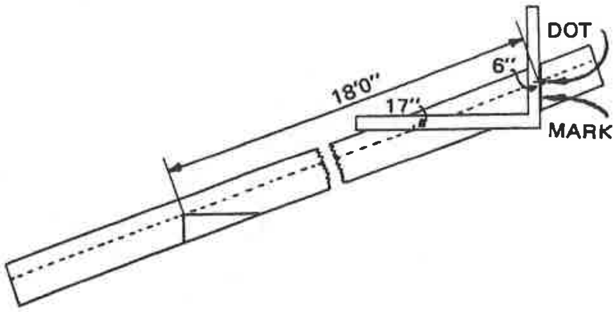


Fig. 34. Measure the calculated length along the marking line and place a dot at 18'. Using 6" and 17", draw a temporary plumb line through the dot.

This mark is temporary because corrections must usually be made, as follows:

1. Correct for the thickness of the ridge piece and common rafters. All figures on the rafter tables are used as though the members had no thickness. The calculated length of the hip rafter is to a line which intersects with point A, Fig. 35.

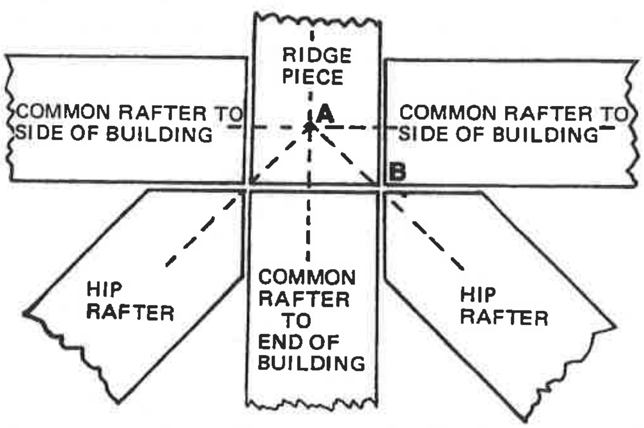


Fig. 35. The hip rafter must be shortened an amount AB equal to half the diagonal of a 1 1/2" square, or about 1 1/16".

For 2" rafters, a standard correction can be made regardless of the thickness of the ridge piece. It is one-half the diagonal of a square which is 1 1/2" on a side. This amount is approximately 1 1/16". Shorten the hip rafter by 1 1/16" measured horizontally as shown in Fig. 36.

2. Correct for the side cuts on the upper end of the hip rafter. Since the upper end of the hip rafter is usually cut to fit into the intersection of common rafters and the ridge piece, the length must be transferred from the side of the rafter to a corresponding spot on the point of the rafter. To do this, square

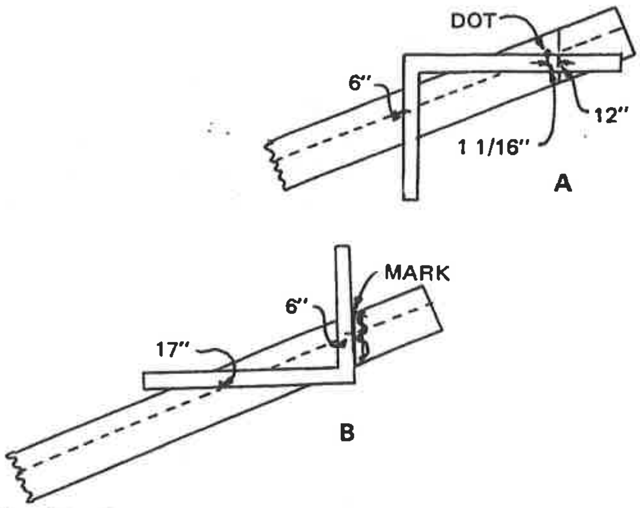


Fig. 36. To shorten the hip rafter, measure along the blade of the square a horizontal distance equal to 1 1/16" and place a dot as in A. Rotate the square and draw a plumb line through this dot. Cross out the original plumb line to avoid error later.

across the top edge of the rafter even with the last correction line and place a dot on this line in the center of the rafter (Fig. 37). The side-cut lines must intersect at this point. For the side-cut angle, consult the rafter table of the square on the line marked "Side Cut of Hip or Valley Rafters." In the column under 6", the figure is 11 5/16". Whatever number appears here in the rafter table is used on one leg of the square and 12" is used on the other. The 12" mark is always placed toward the top end of the rafter. Draw the side-cut angles across the top edge of the rafter, using 12" and 11 5/16" as shown in Fig. 38. Then with 6" and 17" again, draw the final lines on both sides of the rafter. Mark out all other lines and the upper end is ready to cut.

