A PRACTICAL TREATISE

ON

THE STEEL SQUARE

AND

Its Application to Everyday Use

BEING AN EXHAUSTIVE COLLECTION OF STEEL SQUARE PROBLEMS AND SOLUTIONS, "OLD AND NEW," WITH MANY ORIGINAL AND USEFUL ADDITIONS, FORMING A COMPLETE ENCYCLOPEDIA OF STEEL SQUARE KNOWLEDGE, TOGETHER WITH A BRIEF HISTORY OF THE SQUARE, AND DESCRIPTION OF TABLES, KEYS AND OTHER AIDS AND ATTACHMENTS

IN TWO VOLUMES

BY

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VOLUME II

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PREFACE

In preparing this second volume of practical work for steel square users, it was imperative I should, in some measure, give examples and rules that were somewhat similar to a number that appeared in the first volume; though on close comparison it will be found that the similarity is apparent only, as different solutions of similar problems are rendered.

Perhaps it is unnecessary to mention this, as the expert workman will recognize the difference at once; but, in order to make explanation beforehand to the many thousands of readers, who, while not being experts now in the use of the square, intend to become so as quickly as possible, I thought it better to mention the matter in this preface.

The purchaser of this volume will find many things in it that are original, and many more that have been culled from the best work of experts and which have appeared in some one or other of the great number of trade journals that have been published in this country, in England and Australia, during the last twenty-five years. As before stated, there are a number of things original in the volume that have never before been published, some of my own and some that have been furnished by experts. I have made it my business to write to every person—at home and abroad—that I could hear of or read of, who had made a study of the steel square, asking for anything they might have that was new and useful on the subject, and telling them I was preparing a new and exhaustive work on "The Steel Square." While all did not respond, I may state that over 75 per cent of those written to did; and while the great majority had nothing to offer, a great many sent me "cuttings" from journals, on the subject, with diagrams and suggestions. Many, of course, of the problems sent me I could not make use of for obvious reasons, while several gentlemen sent me—for publication—a number of valuable problems and solutions which I have embodied in the work and all the writers, without exception, wished me "God speed" in the work I had undertaken.

It is now in order for me to publicly thank those who have so kindly aided me in getting together so much valuable material for the workman as will be found between the covers of these two volumes, and I am sure my readers feel as I do in the matter.

Among those who might be named as having aided me materially, I may mention Mr. Woods, Mr. Reissman, Mr. Stoddard, and Mr. Penrose of Trafford Park, England, and Mr. Joseph Wilcox of Sidney, Australia, to whom I tender special thanks.

In conclusion, I may add, it is the intention of the publishers, should any new thing arise in connection with the steel square and its applications, to have the same embodied in the present volumes, or issue a supplementary volume if necessary.

If by these volumes I have been instrumental in aiding and assisting the operative workman to earn a little more wages than formerly he received, or have helped him to better his condition in any way, it will be a gratification and pleasure to me, and will, in some measure, repay me for all the effort I have expended in bringing together the matter contained in them.

FRED T. HODGSON.

Collingwood, Ont., 1903.

ANOTHER STEEL SQUARE

Since I wrote up a description of the various squares in the first volume of this work, I have been favored by a correspondent with the following description of a square which is the invention of a man in Augusta, Maine. I have not seen the square, nor have I seen a good illustration of it, but my correspondent says of it, "It is an ingenious tool for framing and can be adjusted so that work may be rapidly and accurately laid out, and it is capable of adaptation to all classes of buildings where wooden frames are used. I have used one for a number of years, and find it quite handy for all kinds of work where timber is employed." The description sent is as follows: The body of the square has two tongues arranged upon it at right angles. Three bars are so secured to the tongues that by loosening set-screws at the ends they may be placed at any points desired, the bolts sliding in slots cut in the tongues. One of these bars has a slot cut in it the greater part of its length, on which two gauge blocks are secured by thumb-screws, and by which they may be slid back and forth and adjusted in any position desired. To the body of the tool, on one side, is secured a gauge, also capable of adjustment by means of screws. A bar, which is secured to one of the tongues and to the slotted cross-bar, is used in framing roof timbers and the like where diagonals are to be cut.

It will be impossible to explain all the ways in which the tool may be used. In laying out mortises and tenons on timber, the gauge on one side is placed so that the inner edge of the body of the square will come at the outer edge of the mortise and there secured. A bar is then adjusted so that the space between it and the body will be the width of the mortise. For single work this is all that is necessary for marking the sides of the mortises and tenons. For double work the second mortise is made by the adjustment of the other two bars, so that all change of the tool or liability to error is avoided. To mark the ends of mortises and tenons, the end gauge is adjusted at the right distance from the tongue lying parallel with it, the tool moved along on the inside of the gauge, and outside of the tongue the marking is complete. For framing roof timbers the bar for this purpose is adjusted at the desired angle, and by this the head and foot of rafters or braces can be marked, without changing the tool, the marks for the pitch of roof being put upon the slotted cross-bar and end tongue. The two small gauges are especially designed for use in cutting gains for shelving, and being adjusted at the proper places on the cross-piece and secured, proper measurement will be given.

As I stated before, I have not seen this square and am obliged to take the foregoing as being correct, but it seems to me that if the square is as useful as outlined it ought to be better known, but, having inquired at several large hardware houses regarding it, I find it entirely unknown among dealers. If any of my readers know anything of this square, as to its usefulness, price, where it may be obtained, and will advise the publishers of this work, I will see to it that mention of it is made at greater length in future editions.

COLOR OF SQUARES

It is only a few years ago since any changes were made on the surface of squares. An old square that has been in my possession for fifty years and upwards had originally a polished steel surface, but to-day it is oxidized and covered with a coating that protects it from rust and from the weather. This happens to all polished steel squares if kept from getting wet or soiled with moist fingers. This condition, however, tends to render the figures and markings less legible; indeed, in many cases the figures and lines become almost invisible, a very great objection, for I have known some very serious cases where the figures have been mistaken and timbers cut too long or too short in consequence of the mistake.

A polished square should never be rubbed with emery paper or other gritty substance. While such rubbing may make the sides of the square look bright and "tidy," it is sure to injure the square, efface some of the figures and markings, and leave the surface more susceptible to rust.

A little neat oil applied once in a while and rubbed with a soft rag is the best way to treat a polished square.

Since nickel-plating came in use, many squares are so treated, and this has many advantages, as under ordinary circumstances there will be no rusting and the square will always be bright and "tidy" looking. Under a bright sun it is often difficult to read the figures or find the lines required, and, if the tool is exposed to the sun's rays for a short time, it will become so hot as to preclude handling. A careful workman, however, will not allow his square—or any of his tools, for that matter—to be exposed to the sun for any length of time, as a two-foot blade often expands as much as one-eighth of an inch in length, when made hot—a condition the good workman cannot allow.

Squares electroplated with copper, in my opinion, are much better than either polished steel or nickel-plated ones. The copper color is not so severe on the eyes, and the shadows cast by the cuttings in the figures and markings bring up the figures almost in relief, so that they are readily seen. Age gives a copper-plated square a fine antique color which is restful to the eye and a protection to the square.

If the square is allowed to oxidize, and is then polished on the surface, we get a fine copper finish on the tool with dark oxidized figures and markings.

Best of all is the blued or what may be termed the "gun metal" square. These squares are oxidized or blued by some process unknown to me, and the figures and lines are filled in with some kind of white enamel, that brings them out in great shape. A very handsome blued and enameled crenelated square was sent me for examination by The Peck, Stow and Wilcox Company, of Southington, Conn., which lies before me as I write; and it seems to me that this method of bluing, and white-enameling the figures, is one of the greatest improvements made on the square for many years. To keep the copper, nickel-plated or blued squares in nice order, they should be rubbed over once in a while with good machine oil applied with a soft rag. By this simple process a square may be kept new in appearance for a long period of years.

These few hints on the qualities of squares and their care will, doubtless, prove of value to my readers.

SOME ODD PROBLEMS

The workman often is confronted with very curious problems, and is as often put to his wits' end to solve them. Here is a problem and its solution that will prove interesting, though it is not likely to be met very often:

Suppose a box twelve inches square to be set

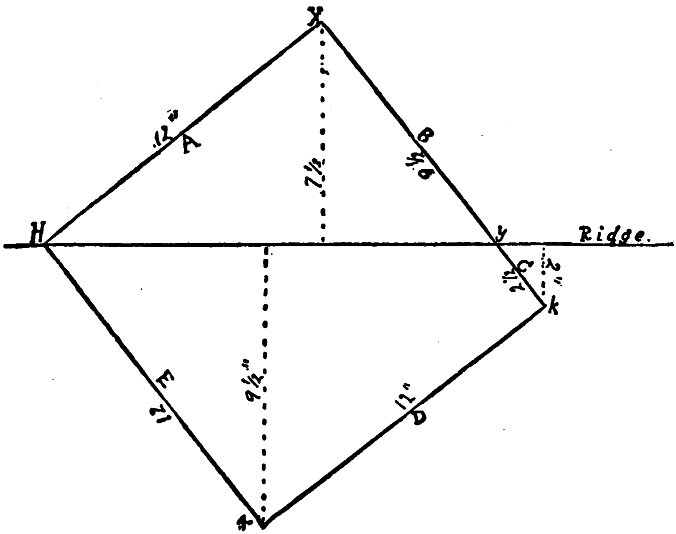

FIG. 1

on the ridge of a roof, as shown in Fig. 1. The roof is half pitch, or rises 12 inches to the foot. Required, the cuts for each side. The corner X is 7½ inches from the ridge; therefore it is 7½ inches lower than H. The cut for side A is therefore 7½ to 12. X is also 7½ inches lower than Y. The cut for B is 7½ to 9½. The cuts for the other side are found in the same way.

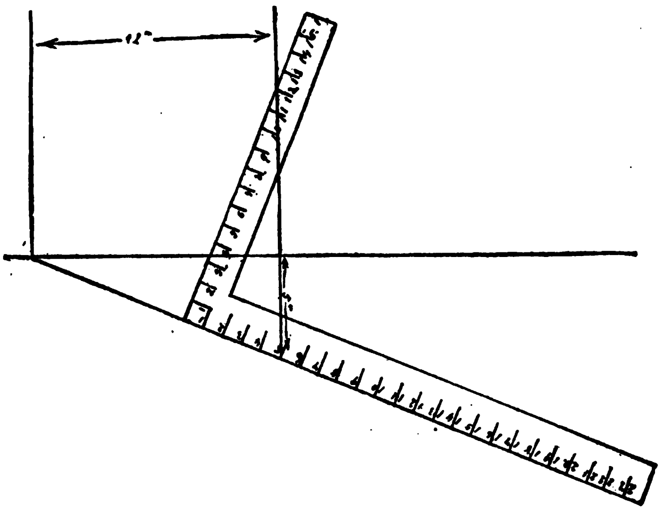

FIG. 2

For proof see Fig. 2. The side of the box being 12 inches, therefore, when set on the roof with one corner touching the ridge, or in any other position, it will reach 12 inches horizontally over the roof. And with a run of 12 inches you have a rise, or rather a fall in this instance, corresponding to the pitch of your roof. With the run on one side of your square and the rise or fall on the other, you will get the correct cut every time.

Two other problems are given here which I am sure will prove interesting:

To determine by a steel square the result of any number, for example, 6, multiplied by the sin 45°. Take 6 on both blade and tongue, and mark the line $ac = bc = 6$. Then cd drawn to the middle of $ab = 6 \times \sin 45°$. Sin 75° = 0.70711. Fig. 3.

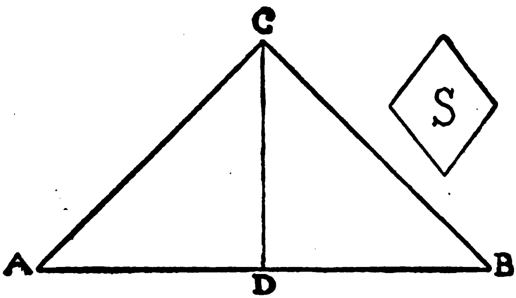

FIG. 3

Problem.—Referring to any rectangular framework which slopes alike on all four sides. *Given*—The rise and seat of the corner posts. *Required*—The cuts for the ends of the corner posts, the blade of the bevel to be applied to the two faces adjoining to the ridge line.

By the Steel Square.—On the blade take the rise. On the tongue take the seat then sin 45°. Mark along the tongue. The angle made by the tongue and the line is the proper bevel.

Problem.—*Given*—The run and rise of a common roof. We wish to place upon it a perpendicular square pipe to stand upon the roof diamond-shape, thus:  *Required*—The cuts for the bottom end of the pipe; the blade of the bevel to be applied to the two faces adjoining the lowermost vertical edge.

By the Steel Square.—On the blade take the run of the roof. On the tongue take the rise $\times$ sin 45°. Mark along the tongue. The angle made by the tongue and the line is the proper bevel.

If the bevel is applied to mark the end of the higher half of the pipe, we have only to reverse the direction of the stock of the bevel so as to make an obtuse angle.

These two problems are very much alike. Their demonstration is a good study in solid geometry.

Suppose we wish to cut an opening in a roof for a round pipe or a tile, so that the pipe or tile will stand vertical through the opening. The exact form of the opening may be obtained by the following method, which is taken from "Carpentry and Building" of New York: set the pipe or tile to be used on the roof at the point where the hole is to be cut, as shown at Fig. 4; plumb it with a level or plumb and place a square alongside of it as is shown in the sketch. Keep-

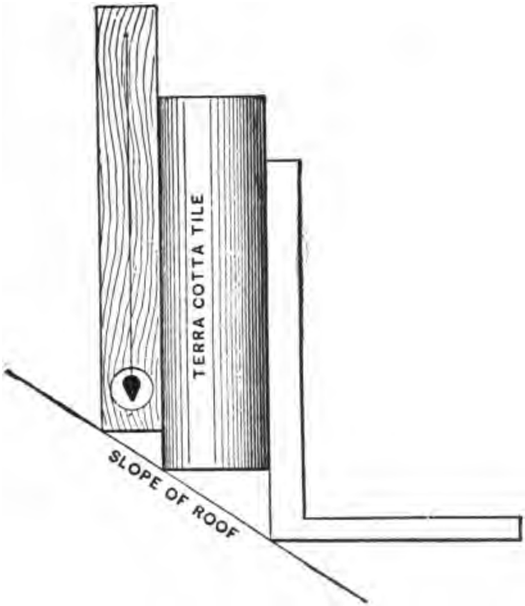

FIG. 4

ing the blade of the square in contact with the pipe, move it around the circumference of the pipe, touching the roof at points about one inch apart and making a mark on the roof at each point of contact. When the entire circumference of the pipe has been traveled, join the points marked on the roof, and the figure outlined will be a perfect ellipse and of exactly the size required. Nothing remains but to cut the hole, and if this is done correctly the pipe will be found to fit exactly. This method is simple and perfectly accurate, and as it requires no calculation, it can be done by any workman who can handle the tools and pipe.

Often men working in wood-working factories find it necessary to increase or decrease the speed of a shaft a few revolutions. To get just the size of pulley necessary for this increase or reduction of speed requires close calculation when figures are used, but a square will do it off-hand and correctly every time. For instance, it has been ascertained that a pulley 20 inches in diameter on a certain shaft will give a speed of 13 revolutions per second. If it be desired to reduce the speed to 11½ revolutions per second, the 20-inch pulley must be removed and one of different size substituted.

To solve this problem with a steel square, take 20 inches on the tongue and 13 inches on the blade. Place both of the marks on the edge of a straight board and draw a line parallel with the blade. Move the square parallel with this line until the tongue shows 11½ inches instead of 13. Notice the reading on the blade and edge of the board. This reading will be size of pulley required in place of the 20-inch concern, necessary to give the desired speed of 11½ revolutions per second. The principles involved in the calculations here made have been amplified and put into a more convenient shape for everyday use in the slide rule.

In this perfected form some mechanics are familiar with the tool, but all do not recognize it in the slide rule. The principle upon which all slide rules work is that of the square and the piece of board above mentioned. There are several more problems of this kind that might be described with interest to the reader.

To find the number of cogs in a wheel, pitch of cogs and diameter of wheel given, set the bevel to the pitch on the tongue and 3.14 on the blade.

Given the diameter of a wheel to pitch line, and number of cogs, to find pitch of cogs. A wheel 70 inches diameter has 146 cogs; what is their pitch? 146 inches being too great to set on the square, we take proportional parts, setting the bevel to $\frac{70}{8}$ inches or 8¾ inches on tongue, and $\frac{146}{8}$ inches or 18¼ inches on blades. Tighten the screw of fence, and move the bevel to 3.14 on blade, and the number given on the tongue multiplied by 8 will be the required pitch.

If we wish to divide a circle into a given number of parts, we proceed as follows: Multiply the radius by the corresponding number in column A, as per table, and the product is the chord to lay off on the circumference.

Given the side of a polygon, to find the radius of the circumscribing circle. This problem has previously been tabulated, but by multiplying the given side by the number corresponding to the polygon in column B, in most cases we obtain the answer more expeditiously.

No. of sides or parts		A	B
3 . . .	Triangle	1.732	.5773
4 . . .	Square	1.414	.7071
5 . . .	Pentagon	1.175	.8006
6 . . .	Hexagon	radius	side
7 . . .	Heptagon	.8677	1.152
8 . . .	Octagon	.7653	1.3065
9 . . .	Nonagon	.6840	1.4619
10 . . .	Decagon	.6180	1.6180
11 . . .	Undecagon	.5634	1.7747
12 . . .	Dodecagon	.5176	1.9318

Given the diameter of a circle, to find the side of a square of equal area.—Set a bevel to 9¾ on the tongue and 11 inches on the blade. Then move the bevel to the diameter of the circle on the blade and the tongue gives the answer. When the circumference is given instead of the diameter, set the bevel to 5½ inches on tongue and 19½ inches on the blade.

To find the number of square yards in a given area we must proceed as follows: These problems require a bevel of 9 on tongue, and the length or width of the surface to be measured on the blade. The bevel is then moved to the remaining dimension of the area on the tongue, and the number on the blade indicates the square yards contained.

If the diameter of a circle is given, we can determine the circumference as follows: Set a bevel to 7 on tongue and 22 on blade; the answer will be found on the latter. In every case when a reverse problem is presented the bevel will solve it unchanged; we merely look for the answer on the other blade of the square. For instance, if, after solving the above, we are required to determine the diameter from the circumference, we still use the same bevel.

SOME DIFFICULT PROBLEMS AND THEIR SOLUTION

I am indebted to Mr. Fred Lascy of San Francisco, Cal., for some of the following interesting problems and their solutions. They make excellent practice for the young student who has made up his mind to learn all possible concerning the square and what may be done with it.

The workman is often confronted with problems in oblique framing that are difficult to solve unless he possesses knowledge of a high order of solid geometry. See how Mr. Lascy handles the square first in splayed work, then in oblique bevels. To construct on a base of any number of salient corners, a solid in which every two adjoining faces slope together toward the horizon forming a hip, and the same rise, of any lengths. To determine by the steel square on a line all the angles that can be required for such constructions, first draw to a proper scale the run AB, Fig. 5, the rise BD, and the slope AD. This triangle is supposed to stand perpendicular to the plane of the paper. Construct the angle ABC=B=any angle whatever. If all the corners of the base are alike in degrees, B=180°

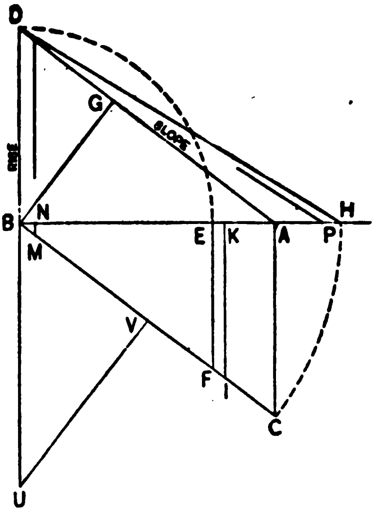

FIG. 5

divided by the number of corners. If the corners are unlike in degrees consider each corner by itself and make B=90°, minus half the degree, of this corner. Draw AC and BC, which is always the seat line of the hip. ABC is always half the corner of the base. All lines drawn from the run to the seat line must be at right angles to the run.

By the steel square. Place the slope on the blade. Place AC (run tan B) on the tongue. Mark along the blade for the face cut against the hip line of boards which have the direction of jack rafters. Mark along the tongue for the face cut against the hip line of horizontal boards; for the top cut of purlins; for the top cut of a miter box to miter the horizontal boards.

By the steel square. Place the slope on the blade. Place EF (rise tan B) on the tongue. Mark along the tongue for the miter cut across the square edge of horizontal boards; for the down cut of a purlin; for the down cut of a miter-box to miter the horizontal boards, lying flat in the box. If the boards be not mitered, we require the butt cut across the square edge of boards. For this draw BG, at right angles to the slope; make BK=AG, and draw KI=run cosine tan B.

By the steel square. Place the rise on the blade. Place KI on the tongue, and mark along the tongue for the butt cut across the square edge. Make BH=seat, then HD=hip line with its top and bottom bevels. For the diedral miter at right angles to the hip line, which is half the angle between any two adjoining sloping faces.

By the steel square. Place the hip line on the blade. Place EF (rise tan B) on the tongue, and mark along the tongue for the diedral miter, To back a hip rafter by a gauge mark, make B*n*=half the thickness of the hip, and draw *nm* to the seat; from the toe of the hip rafter make H*p*=*nm*, and from *p* draw the gauge mark parallel to the hip. For a four-sided hipped roof, we may need the side cut across the top square edge of the hip rafter against the ridge. For this make B*v*=half the seat, and draw *vu* at right angles to the seat, to meet B*u* at right angles to the run.

By the steel square. Place QUV (seat cotan B) on the tongue; place the hip line on the blade and mark along the blade for the side cut, shortening the hip according to the half-thickness of the ridge, thus: If B*n*=half-thickness of the ridge, draw a distance B*m* parallel to the rise; where this line cuts the hip shows the shortening. For a square corner, B=45°, tan B=cotan B=1. In this case tangents of B may be drawn or not.

Again, let the raking molding of a pediment=AD, which is to miter against, as horizontal molding that forms with the run of the pediment any angles whatever. B=90° minus half of this angle. The raking molding must be placed in the miter-box with that part of the molding which is vertical when in position against the side of the box.

Lay the steel square on top of the box. Place AG (run cosine) on the blade; place AC (run tan B) on the tongue, and mark along the tongue for the top cut of the miter-box. Again, place the run on the blade; place the rise on the tongue and mark along the tongue for the down cut of the miter box.

The miter of the horizontal molding equals one-half the corner on the ground plan. If the diagram ADB equals half the gable end of a rectangular building, to miter the raking planceer against the horizontal planceer, which slopes as the roof and runs along the eaves at right angles to the run of the gable, both planceers being in the same plane.

By the steel square. Place the slope AD on the blade; place the run AB on the tongue: mark along the blade for the raking miter; mark along the tongue for the horizontal miter. The horizontal planceer requires the wider board.

In laying off angles for splayed work, lines as long as possible and as few as possible are the essentials of accuracy and comprehension of the subject.

Another problem with its solutions follows: Given a hopper or hipped roof which stands on a base whose corners have any angle whatever, and whose sloping sides have the same run and the same rise of any length. Required the diedral angle between any two adjoining sloping sides without using the hip line; or, what is the same thing, to find the backing of the hip rafter without using the hip line. First lay off AB=run, Fig. 6, BD=rise, A D = slope line. Draw AC at right angles to the run, and lay off angle ABC=90°, minus half the angle of the corner of the base. Angle 6=half angle of corner of

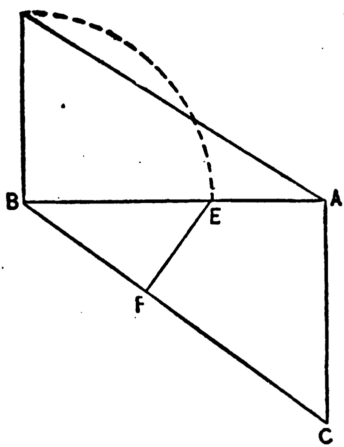

FIG. 6

base. Make BE=rise, and draw EF at right angles to BC, the seat of the hip line. On the edge of a board lay off GF, Fig. 7,=slope AD. By the steel square on the line GF, place EF on the tongue and apply the tongue as shown on the diagram, moving the blade until the blade cuts the point G. Mark along the tongue. EFG= one-half the required diedral angle=diedral miter. By calculation: Cos diedral miter=rise cos half-corner angle C. The demonstration may be studied in any book on solid trigonometry which treats on the right triangular pyramid. It is too long to be given here. Without using the steel square, draw a semicircle on FG, and taking FE in the compasses, mark the chord line EF. This gives the diedral miter EFG to back the hip rafter.

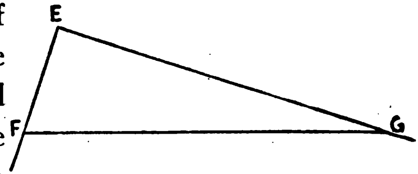

FIG. 7

The following problems in oblique bevels will prove both useful and instructive as well as interesting to the studious young workman: Given the run AC, the rise CB, Fig. 8, and the slope length BA of a stick of rectangular timber, which butts obliquely at the upper end against a vertical plane of indefinite length, and whose seat line=CE. Angle between this seat and the given run=W, which may be any angle whatever. Required the side bevel on the top face of the stick at the point B to fit this end of the stick against the vertical plane. First draw AE at right angles to the run, make AD=slope and draw DE. The required side bevel =EDA. Demonstration: Let the triangle EDA revolve on AE as on a hinge; when the vertex D reaches the required height of the rise, the triangle EDA will stand directly over the triangle ECA, the line ED will coincide with the vertical plane, the line DA will coincide with the top center line of the stick. By calculation, tan side bevel = $\frac{\text{run tan W}}{\text{slope}}$ when W = 45°, tan W = unity. By the steel square on a line: Place AE (run tan W) on the blade, place the slope line on the tongue, mark along the tongue for the side bevel.

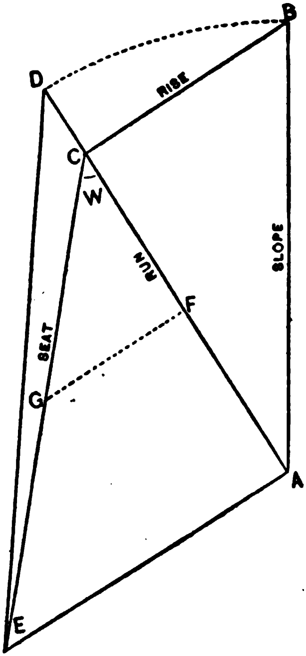

Fig. 8

When W is an obtuse angle it will be more convenient to obtain the length of AE in the following manner: From f, the center point of the run, draw fg at right angles to the run, then AD=twice fg. If the stick should at its lower end butt obliquely against a vertical plane, the side bevel is obtained in precisely the same way as given. By this method we may obtain the side bevel at the lower end of certain jack rafters, making planers and rafting moldings. The other bevels at the top and bottom of the stick do not require any remarks.

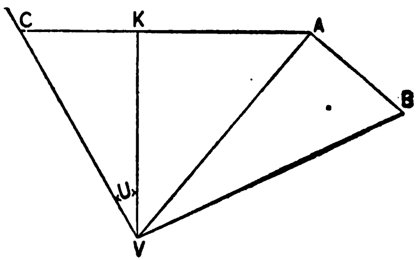

FIG. 9

Again, given the run KV, Fig. 9, the rise KA and the slope AV of a stick of rectangular timber which at its lowered end V butts obliquely against a vertical plane whose ground line is in the direction of VC. The corner KVC=u may be of any size, and is supposed to stand perpendicular to the plane of the paper. Required for the lower end of the stick the miter cut across the top face; also the down cut, so that this end of the stick may fit against the vertical plane whose ground line is VC. First, from the point K, and at right angles to the run, draw KC to intersect the ground line of the vertical plane. From the point A, and at right angles to the slope, draw AB=KC; also draw BB; then AVB is the miter cut across the top face. Demonstration: The triangle VKA being perpendicular to the plane of the paper, let the triangle VAB revolve on VA as on the hinge, until the line AB comes into the horizontal position over KC; then AVB is the required sloping triangle of which KVC is the plan. By the steel square on a line: Place KC on the blade and the slope VA on the tongue. Mark along the tongue for the top face miter. The end down cut may be marked by a bevel set to the angle KAV. The stock of the bevel is applied along the bottom face of the stick with the blade of the bevel pointing upward along the side face. The most common applications are the rafters which butt obliquely against valleys, hips and ridges. If the line VA represents a raking planceer, which at the lower end of a gable miters around a square corner and against a horizontal planceer that slopes in accord with VA, then the angle *u* is always 45°, and CK and AB will each equal the run VK. The miter for the end of the horizontal planceer will be the angle ABV. The horizontal planceer is supposed to have its inside edge beveled to fit against a vertical plane; a square mark down the beveled edge is the down cut through the thickness of the mitered end of the wider horizontal planceer. VA and VK show the relation between the width of the two planceers. If VA is a raking molding, mitering at point V around a square corner and against a horizontal molding. The lower end of the raking molding, mitering at point V around a square corner and against a horizontal molding. The lower end of the raking molding should be cut in a miter-box, with that part of the molding which is nailed against the gable placed against the side box. The foregoing are the proper cuts for the miter-box. The line KC, etc., may be drawn anywhere along the line KV.

Here is an excellent graphical method of finding the areas of different figures. It is taken from "The American Machinist," and is worthy, I think, of a place in this work, because of its compactness and simplicity.

When the area and diameter of any circle is known, by this method the area due to any other diameter, or a diameter due to any other area, may be determined. Suppose we take the diameter 2 with the area 3.1416 as the known quantity from which to calculate all others. Any other diameter and area may be chosen, but this one is the easiest to remember. Draw the indefinite straight line AB, Fig. 10, and, with a diameter equal to 3.1416, draw the semi-circumference ADC. With a radius equal to 2, and with A as a center, cut the semi-circumference ADC in D. Through D erect the perpendicular HE, then will the distance AE be a constant for every diameter and area. Let it be required to find by this diagram a diameter that has an area equal to 5. Lay off AF=5 and draw the semi-circumference AGF, then will the distance AG be the required diameter. If the diameter is given and the area required, take A as a center, and, with the given diameter as a radius, cut the line HE in G. Bisect the line AG at right angles with the line, cutting AB in K, then will K be the center of a circle passing through A and G, and its diameter, AF, will be the required area.

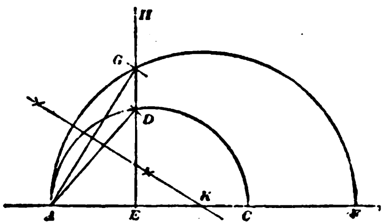

FIG. 10

This diagram is susceptible of a great variety of applications. The diameters on the line

AB may be areas, capacities, weights, tensile strengths, or, in fact, anything that is made up of area and a constant quality. The distances from A to the line HE are always diameters, sides of a square or some constant component of area. The distance AE is different for each kind of proposition, but is constant for every proposition of the same kind. If we say that a bar of 1-inch round iron has a safe tensile strength of 7,000 lbs., then we lay off AF=7, draw the arc on this diameter, and lay off AG=1. The position of G gives the location of the line HE, from which the tensile strength for any diameter may be found. A diameter AD will have a tensile strength AC.