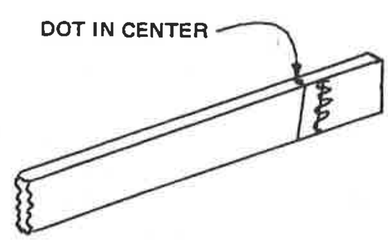


Fig. 37. To transfer the length mark to the center of the hip rafter, square across the top edge and place a dot in the center on this line.

Lay out the lower end of the hip rafter for the overhang. Determine the length of the overhanging part of the hip rafter by the same method used to find its upper length. Use the figure on the square, "Length of Hip or Valley Rafters per Foot of Run", in the column under the number of inches rise per foot of run. In this example, its length will be 18" for each foot of overhang for the common rafters, measured in a horizontal direction. Since

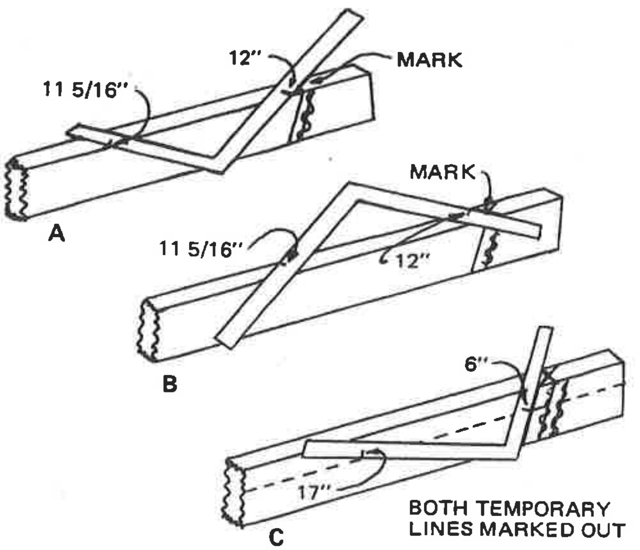


Fig. 38. Draw the side cut angles to intersect the dot, using 12" and 11 5/16" on the square as in A and B. Redraw the plumb line to intersect with the side cut mark as in C. Cross out all temporary marks and repeat on the other side of the rafter.

the overhang for the common rafters is 16", or 1 1/3', the length of overhang measured parallel to the hip rafter is 1 1/3x18" or 24".

Measure down the marking line 24" from the corner of the bird's mouth and draw a temporary plumb line using 6" and 17" on the square (Fig. 39). Square this line across the top edge of the rafter, mark the center, and mark side cuts using 12" and 11 5/16" as you did at the top of the rafter (Fig. 40). The leg of the square on which you are using the 12" mark goes toward the lower end of the rafter this time. Where the crossed side-cut lines intersect the edges of the rafter, redraw the final plumb lines (Fig. 41) and the rafter tail is ready to cut.

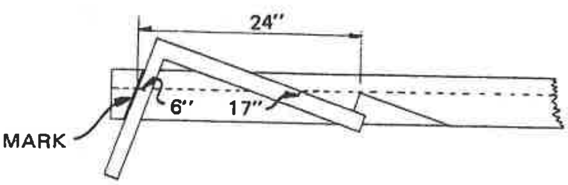


Fig. 39. To lay out the hip rafter tail, measure 24" down the marking line from the corner of the bird's mouth and draw a temporary plumb line through this point, using 6" and 17" on the square.

Make final corrections at the bird's mouth. If the hip rafter were cut as now marked and fitted in place, the corners of the top edge of the rafter would stick up higher than the other rafters. Its height is correct in the center so the difficulty could be remedied by planing the corners down. It is easier, however, and entirely satisfactory to drop

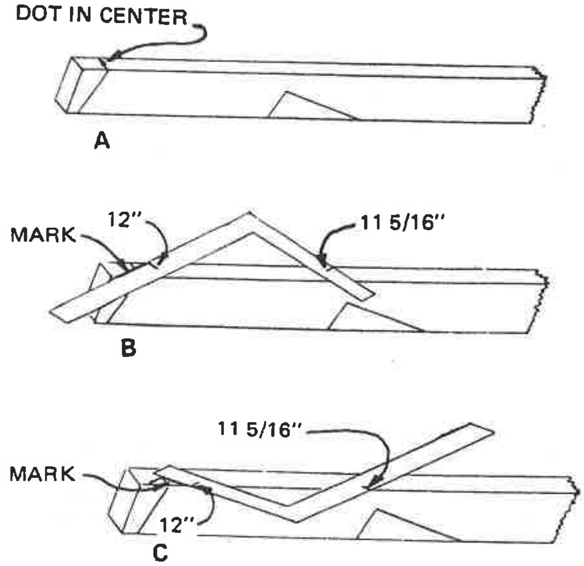


Fig. 40. Lay out the bevel cuts as follows:
(A) Square across the top of the rafter even with the temporary plumb line and locate a dot in the center.
(B) Draw a diagonal through this dot, using 12" and 11 5/16" on the square.
(C) Draw the opposite diagonal through the dot in like manner.

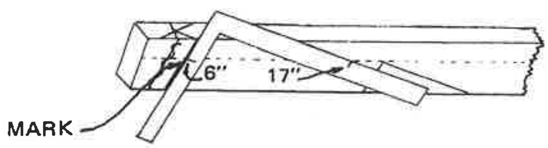


Fig. 41. Redraw the final plumb lines on each side of the rafter tail to line with the diagonal marks. Mark out temporary plumb lines to avoid making errors in cutting.

the hip rafter down so that the corners are at the proper height even though the center of the rafter is slightly low. The sheathing boards rest on the corners of the rafter and can be firmly nailed in place. Figuring the amount to drop the hip rafter is complicated. A rule-of-thumb amount is 1/8" for each 3" of rise per foot of run for the common rafters. Since our problem building has a 6" rise, the hip rafter should be dropped 2 x 1/8" or 1/4". Do this by raising the horizontal line of the bird's mouth by 1/4" (Fig. 42).

Some builders prefer to cut off the corner of the plate at a 45° angle to secure a better fit of the hip rafter. To mark the plate, place the square along one side with two equal numbers such as 12" and 12" in line with the edge (Fig. 43). Move the square along until the diagonal line is 1 1/2" long. Mark this line and saw the corner off the plate. To make the final correction on the hip rafter, move the plumb line of the bird's mouth half of this 1 1/2" diagonal distance, or 3/4" in a horizontal direction as shown in Fig. 44. The hip rafter is finally ready to cut.

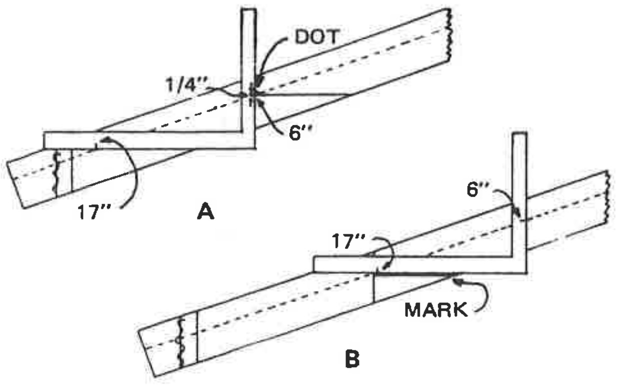


Fig. 42. Lower the hip rafter 1/8" for each 3" rise per foot of run of the common rafter.
(A) Place the square with 6" and 17" on the marking line. Measure up 1/4" from the original level line of the bird's mouth and place a dot.
(B) Move the square up the rafter and draw a new level line through the dot.