The advantage of this diameter lies in the fact that it is impossible to remember all areas, weights, strengths, etc., while it is comparatively easy to remember one out of each table. With this one known, it matters not whether the tables are at hand or not, as it is comparatively easy to find any other without calculation or liability of error.

It is a well-known geometrical fact that the angle within a semi-circumference is a right angle. Pattern makers may take advantage of this in making of core-boxes, in the manner shown in Fig. 11. If the core-box has been cut out accurately, then the square will touch at

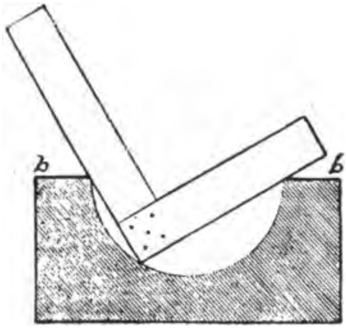

FIG. 11

three places—the two edges and a point in the curve. If it touches at only two places, one being on the curve, then it is not cut out deep enough; if it touches only at the two edges, then it is cut too deep by the amount of clearance between the corner and the curve. By giving the square an oscillation, to make the corner sweep the entire surface of the curve, the accuracy of the curve at that point may be ascertained, and by trying at several points the truth of the whole box may be determined. The square may thus be made to take the place of a templet in making of core-boxes, with the advantage that the square will fit any size, while a templet only fits one. There is an opportunity here for some one to get up a core-box plane that will produce any semi-circumference accurately and quickly. The only care that would have to be exercised by the workman would be the placing of two parallel metal strips as shown at *a* and *b*. These strips are, of course, not necessary when simply using the square to test the accuracy of the work, but would be necessary in the use of a core-box plane made on this principle.

If we wish to find the diagonal of a square or parallelogram, all we have to do is to set the blade of a bevel to 8¾ inches on the tongue and 12⅜ inches on the blade. Then screw the bevel fast; and supposing the side of the square in question is 11 inches, move blade to the 11-inch mark on the tongue, keeping blade against the square, when blade will touch $15\frac{9}{16}$ inches on the blade, which is the required diagonal. There is no special reason for using 8¾ and 12⅜; other numbers may be employed provided the proportion of 70 to 90 exists between them. In the problem just solved, as in all that follow, the bevel being once set to solve a particular question will solve all the others of the same kind, till the bevel is altered.

To find the circumference of an ellipse or oval, we proceed as follows: Set 5⅝ inches on the tongue and 8¾ inches on the blade. Then set the bevel to the sum of the longest and shortest diameters of the ellipse on tongue, and the blade gives the answer.

If it is desired to find the side of the greatest square which may be inscribed within a circle we can accomplish it with the aid of the square as follows: The diameter of a circle being given, set the bevel to 8½ inches on the tongue and 12 inches on the blade. The answer will be found on the tongue.

To inscribe three small circles within a large circle of given diameter, set to 6½ inches on tongue and 14 inches on blade. Move the bevel to the given diameter on the blade and the required diameter appears on the tongue.

Four equal circles require a bevel of 2.91 and 14.

To inscribe polygons within circles.—In the following table, set the bevel to the pair of numbers under the polygon to be inscribed:

No. of sides	3	4	5	6	7	8	9	10	11	12
Radius	56	70	74	side equal to	60	98	22	89	80	85
Side . .	97	99	87	radius	52	75	15	55	45	44

If we require the radius of a circle which will circumscribe an octagon 8 inches on a side, we refer to column 8, take 98 parts on the blade and 75 on tongue, and tighten the bevel. As the side of a hexagon equals the radius of its circle, the side of an octagon must be less than the radius; hence we shift to 8 inches that end of the bevel blade which gives the lesser number, in this case on the tongue of the square, as the 75 parts to which the bevel was set are less than the 98. The required radius is then indicated on the blade.

The following is another table, to be used for the same calculations:

Names	No. of sides	Gauge points
Triangle	3	10.44
Square	4	8.49
Pentagon	5	7.06
Hexagon	6	6.00
Heptagon	7	5.24
Octagon	8	4.59
Nonagon	9	4.05
Decagon	10	3.71
Undecagon	11	3.38
Dodecagon	12	3.11

In a circle 12 inches in diameter, the largest pentagon which may be inscribed is 5.24 inches on a side. Hence for pentagons the bevel is set at 12 inches and 5.24 inches. The number opposite each polygon gives its side when inscribed in a 12-inch circle.

The first table is usually most convenient.

When the side of a polygon is given, to find its apothem or perpendicular.—Set the bevel to the pairs of numbers in the table below. Thus, for a heptagon, set 23 on tongue and 25 on blade, and the answer will appear on the latter.

Sides	3	4	5	6	7	8	9	10	11	12
Apothem	9	1	20	13	25	40	40	20	29	28
Sides	31	2	29	15	23	33	29	13	17	15

The board measure.—A foot in board measure is 1 inch thick and 1 foot square. Set the bevel to 12 inches on the blade and the length of board in feet on the tongue. Then move the bevel to the width of board in inches, on the blade, and the area in square feet appears on the tongue. Whenever the 12 inches is set, whether on tongue or blade, there also must be set the width of board in inches.

To lay off degrees with the steel square, consult a table of tangents, and from this table take the tangent of the angle required, using the first three figures from the left and calling them so many 64ths on an inch. Reduce them to inches, and then, with this quantity on one side of the square and 15⅝ inches on the other side, we will have the figures for laying off the angle. Tables of natural tangents are usually calculated to the radius unit, and are therefore decimal fractions. This method is simply to multiply each by 1,000, thereby obtaining whole numbers. For example, let it be required to lay off an angle of 10°, the natural tangent of which is 0.176327. Multiplying this by 1,000 makes 176.327. Discarding the decimal we have 176, and calling the figures 64ths of an inch, we have $\frac{176}{64}$, or 2¾ inches. The radius 1 treated in like manner makes $\frac{1000}{64}$, or 15⅝ inches. Now, taking 2¾ inches on the tongue and 15⅝ inches on the blade of the square, the blade gives the angle of 10°, and consequently the tongue gives 90° less 10°, or 80°. There are other methods of laying off degrees with the square, several of which I have described and will describe hereafter.

PROPORTIONAL REDUCTION OF MOLDINGS OR OTHER WORK

There are many methods of doing this work by lines, ordinates, and the pantagraph, but I do not know of many by the steel square. The following, which may be new to many readers, has been in use for a long time: First draw the molding bracket or other work, as shown at Fig. 12, in a square as at A, B, E, F. Square out from A and F lines meeting at B. Draw BE, and from E measure off the required projection of the reduced bracket, thus obtaining the point D. Square down from D to the line BE, thus locating the point C. Then the line ED will be the width of the reduced bracket and DC its height.

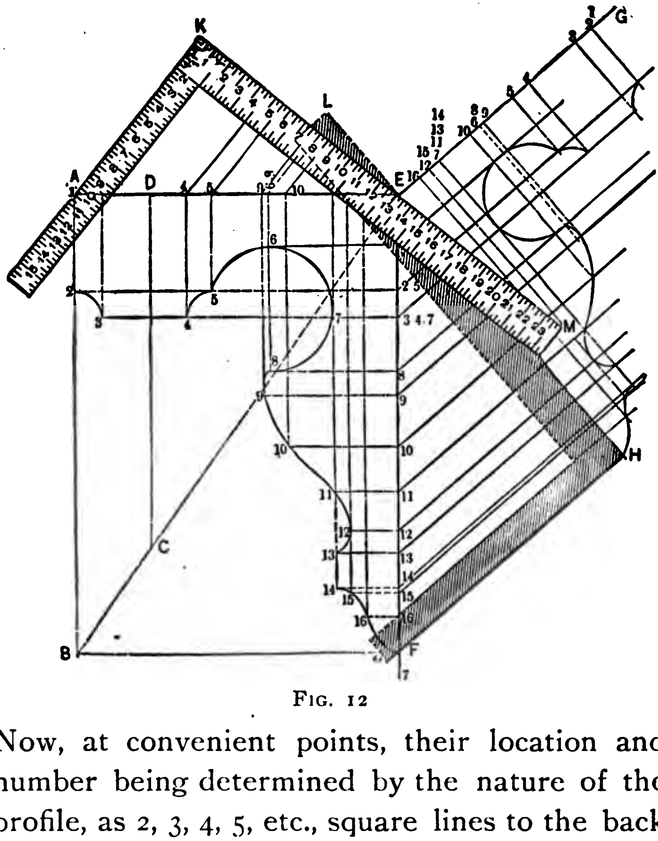

FIG. 12

Now, at convenient points, their location and number being determined by the nature of the profile, as 2, 3, 4, 5, etc., square lines to the back edge, and also to the upper end of the brackets, all as shown in the sketch. Take the width ED of the reduced bracket on the blade of the square, and placing it, as shown in the engraving, against the corner E, carrying the tongue of square up until its edge strikes the outer corner A of the original bracket, draw a line along the blade, all as indicated by KE. Square down from points in this line to the points in the upper line of bracket, 1, 3, 4, 5, etc., already obtained. Take the length of the line DC on the square, which is the length of the bracket after reduction, and place it, as shown by the shaded square in the sketch, at E. Carry the square up until the blade strikes the corner at F. Mark along the blade of the square, thus producing the line EH, which is the back of the diminished bracket. From this line square out the line EG indefinitely; also square out the lines 16, 15, 14, 13, etc., from the points in the back edge of the original bracket, extending them indefinitely across the space the reduced bracket is to occupy. Take a straight-edge and place it against the line KE and mark the points that have already been obtained in it. Then transfer these distances on to the line EG. If preferred, this may be done by the compasses, setting one leg at E and describing arcs from the several points in KE, striking the line EG. From the points thus located in EG lines are then to be carried at right angles to it, being produced until they meet the lines drawn from corresponding numbers on the inner edge of the original bracket. Then a line traced through these intersections will produce the profile of the bracket diminished. The number of fixed points in the profile of the original bracket necessary to be used will vary in different cases. Where the lines are long and regular less will be required than where they are short and irregular. To increase the size of a given bracket the process here described is to be reversed. The same general rule may be also applied in drawing the profile of raking moldings. I think it will be seen that I have not here laid down an arbitrary rule. The principle on which it is founded is in laying down a line the length of the required bracket, and dividing that line in the same proportion as the original bracket.

It is required to get the length of a hoop for a wooden tank, by the steel square.—To accomplish this, proceed as follows: First produce a circle to any desired scale, say 1 inch to the foot, and this on 24 feet would be 24 inches. Then place the heel exactly at the center, as indicated in Fig. 13, and scribe closely to the square, cutting the circumference of the circle, as indicated by BC. Then draw the chord intersecting the points B,C already referred to. The next step is to divide the segment equally, which is done by the line DE. Now three times the diameter plus the distance DE will give the required measurement or circumference.

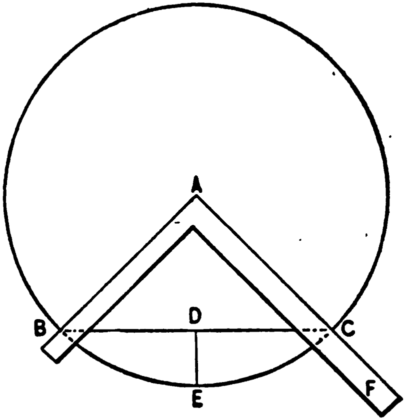

FIG. 13

To perform this by figures alone, take the diameter of the tank and multiply it by 3.1416. If the diameter of the tank is 24 feet, for example, the equation is as follows: $24 \times 3.1416 = 75.3984$; or multiply the diameter by 22 and divide by 7. Thus $24 \times 22 \div 7 = 75\frac{5}{7}$.

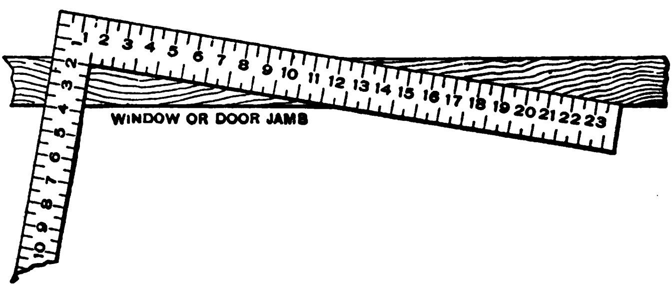

FIG. 14

The proper angle for ordinary door and window sills is about 1 inch drop to the foot. A method of finding this inclination quickly is shown in Fig. 14. The square may be laid on the edge of the bench, or on the edge of a board and the bevel set to suit in short order.

SOME MISCELLANEOUS PROBLEMS

These problems are gathered chiefly from the "Scientific American" Supplement, and were originally contributed by Mr. O'Connell. Some of them are more curious than useful, but all are interesting.

The arms of a straight horizontal lever are 8 and 12. A weight of 9 lbs. is suspended from the shorter arm; what weight will balance it on the longer arm? Set to 12 on blade and 8 on arms. Move the bend to 9 on blade, and 6 is the answer on tongue.

What power is required to support a weight of 4 lbs. on an incline of 5 in 30? Set 5 on tongue and 30 on blade. Move the bevel to 4 (lbs.) on blade, and ⅔ (lb.) is obtained on tongue.

A body is weighed in a false balance and in one scale appears to be 9 oz. and in the other 12 oz. What is its true weight? Find a mean proportional between these numbers, that is, the square root of their product. $9 \times 12 = 108$.

$\sqrt{108} = 10.39$, Ans. The same example is solved by the square by taking 10½, half the sum of 9 and 12, and 1½, which is the difference between 10½ and 9, or 12. The 10½ is now the hypothenuse of an imaginary right-angled triangle, and the 1½ one side. It has already been explained how to find the other side, or the answer.

A spout is 20 inches square; what is the diameter of a cylindrical one with the same area of cross-section? Set the bevel to 31 on tongue and 35 on blade. Move to 20 on tongue and we obtain 22, the answer on blade.

The length and angles of a brace of irregular run, or any run, may be found readily by applying the following rule, using the square as you would a drawing made to scale: Take, for example, the case of a brace of which the run is 49 inches and the height 37 inches. Measuring across the space for the length of the brace with a square will not do; accordingly, then reduce the two lengths by four, which gives 12¼ and 9½ respectively. By taking these points on the two arms of the square and measuring across, the required length will be obtained. To do this take a piece of board, joint one edge and run a gauge mark from the edge the desired width.

Then, placing the square so that the figures fall on the gauge mark, apply it four times, scribing along the blade and tongue respectively for the two ends. This gives the net length of the brace and the proper cuts for the joints. This may not be the best rule which can be employed for the purpose, but it is short and simple. Any ordinary carpenter can work it, and it is undoubtedly correct.

At this point I show a few quick rules to give a square stick an octagonal shape. The rules given on the side of the square as shown in my description of squares in the first volume, while being perfectly correct so far as they go, do not work so well where fractions of an inch are involved, so the following methods of finding the points for the gauge lines are shown at Fig. 15, which shows the square as laid obliquely across the face of the stick so that just 6 inches will be on the stick. At 1¾ inches from each corner draw gauge lines, which will be the correct corners for the octagon. If the timber is over six inches square lay twelve inches of the square upon the

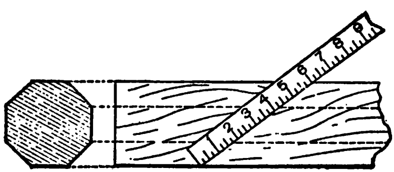

FIG. 15

face and gauge at 3½ inches from the corner. If over 12 inches wide, lay over the whole 24 inches of the square and prick off 7 inches from each end, and these points will be the gauge points. Indeed, it is best to use the whole length of the

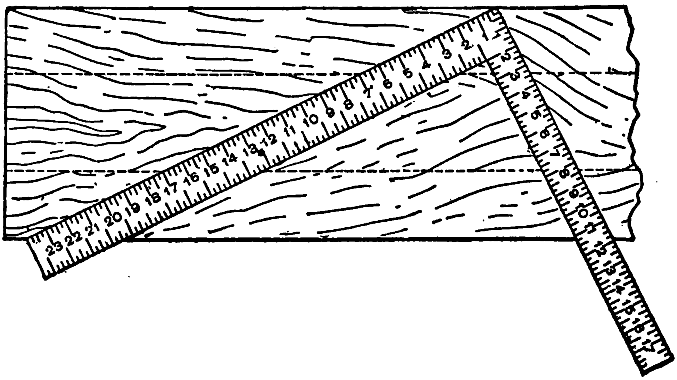

FIG. 16

square in laying off work of this kind, and pricking off 7 inches from each end of the square, no matter what may be the width of the timber. Fig. 16 shows this method quite clearly. The dotted lines represent the gauge marks. Fig. 17 shows a section through one corner of a timber; B and C represent the gauge marks on an adjacent face of the timber, and are each 7 inches removed from the

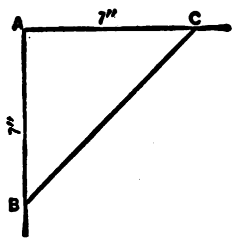

FIG. 17

corner A. The timber, of course, is to be dressed until the line BC becomes a surface. Now, if the rule were accurate, the diagonal BC in Fig. 17 should measure exactly 10 inches, because the adjacent faces, by the rule, would be laid off by measurement to that dimension, and all the faces of the octagon should be the same dimension. That BC in this case is not exactly 10 inches may be easily proven. Since CAB is a right angle, the length of CB must be equal to the square root of the sum of the squares of BA and AC ($7 \times 7 = 49$, $49 + 49 = 98$), the square root of which is less than 10, the square of 10 being 100. It follows that a stick of timber reduced to octagon shape by this rule will have four of its sides 10 inches in width and four of its sides a fraction less than 10 inches, equal to the square root of 98. Fig. 18 shows the same thing in a little different shape, by representing a partial section through a timber 24 inches square. The gauge marks C and D are each 7 inches from the corners A and B; the side CD is 10 inches, but the sides CB and

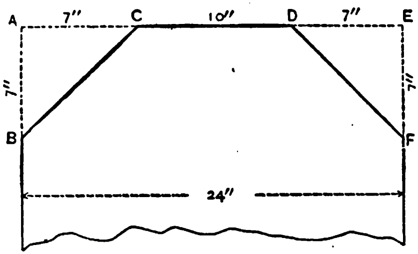

FIG. 18

DF are less than 10 inches. As this rule, like some others in common use, is supposed to be mathematically accurate, I think the diagrams introduced will be of interest to readers.

SOME GOOD THINGS

A whole bunch of good things, some original, some gathered from the four quarters of the earth, are shown in the two illustrations following, which have been handed me by Mr. Stoddard, to include in my "Odd Things Done by the Steel Square." Some of these examples have already been given under various heads, but a repetition is excusable when placed before the reader in another light. These problems were published in "The Carpenter" some time ago, and were well spoken of by a large number of woodworkers.

After stating that he was much indebted to Hodgson for his knowledge of the steel square, Mr. Stoddard goes on to say to the workman "that, to advance rapidly he should be a faithful student and observing, and should notice how every new piece of work is done, and should purchase some good works on the subject in hand." Then he goes on to describe the various methods of roof framing as illustrated in the seven illustrations shown in Fig. 19, as follows:

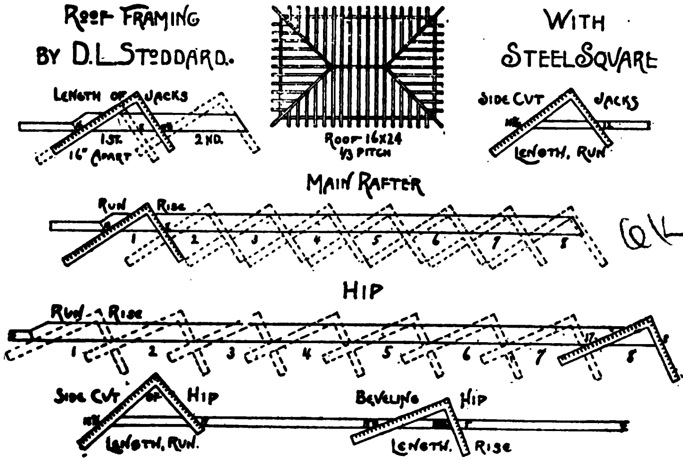

FIG. 19

ROOF FRAMING

In the cut I have illustrated a ⅓ pitch hip roof, 16×24 feet, rafters 16 inches apart.

MAIN RAFTER

One-third pitch rises 8 inches to the foot, and as 8 feet is half the width of the building, the run must be 8 feet. Therefore put the square on 12 and 8 and eight times gives the length and bevels (as illustrated). Notice how it is squared up at heel, and amount allowed for ridge.

CENTER HIP RAFTER

As the diagonal of a foot is 17 inches, take 17 inches on blade in place of 12, and we have hip rafter (as illustrated).

Now these methods are not new or original, as they have probably been used for ages, yet it is surprising how few carpenters know them.

JACK RAFTERS

My method for jacks is an original idea to me, yet it may have been used before I was born.

I simply lay the square on the same as for common rafter. If you wish them 16 inches apart, move the square up to 16 inches; if 18 inches apart, move up to 18, etc. The side cut is the length and run. Cut on length. If you wish to bevel top of hip, take length and rise. Cut on rise.

OBSERVE ALL THE ILLUSTRATIONS

Now remember the same method applies to all pitches. Run the same; simply change the rise to whatever rise the roof is to the foot. This applies to cornice as well as rafters.

Do not be satisfied with this knowledge, but study the use of the square and go further, as there is no limit to what can be accomplished with it.

PRACTICAL USE OF SQUARE AND RULE

Study and fully understand the eight illustrations in this one little cut, and you will find, by thought and application, as the occasion requires, you have learned a great deal, as you will readily learn more.

If you have a board 7 inches wide and wish to divide it into four equal parts, turn the rule until

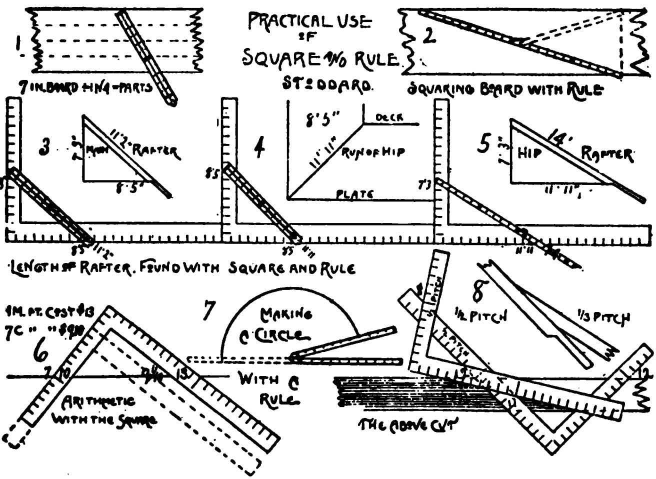

FIG. 20

it strikes eight inches, and mark at each 2 inches, as in No. 1, Fig. 20.

I use that almost daily not only in ripping up boards but in drawing, etc.

If you happen to wish to square a board and do not have a square, take a rule and apply as shown in No. 2, Fig. 20.

IN LAYING OFF RAFTERS

Some may not like to place the square on once for every foot of run, as I illustrated in another cut. Also, if it is to go to a given height one may not wish to stop to figure the exact rise to the foot, figuring out the fraction, etc. Take a roof to be 7 feet 3 inches high and run 8 feet 5 inches. Put your rule on $7\frac{3}{12}$ and $8\frac{5}{12}$, and you will have $11\frac{2}{12}$ or 11 feet 2 inches length of rafter, as seen at No. 3, Fig. 20.

If you wish to hip the same roof, as it is 8 feet 5 inches to the deck, the run of hip must be the diagonal of 8 feet 5 inches, which is 11 feet 11 inches, as illustration 4. The run being 11, 11, and the rise 7, 3, place the rule on them, and we have 14 feet, as shown in No. 3, Fig. 20. If you are buying lumber at $13 per M, and you wish to know what 7000 feet costs, place the square on 10 and 13, bring it down to 7 on the tongue, and we will find we have $9\frac{1}{10}$ on blade, or $9.10, which is the correct answer, as shown in No. 6, Fig. 20.

If you wish to strike a circle and have nothing but a rule, apply as shown at No. 7.

One noon a large crowd of workmen was asked by the foreman how to cut a third-pitch rafter so it would lay on half-pitch roof. It seemed to me to lay off half-pitch and then from that half-pitch line lay off ⅓ would cut it. I tried it, and we were all surprised to find it O.K., as shown at No. 8, Fig. 20. All of these problems, as formulated by Mr. Stoddard, are valuable in themselves because of their simplicity and because of their paving the way to many other things. Indeed, as I have often stated, there appears to be no limit to the use of the square; and I am sure there are hundreds of workmen scattered over the country that have found out things that can be done with this tool, of which we never hear, and I would like to impress on the minds of the readers of these volumes the fact that if they have any new "kink" they have worked out with the square, they will be doing a public good by sending a description of same to the publishers of this work, so that it may be published in future editions, and thus saved to the trade.

X TO OBTAIN THE LENGTH OF A HOOP FOR A BARREL OR TANK BY THE STEEL SQUARE

There are a number of ways by which the length of a tank or barrel hoop may be obtained, some of them being much easier than the one I am about to describe, as using a traveler, for instance, after the tub is standing, or stretching a tape-line around the tub, and other ways; but where these methods cannot be applied—which is very often—then the following method may be employed with profit: The diameter being known, the circumference may be obtained by the ordinary rule of multiplying the diameter by 3.1416, which will give the circumference nearly, then take a pair of dividers and strike a circle to a scale of say 3/8 or 1/2 inch to the foot; then

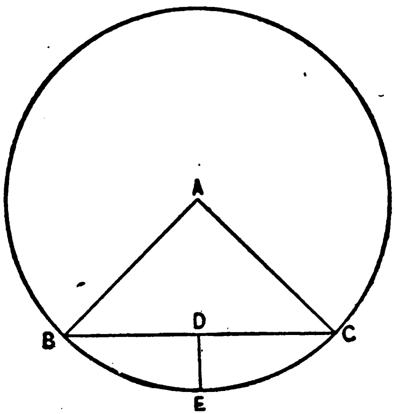

FIG. 21

place the outside corner of a steel square to the center of the circle, as at A, Fig. 21. Referring now to the sketch, scribe along the outside of the square from B to A, and from A to C, then draw a line from B to C, intersecting at the points where the lines previously drawn cut the circumference of the circle. Now obtain the center on the line BC, as at D. Take the square and place it with one edge at the center of the circle, cutting the line BC at D, and draw the line DE. Multiply the diameter of the circle by 3 and add the distance from D to E. For example, suppose the tank is 24 feet in diameter; the circumference would be 75 feet 6 inches; thus $3 \times 24 = 72$ plus the distance from D to E, which is 3 feet 6 inches, making 75 feet 6 inches. The sketch so clearly shows the method that further explanation would appear to be unnecessary.

TO MEASURE INACCESSIBLE DISTANCES BY THE AID OF THE SQUARE

A number of writers on the steel square have written on this subject and have got the matter down fine; but the best of the articles I have met with are those of Lucius Gould of Newark, N. J., and A. W. Woods of Lincoln, Neb., the latter, in my opinion, being the better of the two, and it is from the latter that the following is largely taken, as it is placed before the readers in a simple unostentatious manner.

Every mechanic knows that a triangle whose sides measure 6, 8 and 10 forms a true right angle and is the method commonly used in squaring foundations. But how many ever stopped to think what other figures on the square will give the same result?

By referring to trigonometry we find only three places, using 12 inches on the tongue as a basis and measuring to the inches on the blade that do not end in fractions of 1 inch on the hypothenuse side. They are as follows: 12 to 5 equals 13, 12 to 9 equals 15, and 12 to 16 equals 20.

Now, as we usually use a 10-foot pole to square up a foundation, we find that all of the above contain lengths greater than our pole, so we must take their proportions. The first contains numbers not divisible without fractions, consequently we will pass on to the next. We find that three is the only number that will equally divide all the numbers with quotients, as follows: 4, 3, and 5, but these are too small to obtain the best results.

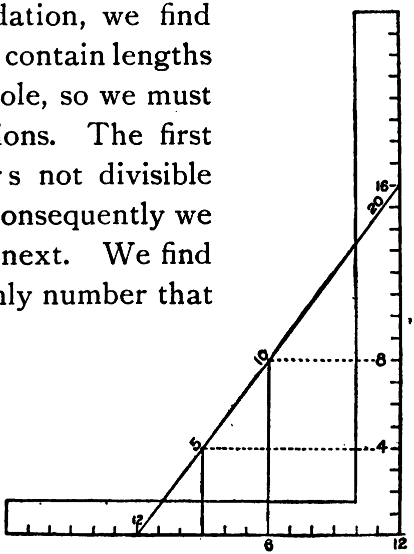

FIG. 22

Now let us examine 12, 16, and 20. They are even numbers, and are divisible by 2 and 4, Fig. 22. If we take one-half their dimensions, we have 6, 8, and 10.

These being convenient lengths and easily remembered, custom has settled on these figures.

There are other places that 6, 8, and 10 can be used to advantage.

Suppose for some reason we want to know the distance across a body of water. We cannot wade it, neither can we depend on a line stretched across, because when it is re-stretched on an accessible place of measurement we have no way of determining when it is drawn to the

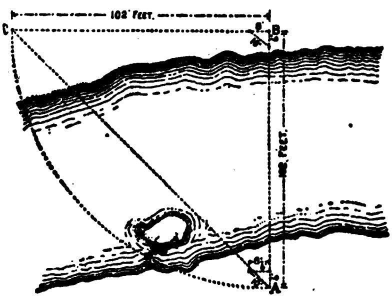

FIG. 23

same tension. Now, referring to Fig. 23, we want to find the distance from A to B. Lay off the angle of 6, 8, and 10, at both A and B, as shown.

Since the base and perpendicular of a right angled triangle are of equal lengths when the hypothenuse rests at 45° with the former, we measure off 6 feet on the 8-foot side as shown, and this will be the point of sight from A. With a man sighting from both A and B, a third sets the stake at C. Then BC must be the same length as AB. (The arc is shown here to prove the accuracy of the diagram.)

By measuring from A and B to the water's edge and subtracting the amount from BC will be given the width of the body of water.