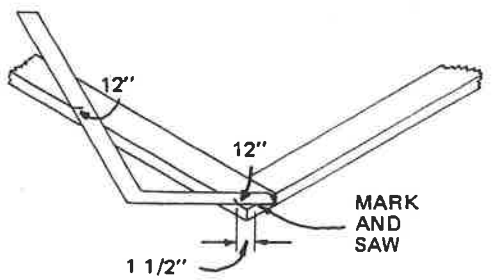


Fig. 43. To mark the corner of the plate, place the square on one plate using 12" and 12". Mark a diagonal line at the point where it is 1 1/2" long.

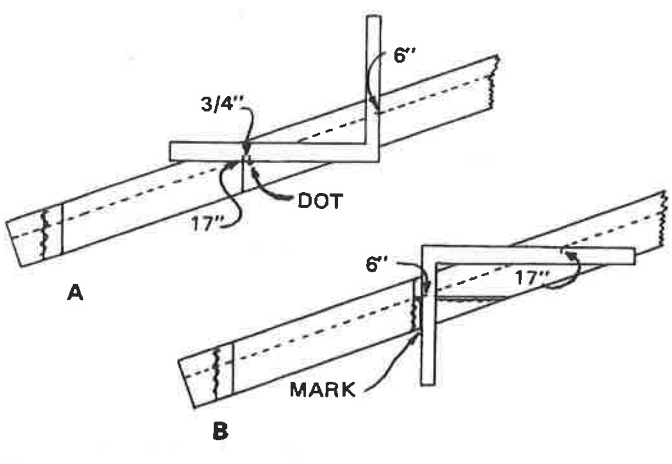


Fig. 44. Shorten the bird's mouth by 13/16".
(A) Place the square on the marking line, measure 3/4" in a horizontal direction, and draw a dot.
(B) Rotate the square and draw a new plumb line through this dot. Mark out all temporary lines.

Laying out a jack rafter

The jack rafters for a hip roof extend from the plate to the hip rafters. They are usually spaced, like common rafters, on 16" or 24" centers so that when you move away from the corner of the building, each succeeding jack rafter is substantially longer than the one before (Fig. 45). Jack rafters are placed in pairs and the cheek cuts where they fit against the hip rafter are necessarily opposite.

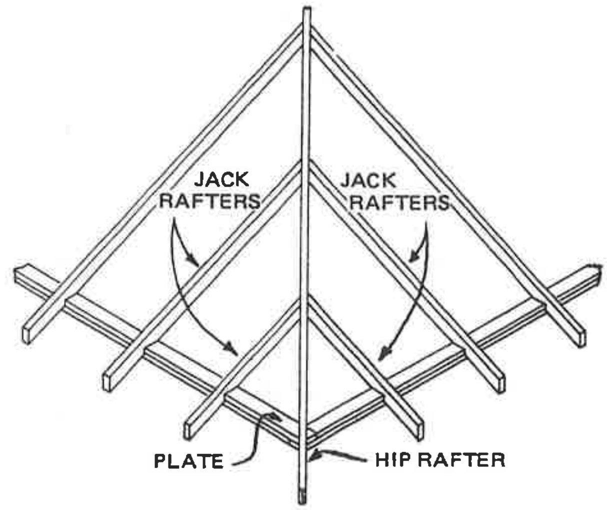


Fig. 45. Jack rafters extend from the plate to the hip rafter.

Lay out the bird's mouth and tail of the jack rafter. Since the jack rafters parallel the common rafters, they have the same rise per foot of run and the same overhang. Therefore the bird's mouth and the overhang is laid out in exactly the same manner as that described for the common rafters.

Determining the length of jack rafters. Consult the rafter table on the square and trace the line "Difference in Length of Jacks, 2 feet centers" over to the column under the number of inches rise per foot of run (6" in the example). The figure for the problem building is 26.83". This means two things: The length of the first jack rafter is 26.83", and each succeeding jack rafter is 26.83" longer than the previous one. To lay out the first jack rafter, measure 26.83" (26 13/16 + ") from the corner of the bird's mouth along the marking line. Draw a plumb line (using 6" and 12"), through the mark (Fig. 46).