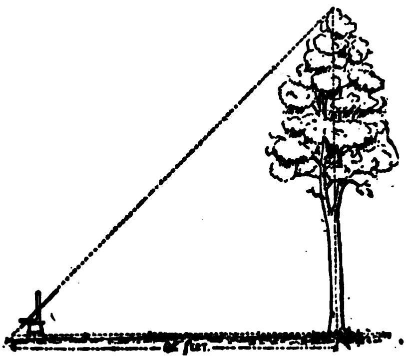

FIG. 24

Fig. 24 illustrates how a tree or inaccessible height can be measured on the same principle with the aid of the steel square. Take a straight-edge and fasten at any of the equal figures on the tongue and blade. Level and set as shown, and the base will be equal to the perpendicular.

MAKING TRESTLES BY THE AID OF THE STEEL SQUARE

The usual batter given to trestles is 3 inches to the foot, but any figures may be taken, according to the amount of batter required.

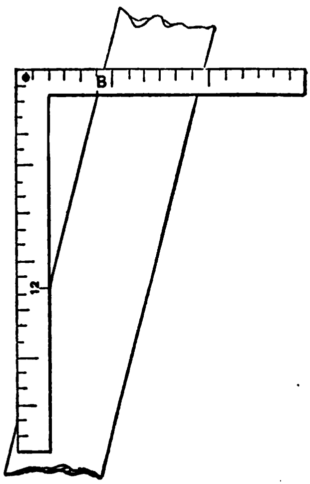

FIG. 25

The manner of using the square to obtain the proper angles and bevels is shown at Fig. 25, which shows how the vertical and horizontal cuts can be determined.

Fig. 26 shows the end of a framed trestle, with posts on the same inclination as shown at Fig. 25. It also shows braces, one framed in the angles and the other spiked on.

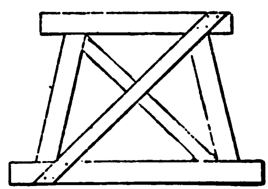
FIG. 26

This problem may be applied to all tapering framework when the taper or lean is in one direction only. When the work is pyramidal, or leaning two ways at the corners, then a different mode of obtaining the bevels must be adopted. I will refer to this again.

SOMETHING MORE CONCERNING ROOF FRAMING

In cutting the timbers for a hip or valley roof, or for both, it will readily be seen that the principle involved in getting the lengths and bevels is the same as for getting the lengths and bevels for braces, for if you compare the top end of a brace with the ridge and valley rafter in a roof, it will soon be seen that they are the same.

Let us take a square stick, say a 4x4, it will form a half-pitch. If the brace is set at an angle of 45°, you get the bevel as shown at Fig. 27.

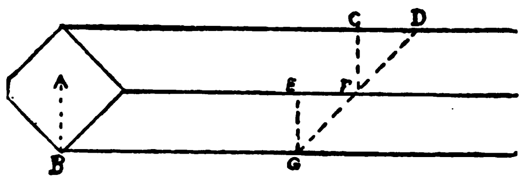

FIG. 27

Now take one-half of the diagonal width, as at AB, and measure this distance along the edge of the stick, as at CD. Square over to the other angle and join DF. Measure as before, making EF equal to CD. Square across timber again, and FG will be the cut.

For a simpler way, that will suit all braces and at any angle, take a piece of timber and mark as above. Suppose you have a 4x4 to be cut, say 6 feet from a post, and run up on the post 8 feet 6

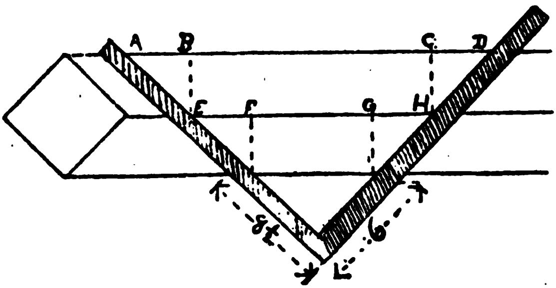

FIG. 28

inches. Lay the square on the lines laid down thus (see Fig. 28):

Transfer the distance AB in Fig. 28 to the side

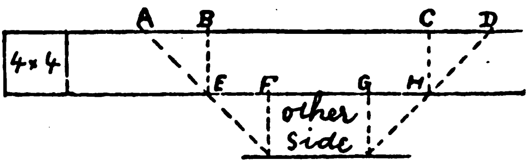

FIG. 29

of the timber in Fig. 29. Square over to the other edge, and join the angles as before; then cut.

Another way: Take your square and find the distance across from 8½ on one arm of the square to 6, Fig. 30, on the other same as for a common rafter. This distance will mark the side, using the line formed by the arm of the square with the 6.

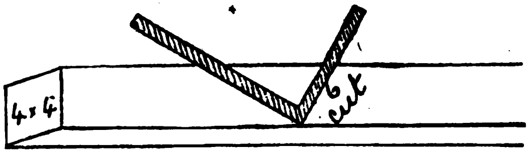

FIG. 30

Cross over on the other side and cut, as shown.

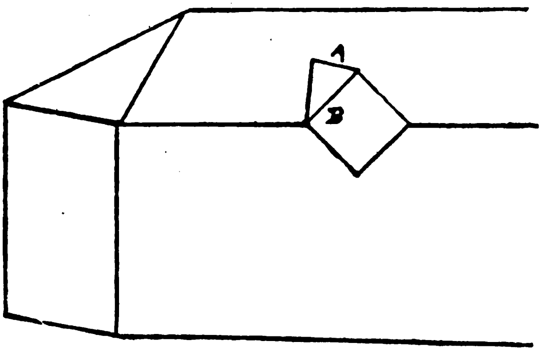

FIG. 31

AB, Fig. 31, represents the ridge or edge of the 4x4; line to the left of B the valley or side of the 4x4. It will be noticed that the ridge A is one-half the width of the width B.

Of course this proposition holds good, and practical experience has so proven it. Any distance may be used instead of those given, by applying the instructions as shown.

These instructions apply more particularly to roofs when the pitches are equal, but there are many cases where the pitches are not the same on each side of the roof, and to meet this inequality the following diagrams and explanations

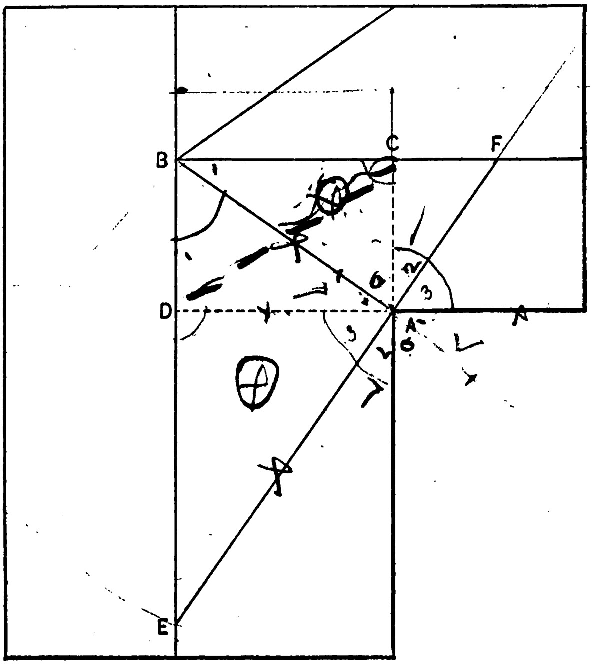

FIG. 32

are given: Let us examine Fig. 32, here we have the valley AB and the run of the common rafters AC and AD, of unequal lengths. To obtain the cuts for the top of the valley rafter draw AE and

AF at right angles to AB, extending them to the ridge line. Now AE and the length of the rafter on the square gives the cut ABE, and AF with the rafter gives the cut FBA, marking on the side representing the rafter. The lengths of these auxiliary lines may be obtained by laying the square on the roof plan and noting their lengths by the scale of the drawing, or, better yet, by a little simple proportion, as exemplified in Fig. 33, of the sketches—AC : AD :: AB : AE.

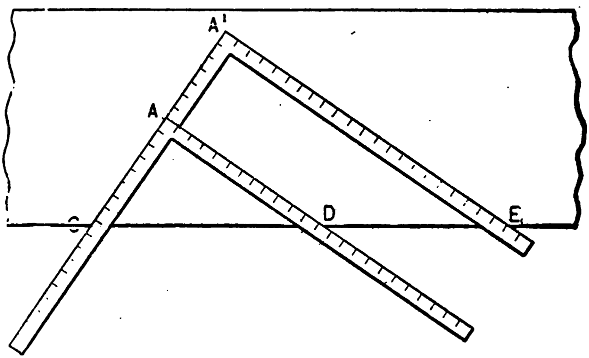

FIG. 33

That is, take the runs of the common rafters, as AC and AD, on the square, place them on the edge of a board and mark along AC; then slide the square on the line AC until A'C equals CD; then A'E equals AE of Fig. 32. For the valley jacks use the length of rafter over AD with run

AC for the angle DAB and the reverse of the opposite side. It is seldom if ever that a drawing is necessary.

On the subject of the steel square as used in laying out roofs, I cull the following from an English source, which, while containing nothing new to those who have made a study of the steel square and its applications, yet is interesting as it offers another side light, as it were, to the subject, and contains some things that may prove instructive.

Regarding the lengths and cuts of hip rafters on a pitch of 45°, the principle is the same in all pitches. Take the run and rise of the common rafter on both tongue and blade, and measure across, and the length of the common rafter is ascertained. Take the run on both tongue and blade, and measure across, take the distance obtained on the blade and the rise (12 inches) on the tongue, and measure across again, and the length and bevels of the hip rafter are found. The above is to 1-inch scale.

Again, by taking 12 on both tongue and blade and measuring across, the actual length of rafter for 1-foot run is found. Take 17 on the blade and 12 on the tongue, and measure across, and the length of hip rafter for 1-foot run of common rafters is found; that is—if, say, the half-width of the building is 15 feet, take for the length of the hip the length of 1-foot run 15 times, which is always 17 on the blade, and the rise for 1 foot on the tongue. If the instructions given are followed anyone will be able to get all the cuts, lengths and bevels for a roof of any pitch whatever.

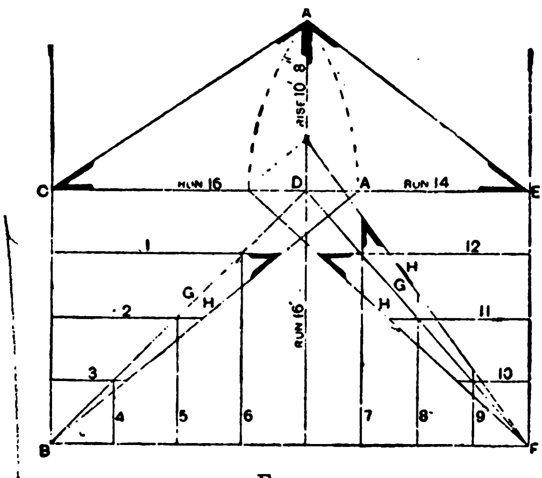

FIG. 34

Supplementing the foregoing it may be said that the line diagram, Fig. 34, shows the plan of one end of a hipped roof, the elevation of a pair of common rafters, and the development of the four quarters of the hip. These will be sufficient to show clearly how the steel square is applied.

As both sides of the hip are alike, I have on the left side of the hip developed only one side. The process is as follows: First drop the point of the common rafter A to A′, and draw a line from it to corner B. If this diagram is made on card-board to a scale of ¼ inch to 1 foot, and the tri-angle formed cut through with a penknife from A′ to B, and from A′ to C, leaving from C to B as a hinge, also cutting through the lines from C to A, and from A to E, and folding this up on the line C to E as a hinge, raising the other tri-angle up and letting it rest on the first, one side of the hip will be represented in the position it would occupy when fixed; the points A and A′ would stand plumb over the point D. Now apply the steel square, and note its position. Lay the tongue on the line C to B, which equals the run, and the blade on the line C to A, which is the length of the common rafter, while from B to A′ is the length of the hip rafter. Marking alongside the blade, it will be seen, must always give the bevel for jack rafters. The numbered lines represent the jack rafters.

On the right side of the hip both quarters are developed, because the run of one is 16 feet, and that of the other 14 feet. Now note the differ-ence in the application of the square. Take the run of the common rafter on the end, on the tongue, that is, from E to F (not from E to D), and the length of the common rafter on the right on the blade, and mark by the blade. This gives the top cut or bevel for the jack rafters on the right. Now take the run of the common rafter on the right side—that is, from D to E on the tongue, and the length of the common rafter on the end (which is the same length as on the left side) on the blade, and mark by the blade. This gives the top cut of the jack rafters for the end. If the triangles are cut and placed in positions as suggested for the other side, the correctness of the measurement will be demonstrated. The length and bevels of the hip on the right side are obtained by taking the run of the end (16 feet) on the blade, and the run of the right side (14 feet) on the tongue, and measuring across, then taking the length thus obtained (which is the run of the hip rafter) on the blade and the rise (10 feet 8 inches) on the tongue, and measuring across, which gives the length, and likewise the bevels, of the hip rafter. G indicates the run of hip, and H the length of hip.

The following is a useful application of the steel square: On the left of diagram, 8 and 12 inches on the square, cut the common rafters; if it rises 8 inches in 1 foot it will rise 10 feet 8 inches on 16 feet. Using ¼-inch to 1 foot scale, place the square on the line (Fig. 35) at 3 and 2,

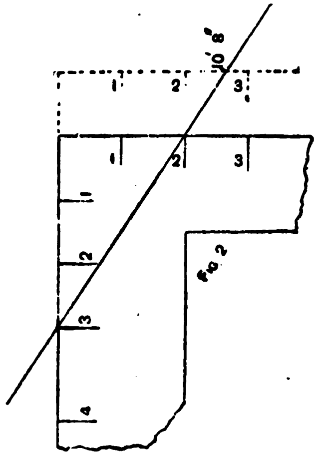

FIG. 35

representing the 12 feet 8 feet. Now slide the square up, to bring 4 on the line, as shown by dotted lines, which gives 10 feet 8 inches rise in 16 feet, which may be stated thus,—12 : 8 :: 16 ft. : 10 ft. 8 in. It will be seen that the steel square, as a mechanical device, will solve problems both in square root and simple proportion.

Perhaps the following examples on the subject which were submitted by correspondents to "Carpentry and Building" may prove useful to my readers, as they contain several good ideas which are worth considering. I have made some slight changes in the text in order to make it suitable to these pages, but this does not affect the subject-matter in the slightest: In the lay-out shown at Fig. 36, we have a 3x6 valley rafter and find

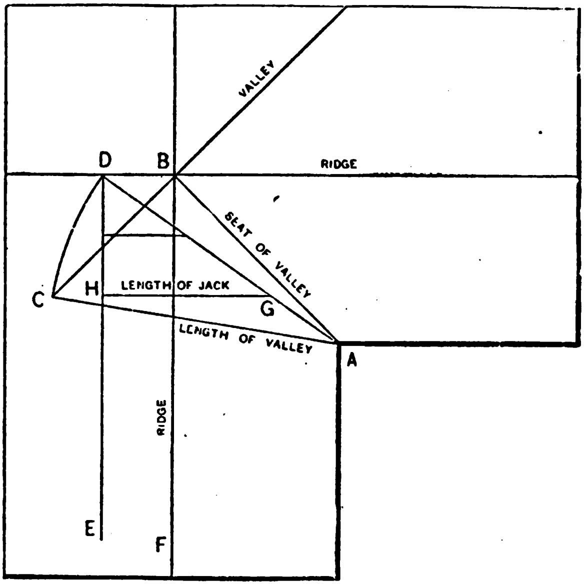

FIG. 36

the center of the face side at the point A, where it intersects the two ridges, as shown in Fig. 37, the center line being AB. Now measure one-half the thickness of the rafter—that is, 1½ inches from A, which gives the point C. Squaring across gives the points D and E. Connecting the points A, D, and E gives the angle cut where the ridges meet at D, as shown in sketch. It must be evident that if C is raised to stand directly over B we get the angle or slope of the valley rafter, also the angles of bevels. In the

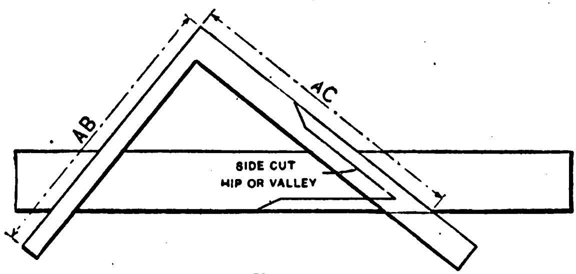

FIG. 37

diagram shown at Fig. 37, the square is set to show the method of getting the proper cuts and lengths, AB shows the horizontal line or seat of valley, while AC shows the run or length of valley rafter. CB on diagram, Fig. 36, shows the rise of the rafter. If the distance CB be used on the tongue of the square, and AB, the seat, set off on the blade, these will give the plumb and bevel cuts of the rafter; while the bevels shown in Fig. 37 give the cuts for *sides* of hip or valley.