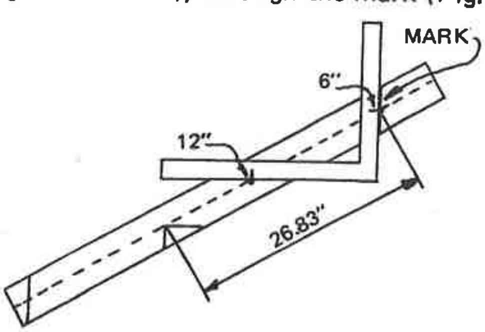


Fig. 46. Lay out the tail and bird's mouth of the first jack rafter like a common rafter. Then, measure up the marking line 26.83". Using 6" and 12" on the square, draw a plumb line through this point.

Since the figure on the square table is the length to the center of the hip rafter, the jack rafter should be shortened by an amount equal to half the thickness of the hip rafter, measured in a horizontal direction. This again is half the diagonal measurement of a 1 1/2" square, or about 1 1/16" (Fig. 47).

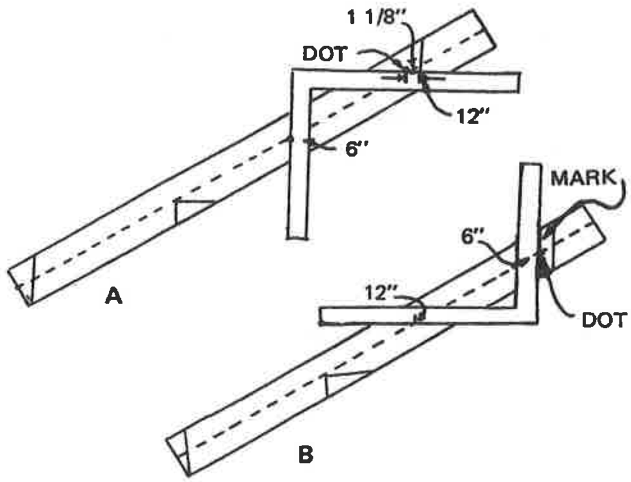


Fig. 47. To adjust for the thickness of the hip rafter, measure back horizontally 1 1/16" (A). Rotate the square and draw a revised plumb line through the dot (B).

Marking the side cut of the jack rafter. At the point where the plumb line intersects the top edge of the jack rafter, square across the top edge, mark the center of this line, and draw the line for the side cut through this mark (Fig. 48a). Consult the square table on the line "side cut of jacks" and follow over to the column under 6". The figure here is 10 3/4". Use this figure on one leg of the square and 12" on the other leg, with the 12" end toward the upper end of the jack rafter. Mark the side-cut angle (Fig. 48b). Then remark a plumb line on the side of the jack rafter so that it lines with the side-cut mark at the upper edge (Fig. 48c). This is the last correction and the rafter is ready to cut.

Marking other jack rafters. To avoid the necessity of making corrections on the other jack rafters, measure the length of the first one from the corner of the bird's mouth to the point on the side where the plumb line intersects the marking line. Then lay out the next jack rafter so that this dimension is 26.83" longer than the first one, and so on for each succeeding jack rafter. The finished building will require four jack rafters just alike and four of equal length but with the side cut angles made the opposite direction for each different length. In the problem building there will be 5 pairs of jack rafters for each hip.

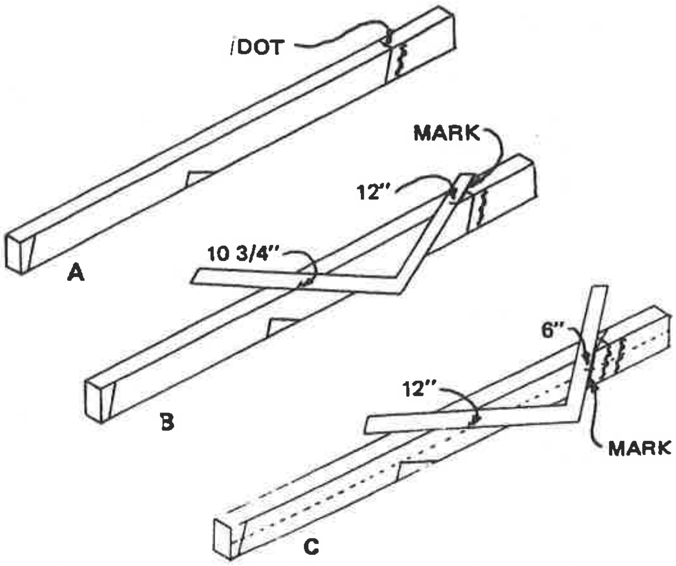


Fig. 48. Complete the upper end of the jack rafter as follows:
(A) Square across the top of the rafter even with the second plumb line and place a dot in the center.
(B) Draw a diagonal line through the dot using 12" and 10 3/4" on the square.
(C) Draw the final plumb line to intersect with the diagonal line and cross out both temporary lines.