FIG. 38

A plan of the valley rafter as laid off for cutting bevels, is shown at Fig. 38.

Fig. 39 shows position of rafter where ridges meet.

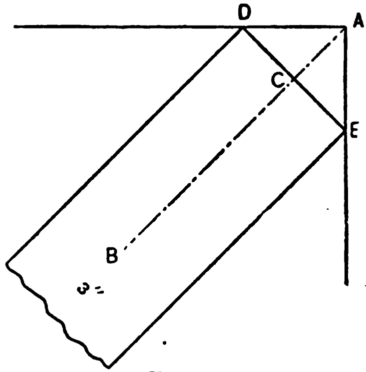

FIG. 39

Fig. 40 shows an elevation of the valley rafter in its proper position on the wall plates. We will suppose that the rise is 9 inches to the foot run, as shown, in which case the hy-

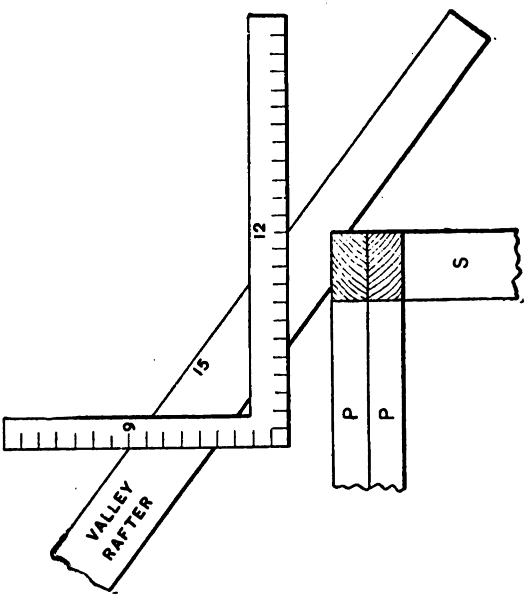

FIG. 40

pothenuse or line of rafter is 15 inches to 1-foot run. Fig. 41 shows the method of obtaining the

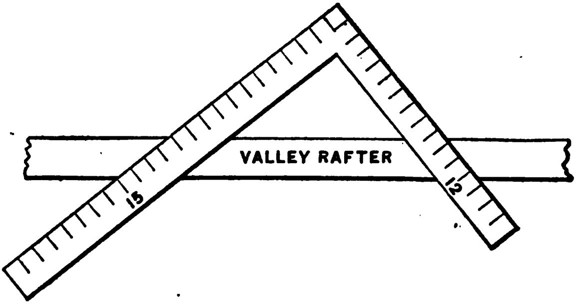

FIG. 41

bevel. Take 15 on the blade and 12 on the tongue of the square, place it on the rafter as shown and the tongue will give the desired bevel, marking along the blade. In order to frame a rafter against two ridge boards running at right angles, draw a line in the center of the rafter and reverse the square. This rule works on all pitches.

Again, suppose the half-width of a roof having a pitch of 45° is 10 feet, and that an adjoining roof is one-third pitch, then it will take 15 feet of it to make an equal rise. By the conditions of the problem we then have a rectangle 10x15 feet by which to get the length of the valley rafter sought. A line drawn diagonally through this rectangle will give the run of the valley rafter. Lay off at right angles each way from the diagonal a distance equal to the rise, Fig. 42,

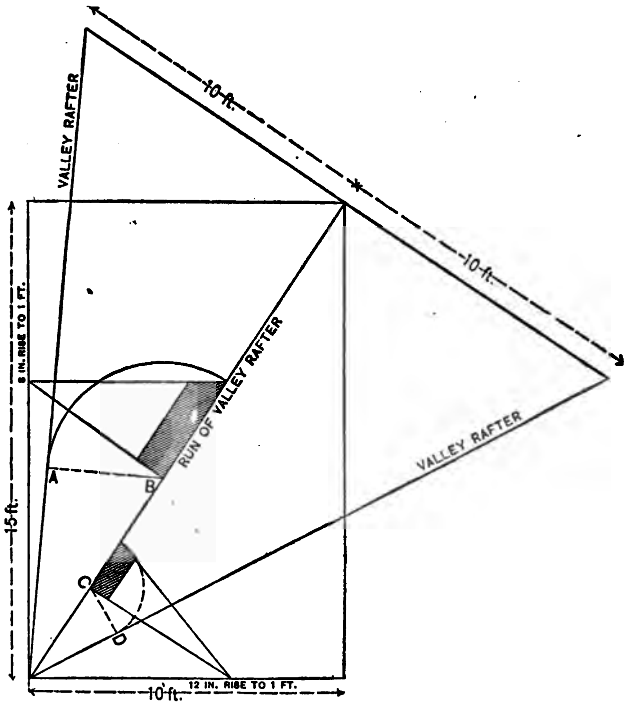

FIG. 42

and connect it as shown in the diagram. This will give the length of the valley rafter. Let fall on each side of the diagonal a perpendicular equal to the half-width of the rafter terminating at the sides of the figure. From B and C thus established let fall perpendiculars BA and CD from the line of the valley rafter. Then AB will be the backing or distance above the edge of valley to set the jacks for the 45° pitch, and

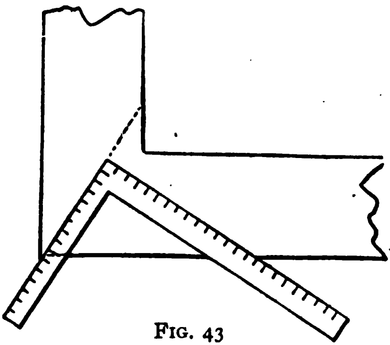

FIG. 43

CD will be the height above the edge of valley to set the jacks for the third pitch. The line on the plate will be obtained as shown in Fig. 43, using the square with 10 on the tongue and 15 on the blade.

From W. H. Croker, of Orillia, Ont., who is

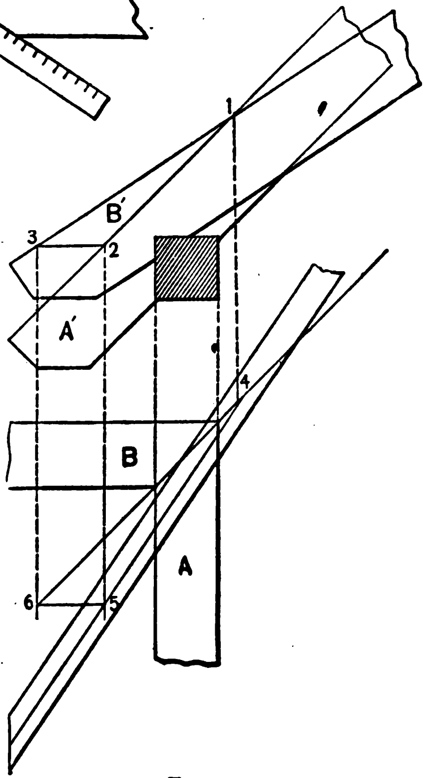

FIG. 44

an excellent authority, I get the following on the same subject: Suppose the plan of the plates is AB, Fig. 44, in any given building, and the corresponding rafters A′B′. Where the top lines of rafters intersect, marked 1 on the elevation, drop a plumb line 14 to intersect 4-6, made at an angle of 45°, and passing through the internal angle of the plates. At any point eaveward draw 2-3 horizontal, and from the point of intersection 3 drop the plumb line 3-6, and from where it intersects the line 4-6 draw 6-5 parallel to 2-3. Make 6-5 equal to 2-3. Then a line drawn as shown by 5-4 will be the plan of the center of the valley rafter. One-half of the thickness of the rafter laid off on each side of 4-5 will determine the relative position of the valley rafter to the plates. In order that the student of this work may be armed with the proper theory underlying the formation of hip roofs, I submit the following, which is taken from Peter Nicholson, whose methods for finding "working lines" in timber framing have never been excelled.

Let *abcd*, Fig. 45, be the plan of a roof, *wy* the width or beam, *ix* the height of the roof, *wx* and *wy* the length of the common rafters; to find the length of the hip rafters from the data here given proceed as follows:

Bisect each end of the plan *ab*, *cd*, in the points *r* and *q* and draw the plan *qr* of the ridge line.

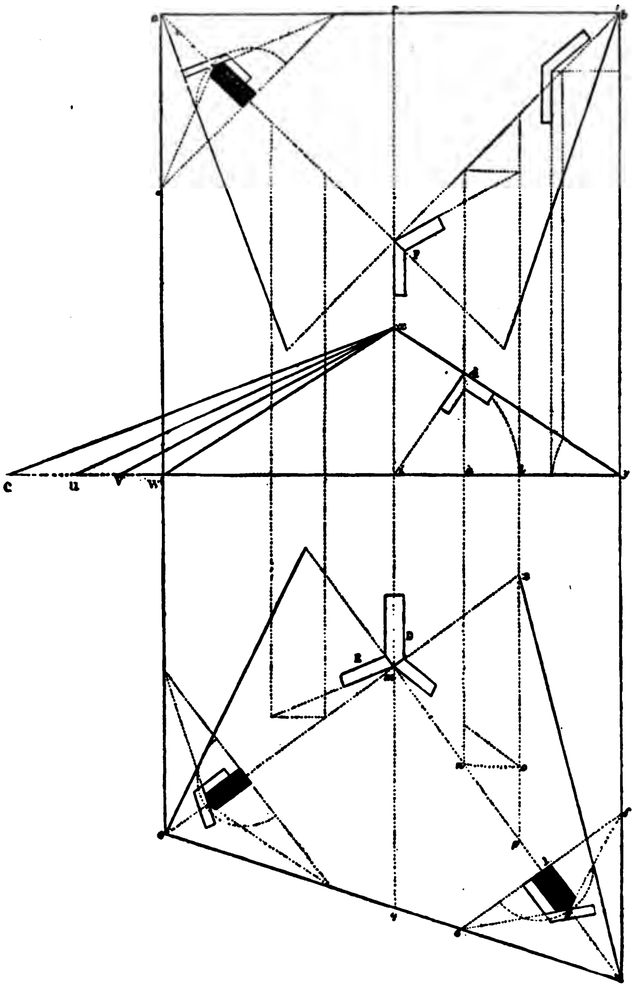

FIG. 45

Bisect the angles at *a*, *b*, *c*, *d* of the roof, by the lines *as*, *bs*, *cm*, *dm*, meeting the plan of the ridge line in *s* and *m* and the lines *as*, *bs*, *cm*, *dm* are the plans of the hip rafters. From the point where the plans of the hip rafters meet the ridge line, draw a perpendicular to each of the hip rafters, and set the height *ix* of the roof upon each perpendicular; and the hypothenuse of each right-angled triangle will be the length of each hip rafter. Thus find the hip rafter over *dm*: Draw *mz* perpendicular to *dm*; make *mz* equal to *ix*, and join *mz*; then *mz* is the length of the principal rafter over *dm*.

The hip rafter may be found very conveniently in the following manner: Produce *iw* to *t*; make *it* equal to *md*, and draw *tx*, which will be equal to *dz*; and thus the remaining three will be found. To find the backing of the hips, draw *ef* at right angles to *md*; from the point *l* as a center find the radius of a circle which will touch the line *dz*; make *ig* equal to that radius, and join *gf* and *ge*; then the angle *egf* is the angle of the back of the rafter. This method of finding the backing of hip rafters is said to be the invention of a Mr. Pope. In this illustration and description almost every possible shape of hip roof plan is involved, and from it hips and jacks may be determined with their lengths, bevels, and inclinations, without much trouble.

It will be noticed that the steel square is not employed in this description, or in the illustration. This is due to the fact that Mr. Nicholson's works were published long before the American steel square came into general use. This illustration is the most complete of its kind known, and this is partly my excuse for its reproduction in this work.

UNEVEN PITCHES

Irregular, uneven, or unequal pitches, are simply different pitches in the same roof. When they are the same on all sides and the building is square, the hips or valleys run in from the corners at an angle of 45 degrees, regardless of the rise of the roof; but should one side be steeper than the adjoining side, or the gables be of different pitch from the main roof, then the hips or valleys depart from the 45° angle.

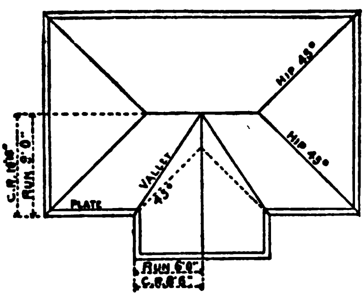

FIG. 46

Fig. 46 shows a roof plan with the one-third pitch on the main part, with a half-pitch gable. The seat and down cuts of the jack and common rafters remains the same as in the even-pitch roof, except the top cut of the jack.

I will not take up space to explain this cut at length, but will give that obtained by the square as follows: Take to scale the length of the left common rafter, on the blade and the run of the right common rafter on the tongue.

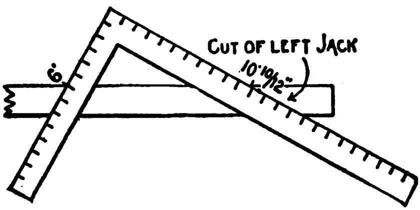

FIG. 47

Blade gives the cut of the left jack—*vice versa* for the right jack. Figs. 47 and 48 illustrate these cuts.

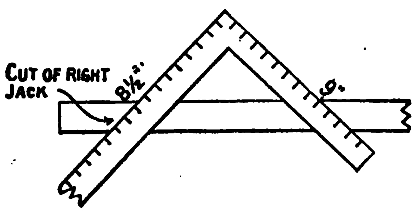

FIG. 48

Here is another problem that comes in connection with the uneven-pitched roof. Where a projecting cornice is desired, with planceer, the valley will not rest at the angle of the plate, but at a point in line with the intersection of the cornice, as shown.

This necessitates the plate on the steeper pitch being raised as much as the difference in the rise of the pitches in the width of the cornice.

Thus, if the cornice be 18 inches wide, the rise of the half-pitch is 18 inches, and that of the one-third pitch is 12 inches, a difference of 6 inches. Therefore, the proper height of the plate above that of the lower pitch is 6 inches.

In connection with the above, Mr. Woods gives the following explanations and diagrams for finding the lengths of rafters where the rises in the roof are of different heights. For example, we will suppose the main gable, Fig. 49, to be 24 feet wide with a 14-foot rise, and the side gable to be 16 feet wide with a 10-foot-8-inch rise. In a case of this kind it is better to let one of the valleys extend on up to the ridge board of the main gable and let the other valley rest against it (the long valley). But how to locate them on the square is the main question. 1st. Place the squares as shown. On square No. 1 lay off the run and rise of the wide gable, and the same for the narrow gable on square No. 2.