Using the stepping-off method

Instead of determining the length of braces and rafters by measuring or calculating, some builders prefer to "step-off" the length. This method does not require the use or knowledge of square tables and may be simpler to understand. It must be used very carefully, however, to prevent errors which accumulate each time the square is moved and may build up to a serious amount.

If a brace or rafter has a rise of 16 inches or less, and a run of 24 inches or less, it can be marked off by applying the square once. Usually, however, the rise and run will be more than 16 and 24 inches, respectively. The square can then be applied more than once, or the total distance can be arrived at by stepping. Three general rules are followed in stepping off a brace or rafter. They are:

1. Use as many inches and 12ths on the tongue of the square as there are feet and inches in the total rise (Fig. 49).
2. Use as many inches and 12ths on the blade of the square as there are feet and inches in the total run (Fig. 50).
3. Apply the square 12 times (Fig. 51).

Note that this method uses a scale of one inch on the square to represent one foot. Obviously, it is then necessary to apply the square twelve times in order to step off the actual length. The outer edges of the tongue and blade on the back of the square are marked in 12ths for convenience in stepping. Errors often occur in the width of pencil marks. If each error is only 1/32", by the time the square has been applied 12 times the total is 3/8" which is a sizeable amount. Part of this error can be avoided by multiplying the figures on the square by 2, 3, 4, or more, as long as the figures do not exceed 16 and 24, respectively. If the figures can be multiplied by 2, the square is applied only 6 times; if multiplied by 3, only 4 times; if by 4, only 3 times, etc.

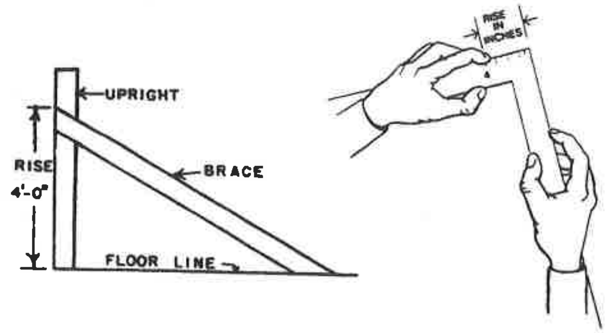


Fig. 49. To step off a brace with a rise of 4 feet, use 4" on the tongue of the square.

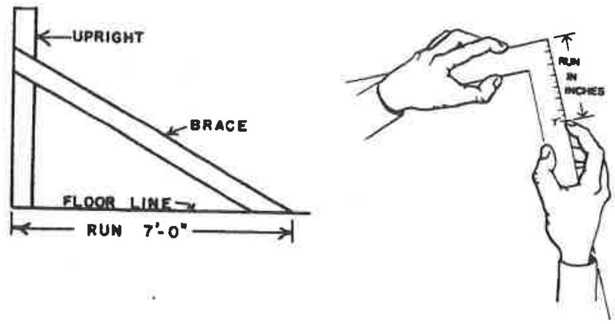


Fig. 50. To step off a brace with a run of 7 feet, use 7" on the blade of the square.

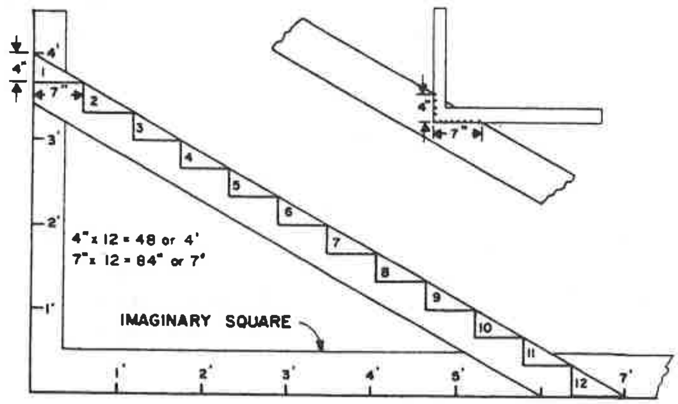


Fig. 51. Step off the brace by applying the square 12 times. The effect is the same as if you used a large square and applied it only once.

6. STUDENT SHOP PROJECTS

1. Construct a wooden fence for use with carpenter's square.

   Materials needed: Hardwood 3/8" x 1 1/2" x 24"
   2 capscrews 1/4" x 3/4"
   2 wingnuts for capscrews

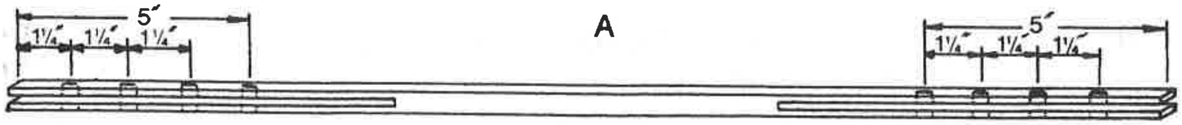
   Select a piece of oak or other straight grained hardwood and saw a narrow piece 3/8" x 1 1/2" x 24".

   Rip the piece from each end leaving an 8-inch section in the center. Due to the saw cut it will not be a full 8" on both sides (illustration B).

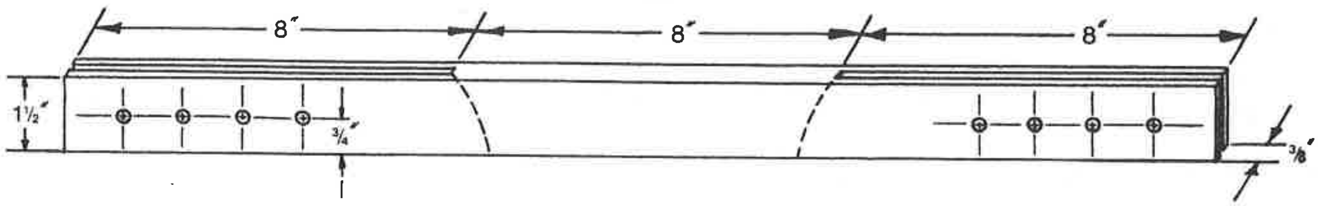
   Drill four holes in each end with 1/4" bit.

   Insert a 1/4" x 3/4" capscrew with wingnut in one hole in each end and the wooden fence is complete and ready to use.

A



B



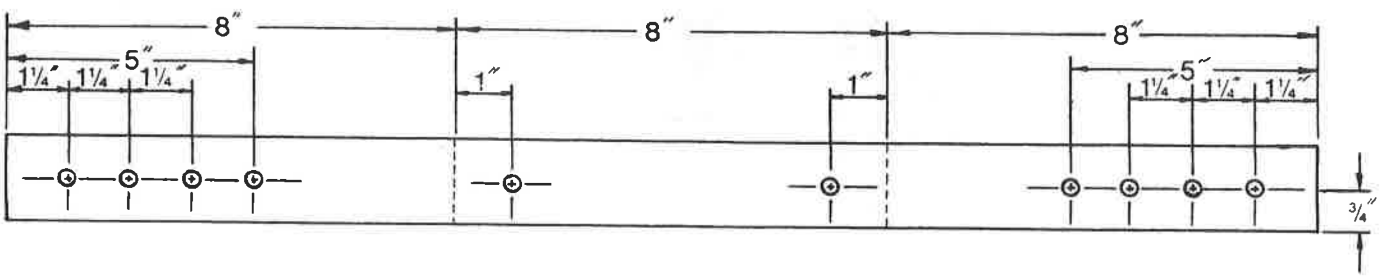
2. Construct a <u>metal fence</u> for use with a carpenter's square.

   This fence may be constructed of brass, aluminum, or steel.