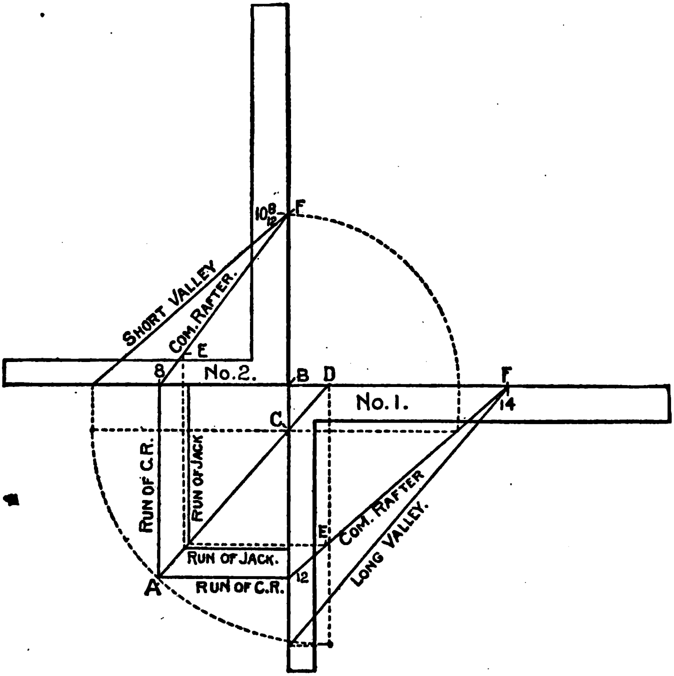

FIG. 49

2d. By connecting the run and rise, as shown by the diagonal line, on each of the squares will be the length of the common rafter.

3d. Square out from the tongues as shown, till they intersect at A, which will be the runs of the gables or of the common rafters.

4th. Set compass at B, and open to equal the rise of the narrow gable and swing to the blade of No. 1, and square in to the common rafter, thence run an imaginary line parallel to the blade, and where it intersects the tongue establishes the point where the ridge of the narrow gable dies or intersects on main roof and which point I will call C.

5th. A line drawn from A to C represents the run of the short valley, and by extending the line on to the blade of No. 1 establishes point D, from which to B represents the run of the long valley, and these lengths taken on the tongues as shown, and connected with their respective rises, will be their lengths.

6th. The lengths of the jacks are found as shown from E to F, which I trust is clear enough without further explanation.

The cuts and bevels are all contained in this diagram.

GENERAL ITEMS

On the subject of roof framing, Mr. Stoddard says: "I have given some thought and study to roof framing, and have concluded the square is master of the situation, as it is much quicker and less liable to mistake than any method I know of."

Let us take the number of inches the roof is to rise to the foot on the tongue and one foot on the blade (which is the rise and run of one foot). If the building is 14 feet wide at a 7-foot run,

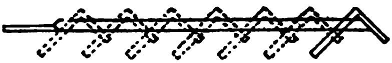

FIG. 50

apply seven times, as illustrated in Fig. 50. To cut octagon rafter, apply same as common, except use 13 inches in place of 12 inches on blade, hip or valley, use 17 inches.

To cut jacks, if you wish them 16 inches apart, slide the square up to 16 inches; if 20 inches, slide up to 20 inches, and so on.

The *rise* and *run* cut on rise gives top cut and all plumb cuts; the run gives cut on plate and all level cuts.

The side cut of jacks to fit hip, and valley to fit ridge, etc., is *length* of *rafter* and run, cut on length.

These general rules apply to all roofs, and this is roof framing in a "nut-shell," although it may not be new, original, or even the best.

But a better way yet is to take rise and run, measure across and get length of rafter; this gives length of all rafters for even or uneven pitches, and all main cuts, which is a very important matter and saves much trouble and worry where unequal pitches are to be worked out.

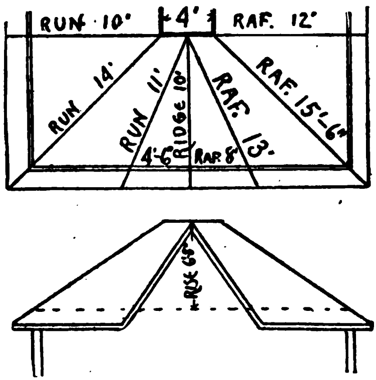

FIG. 51

To illustrate this I will take a little 24-foot cottage, one-third pitch hip roof, 4-foot deck and gable in front. See cut, Fig. 51.

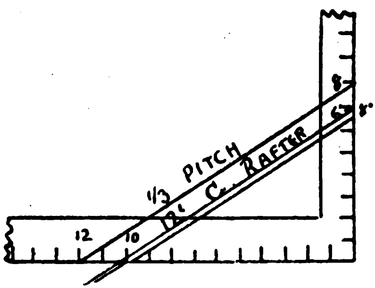

FIG. 52

As it is only the principle involved, for convenience in illustrating we will use even feet as much as possible, and not give accurate measure ments as to inches, although in real framing accurate measurements should always be made.

One-third pitch roof rises 8 inches to the foot. As this 24 foot house has a 4 foot deck, the run of common rafter would be 10 feet, as the rise is 6 feet 8 inches and the run 10 feet, the length of common rafter is 12 feet, Fig. 52.

As the run of the hip is the diagonal of 10 feet

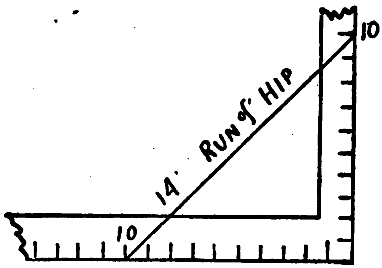

FIG. 53

or 14 feet, Fig. 53, and the rise is 6 feet 8 inches, run 14 feet, length of hip is 15 feet 6 inches, Fig. 54.

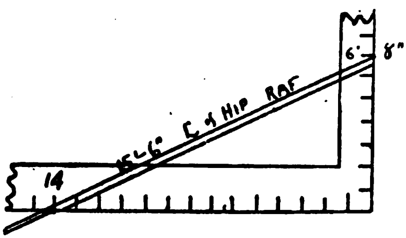

FIG. 54

If the jacks are to be 16 inches apart, measure across your square at 16 inches, at one-third pitch, and you have 19 inches, Fig. 55, length of short jack; twice that length is length of second

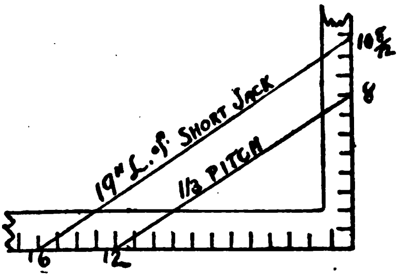

FIG. 55

ones, and so on; or divide the common rafter into the number of jacks required and get your lengths from common rafter.

As the length of common rafter is 12 feet and run 10 feet, place the square on 12 and 10; cut on 12 for bevel of jack rafter, Fig. 56.

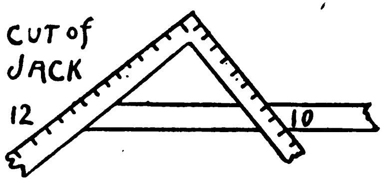

FIG. 56

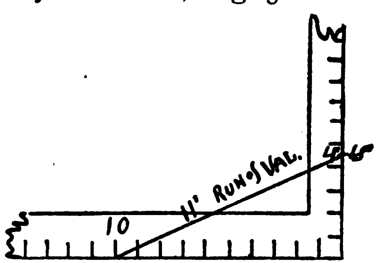

FIG. 57

Now, as the front gable is to show the roof, divide into about three equal parts, allowing for projections; set the foot of valley 4 feet 6 inches from center of building, as it runs back 10 feet to deck.

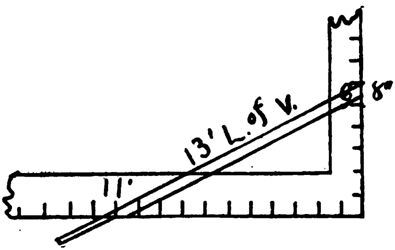

FIG. 58

The run of valley is 11 feet, Fig. 57; as the rise is 6 feet 8 inches, run 11 feet, length of valley rafter 13 feet, Fig. 58.

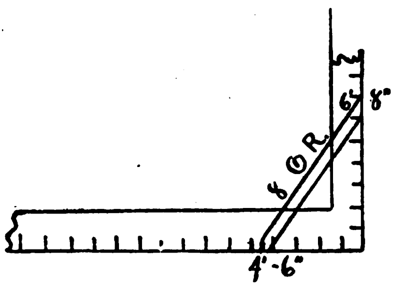

FIG. 59

As the rise of front gable is 6 feet 8 inches and run 4 feet 6 inches, length of gable rafter 8 feet, Fig. 59.

As the length of common rafter on main roof is 12 feet and run of gable 4 feet 6 inches, place the square on length and run cut on length, and

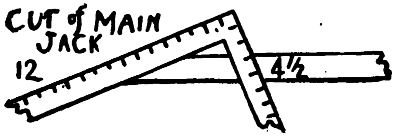

FIG. 60

it gives side cut of main jack to fit valley, Fig. 60.

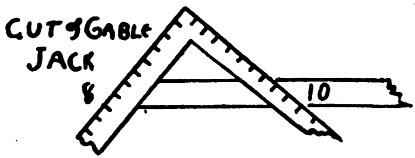

FIG. 61

As the gable rafter is 8 feet and run of main roof 10 feet, length and run cut on length gives side cut of gable jack, Fig. 61.

Most workmen who have followed all the examples given in this work are aware that the rise of the valley or hip taken on the square will give the seat and plumb cuts, but to cut the seat so that the top edge, backed or unbacked, will coincide with the plane of the common rafter is a problem that many are not so sure of; but go ahead and make the cut, trusting to luck, and if it doesn't come right, block up or cut down as the case may be, and the matter is dismissed for the time, only to reoccur on the next job.

In order to enable the workmen to get positive results, the following illustrations and text are submitted; they have appeared before in a different shape, but, as I stated in the outset, it is my intention to publish in this work everything that in my judgment, will be of service to the reader and that is in anyway connected with the use of the steel square.

The illustration shown at Fig. 62 exhibits the position of a hip or valley rafter when the roof is of equal pitch. A, being at the corner of plate for either a hip or valley. If the former, its sides will intersect the edge of the plate at B and B, or at C and C, for the latter.

The distance from A to B and B, or C and C, is always equal to the diagonal of a square with sides equal to one-half the thickness of the rafter. If the rafter be 2 inches, then the distance will be $1\frac{5}{12}$ inches. BC′ (along the side of the rafter) is equal to the thickness of the rafter, and this measurement taken square out from the plate at BC′, and by transferring the center as *a*, will give the different positions of the seat cuts with that of the common rafter.

Now passing up to the common rafter, DE is the depth desired from the plate to the top edge of the rafter.

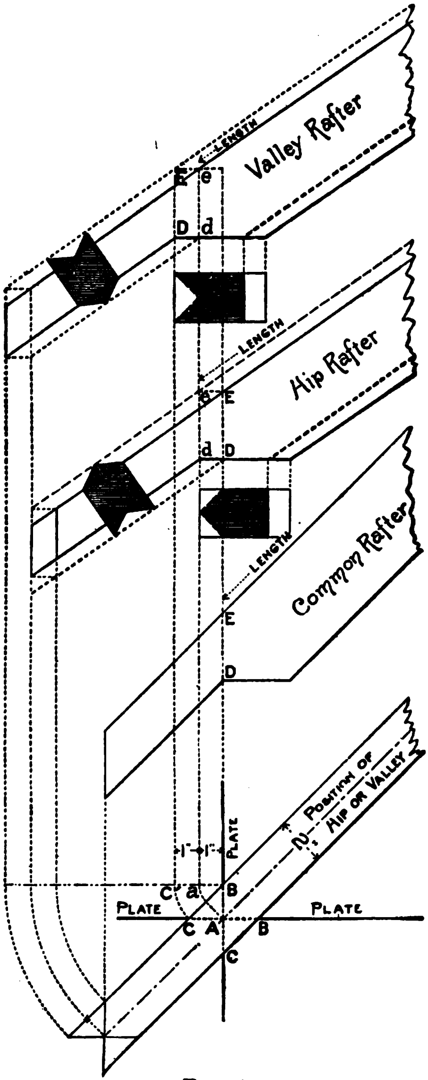
Valley Rafter
LENGTH
E
e
D
d
Hip Rafter
LENGTH
E
d
D
Common Rafter
LENGTH
E
D
PLATE
Position of
Hip or Valley
1"
1"
C
a
B
PLATE
PLATE
C
A
B
C

FIG. 62

Passing on to the hip. If the same is not to be backed, DE will be the same as of the common rafter, but the seat cut will extend to *d* on the *a* line, but if to be backed, *de* will be the depth and will equal DE when backed where the sides of the rafter pass over the edge of the plate at BB. The face view of the seat would show as per the shaded part of section at F.

Passing up to the valley, the depth above the plate at A will be *de*, backed or unbacked. The seat cut will extend to D at the sides, and will intersect the plates at CC.

If to be backed, DE will be the depth above plate at CC. The shaded part of section at G, shows the face of the seat cut in case the under side of the tail is backed; however this is generally omitted. The reader will understand that like letters represent like measurements. DE being over the plate at B or C, and *de* over A. The solid lines represent the rafters when not backed, and the broken or dotted lines when backed. From this it will be seen that the backing of a hip or valley is obtained by setting off one-half of its thickness on the seat bevel, as at *e* E, or *d* D.

In Fig. 63 is shown the plan of a hip and common rafter in place, also an elevation of same with the hip swung parallel to the common rafter, AC and AB being their respective lengths.

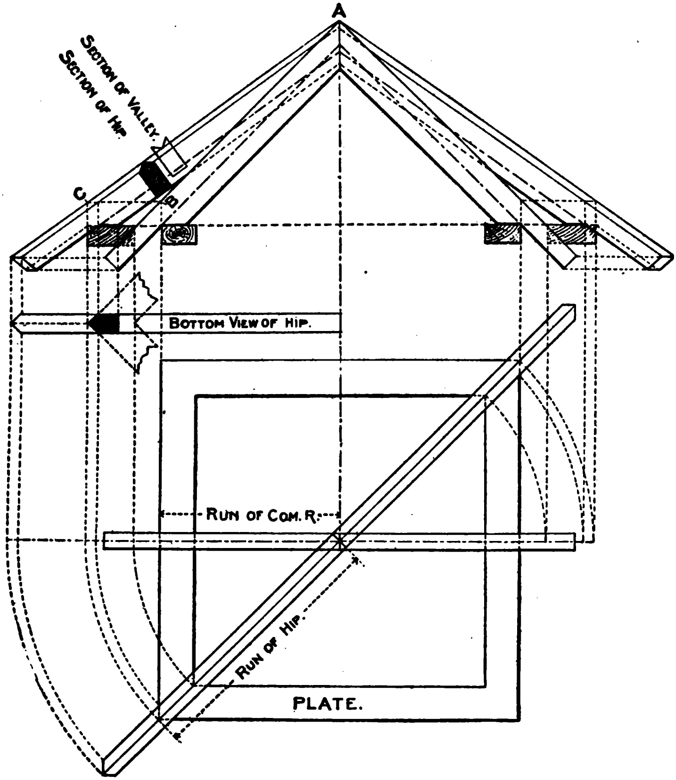

FIG. 63

A method of laying out a hip roof and making a cardboard model for same was published in "Carpenter," some time ago by Mr. Henry D. Cook, of Philadelphia, Pa., and which is reproduced here, as I think it worthy of a place in the present work.