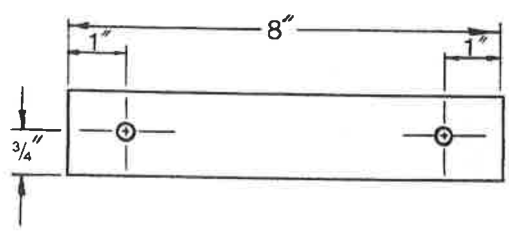
   Materials needed: 2 pieces 3/16" x 1 1/2" x 24"
   1 piece 3/16" x 1 1/2" x 8"
   4 capscrews 1/4" x 3/4"
   2 wingnuts for capscrews
   2 nuts for 1/4" capscrews

Mark the 24" pieces of metal into three sections 8" long.

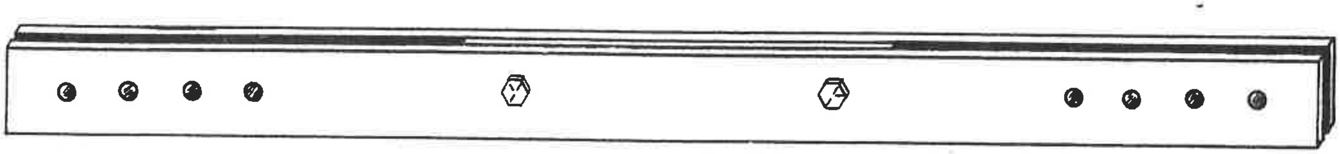
Mark and drill 1/4" holes in the 24" pieces as shown below.



Mark and drill 1/4" holes in the 8" piece as shown.



Assemble the fence with the short piece in the center using two capscrews and the nuts.



Insert the 1/4" x 3/4" capscrews, one in each end of the fence and secure in place with the wingnuts and the metal fence is ready to use.

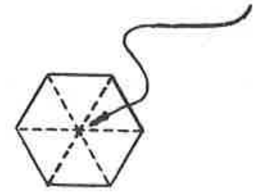
3. Construct metal clips to hold the square for marking angles.

   Materials needed: 1 1/2 inches of 5/8" hexagonal brass or steel stock
   2 capscrews 1/4" x 1/2"

   Cut the hexagonal stock in two pieces of equal length.

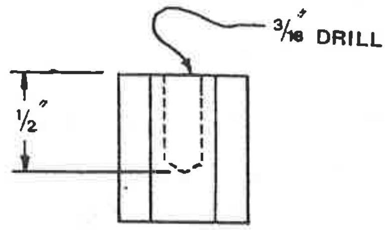
   Mark the ends with a scriber to locate the center.

   Center punch the stock for drilling.



Place 3/16" bit in drill press. Place stock in drill press vise. Set stop on drill press so hole is drilled 1/2" into stock.

Select 1/4" tap and tap hole for 1/4" capscrew.

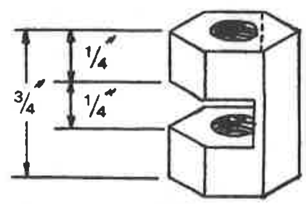


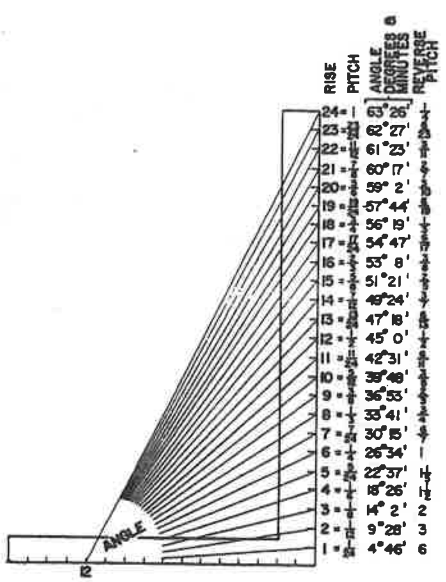
Mark stock on four sides to remove 1/8" from center by hacksawing, leaving 1/4" of metal above and below the saw cut.

Use file to remove metal between saw cuts until stock remains as shown by dotted line.

Smooth finished clips with emery cloth.

Insert capscrew and square clip is ready for use.





Use this table with the square to determine roof pitch and angles for seat cuts.

This subject matter unit was revised by R. F. Espenschied.