The most simple form of hip roofs is that where the ground plan of the building makes right angles. In the ordinary hip roof but little constructive skill is required, the only points requiring particular attention are in finding the proper lengths and side cuts of jack rafters, and those can be made quite simple. To do this, suppose we get a piece of cardboard and commence laying down the ground plan of a building, which we will represent by letters A, B, C, D. Next lay out the elevation of one pair of rafters B, E, C, shown at A, Fig. 64. Next lay down the seat of the hip at an angle of 45°; on each side set off half thickness of hip which draw parallel with center line AF; from the seat line AF square out from F to G; make GF in A, Fig. 64, equal HE in the same diagram, and square out lines IJ and KL, and join AG, which gives the back line of the hip rafter; next lay off the seats of the jack rafters on line AD, and make MN equal the given rafter BE or CE, and join D, N, on each side of which set off half thickness of the hip; next square over the seat lines of the jacks on line AD, and let them cut the seat of hip as represented on the plan; then with your dividers take D as center and M as radius, and strike the curve line cutting at O, make ON

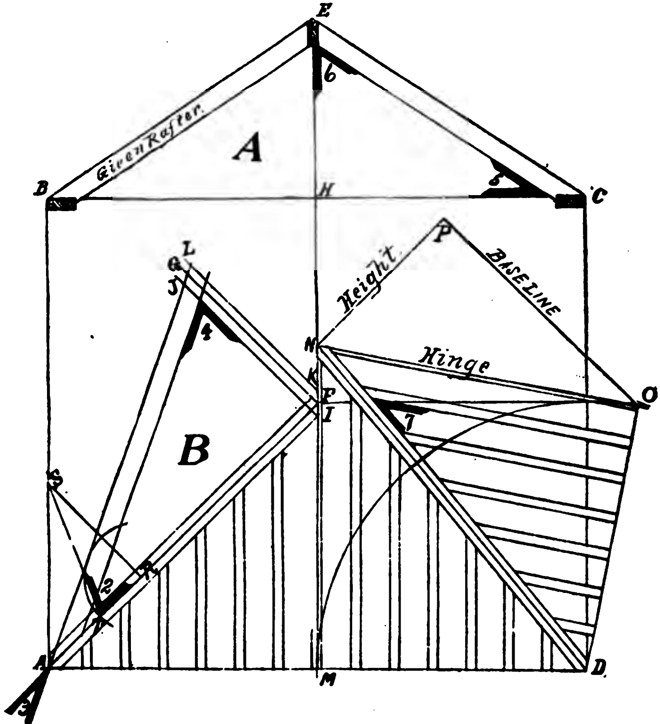

Fig. 64

equa MN, and make OP equal OD, and PN equal HE, in A, Fig. 64, and lay off your jacks on line OD. Now with one point of your dividers press it through at center point, A, also at F; from these impressions on back side of card, and with a sharp-pointed knife, cut partly through the cardboard only. And from A to G, and G to F, on face side cut clear through the card; the hip is now ready to raise; the line AF will form a hinge; but before doing this turn your attention to center line at M; on this line you will cut through from M to N, and on line from D to O you will cut clear through, from O to P will also have to be cut clear through, and on line from P to N must be cut through.

Next, on line NO, on face side, cut partly through only, as this must form a hinge when you begin to turn up the work, next on center line ND, on face, cut partly through only, and on line from M to D cut partly through from the back.

You are now ready to raise this section of the roof. Now, at point N, commence to raise up your work, and you will notice as you raise the point N the point P will fall and will stand at letter F, and the point at O will swing around and stand on line CD. You will then have a perfect model of one corner of the roof of the building, and at the same time the hip will show its perfect backing.

Next come to AG and raise or turn up the hip, and see how nicely it agrees with the other portion of the roof; two hips will come together when points N and G will meet.

You can go still farther by pressing the point of your dividers through points B and C, and from these impressions on back cut partly through the card only, and on lines BE and EC you will cut clear through; you are now ready to raise the given rafters, which should stand at a right angle with the cardboard, when it will be seen that the backs of the given rafters, also the jacks and the hip, all agree and will all be on a straight line.

Backing the hip at any point on the seat, say R, square out a line cutting line AB at S; take R as center, and a circle cutting back of hip, also center of seat at T, join ST, which gives bevel 2 for the backing. The bevels for the plumb and foot cuts of the hip are seen at 3 and 4, and the bevels for the plumb and foot cuts of the given and all the jack rafters will be seen at 5 and 6, and the bevel for the side cut or face of the jacks will be seen at 7.

To cut the hip so as to fit against the ridge, you will notice the points J and L, in B, crossing the line of the hip at the point L, will be the longest point of the hip, and at point J, square over the back of hip and marked on the other side, gives the shortest cut. As all measurements are taken from the center, one-half thickness of the ridge will yet have to be taken off at the upper end.

The construction of a model roof in cardboard, after the method as advanced in the foregoing, will materially assist the workman in grasping the true principles of roof framing, and enable him to understand the reasons "why and wherefore" all the necessary lines for laying out such a roof as described may be obtained by an intelligent application of the steel square.

Before leaving the subject of ordinary roof framing, I wish to reproduce from "Modern Carpentry" an extract from an English source, which deals with roof framing somewhat different to American practice. I have changed and amended the text somewhat in order to make it more easily understood by American workmen. In order to give a general idea of the use of the square there is herewith appended a few illustrations of its applications in framing a roof of, say, one-third pitch, which will be supposed to consist of common rafters, hips, valleys, jack rafters, and ridges. Let it be assumed that the building to be dealt with measures 30 feet from outside to outside of wall plates; the toe of the rafters to be fair with the outside of the wall plates; the pitch being one-third (that is, the roof rises from the top of the wall plate to the top of the ridge one-third of the width of the building, or 10 feet); the half-width of the building being 15 feet. Thus, the figures for working on the square are obtained; if other figures are used, they must bear the same relative proportion to each other.

To get the required lengths of the stuff, measure across the corner of the square, from the 10-inch mark on the tongue to the 15-inch mark on the blade, Fig. 65. This gives 18 feet

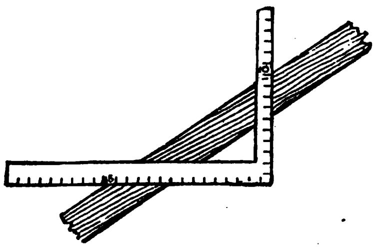

FIG. 65

as the length of the common rafter. To get the bottom bevel or cut to fit on the wall plate, lay the square flat on the side of the rafter. Start, say, at the right-hand end, with the blade of the square to the right, the point or angle of the square away from you, and the rafter, with its back (or what will be the top edge of it when it is fixed) toward you. Now place the 15-inch mark of the blade and the 10-inch mark of the tongue on the corner of the rafter—that is, toward you—still keeping the square laid flat, and mark along the side of the blade. This gives the bottom cut, and will fit the wall plate. Now move the square to the other end of the rafter; place it in the same position as before to the 18-foot mark on the rafter and to the 10-inch mark on the tongue and the 15-inch mark on the blade; then mark alongside the tongue. This gives the top cut to fit against the ridge. To get the length of the hip rafter, take 15 inches on the blade and 15 inches on the tongue of the square, and measure across the corner. This gives 21$\frac{3}{16}$ inches. Now take this figure on the blade and 10 inches on the tongue, then measuring across the corner gives the length of the hip rafter.

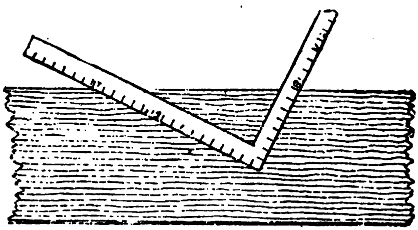

FIG. 66

Another method is to take the 17-inch mark on the blade and the 8-inch mark on the tongue and begin as with the common rafter, as at Fig.

66. Mark along the side of the blade for the bottom cut. Move the square to the left as many times as there are feet in the half of the width of the building (in the present case, as we have seen, 15 feet is half the width), keeping the above-mentioned figures 17 and 8 in line with the top edge of the hip rafter; step it along just the same as when applying a pitch board on a stair-string, and after moving it along 15 steps, mark alongside the tongue. This gives the top cut or bevel and the length. The reason 17 and 8 are taken on the square is that 12 and 8 represent the rise and run of the common rafter to 1 foot on plan, while 17 and 8 correspond with the plan of the hips.

To get the length of the jack rafters, proceed in the same manner as for common or hip rafter; or alternately space the jacks and divide the length of the common rafter into the same number of spaces. This gives the length of each jack rafter.

To get the bevel of the top edge of the jack rafter, Fig. 67, take the length, 14⅜ inches of the common rafter on the blade, and the run of the common rafter on the tongue, apply the square to the jack rafter and mark along the side of the blade; this gives the bevel or cut. The down bevel and the bevel at the bottom end are the same as for the common rafter.

To get the bevel for the side of the purlin to fit against the hip rafter, place the square flat against the side of the purlin, with 8 inches on the tongue and 14⅜ inches on the blade, Fig. 68. Mark alongside of the tongue. This gives the side cut or bevel. The 14⅜ inches is the length of the common rafter to the 1-foot run, and the 8 inches represent the rise.

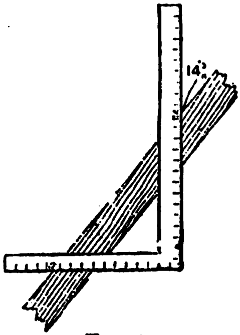

FIG. 67

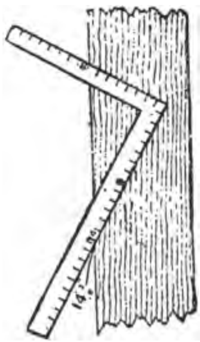

FIG. 68

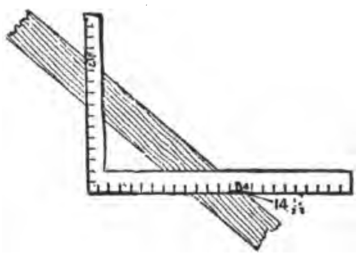

FIG. 69

For the edge bevel of purlin, lay the square flat against the edge of purlin with 12 inches on the tongue and 14½ inches on the blade, as at Fig. 69, and mark along the side of the tongue. This gives the bevel or cut for the edge of the purlin.

The rafter patterns must be cut half the thickness of ridge shorter, and half the thickness of the hip rafter allowed off the jack rafters.

A few remarks regarding the backing of hip rafters and the getting of the proper lengths of jack rafters, or "cripples" as they are called in some sections of the country, and I have done with ordinary roof framing for the present.

I have shown in several instances how the lengths of jack rafters and their bevels may be obtained, but I have not specially shown how these results are obtained, so will devote some little space now to this purpose. Let us suppose AB and BC, Fig. 70, to be hips, and AD and CD valleys laid out from any particular plan, then the jacks cutting in between valley and hip may be laid out as shown at FE; the bevels showing the angles of the cuts, the plumb cuts being the same as for common rafters. The bevel at E shows the side cut against the hip, and the bevel at F the side cut against the valley rafter.

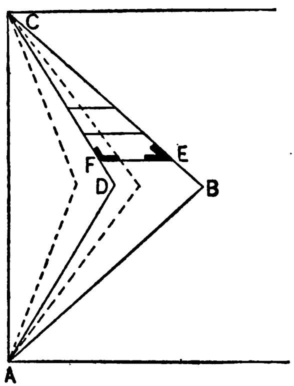

FIG. 70

Another way to determine the length of jack rafters is given as follows: On the steel square, take 12 inches on the blade and the rise of the roof, 12-foot run, on the tongue, and measure the distance across. This length in inches, multiplied by the number of feet the jack rafters are to be on centers, will give the required length in inches. For example, if the roof rises 11 inches per foot run, measure the distance from 11 on the tongue to 12 on the blade of the square, which is 16¼ inches. Now, supposing the jack rafters to be 16 inches, or 1⅓ feet on centers, we have 16¼ x 1⅓=21⅔ inches, which is the difference in the lengths of the jack rafters.

The lengths may also be found by first getting the length of the common rafter in inches for a 12-inch run, and multiply this by the distance in inches the jack rafters are to be from center to center, and divide the result by 12. This gives the difference in the length of jack rafters in inches. For example, if the rise is 12 inches and the run is 12 inches, the run of the rafter is nearly 17 inches. Now, 17 multiplied by 28 and divided by 12 gives 39⅔ inches. This is the difference in the length of the jack rafters for a one-half pitch roof where the jacks are 28 inches from centers. This rule will work on any pitch of roof.

Mr. Hicks gives the following rule, in his "Builder's Guide," for obtaining the lengths of jacks, which is somewhat similar to that already shown: Take the run of common rafter on the blade, 12 inches, and the length $14\frac{7}{16}$ inches, on the tongue, and lay a straight edge across, as

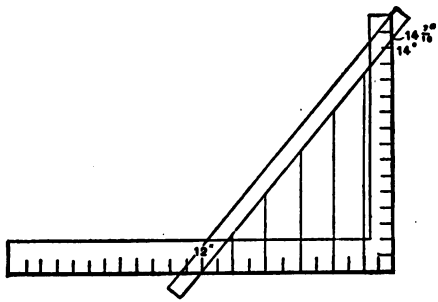

FIG. 71

shown in Fig. 71. Space the jacks on the blade of the square, which represents the run of common rafter, and measure perpendicularly from the tongue to the straight edge on the line of each jack for their length.

For cutting jacks for curved roofs, while not exactly within the scope of the steel square, yet the bevels may be laid off by that instrument as the reader will no doubt discover; so I give here Mr. Hicks' method of determining the lengths.

The curvature of these rafters will, of course, be governed by the position they occupy with relation to the hips. The method offered is not new by any means, but is presented in a manner easily to be understood by the ordinary workman. Let us suppose AD, Fig. 72, to be the run of the common rafter, DE the rise, and AE the length and work line. To find the length of jack set off the run of jack AB and square up the rise BC to the work line of the common rafter; then AC is the length of jack on the work line. This method is very simple, yet, as it is a new and novel way of finding the length of jack rafters, it will be well to point out a common mistake which the inexperienced might chance to make. Bear in mind that AE is the length of common rafter. BC is not the length of jack, as some might suppose, but the rise of jack; AC is the length of jack. The down bevel is the same as that of the common rafter. To find the bevel across the back, set off from D the length of

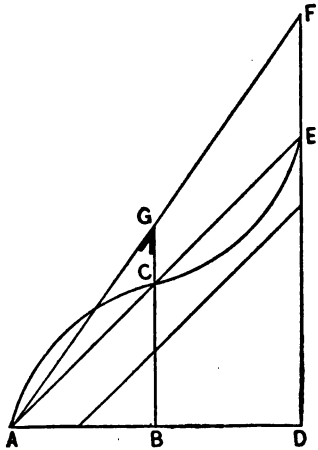

FIG. 72

common rafter to F, and connect F with A, which shows the work line of the hip. Now continue the line BC to the work line of the hip, and the bevel at G will be the bevel across the top of jack. BG is also the length of jack, and will be found to be the same as AC.

When the bevel of the jacks is known all that is necessary is to square up the rise of each jack from the base line of common rafter AD to the work line AE, and take the length from A to the point where the rise of each jack joins the work line of common rafter, as shown.

In connection with hip rafters for curved roofs, it may be well at this point to depart from the course pursued so far in the making of this book and give the ordinary lines for laying out such work without using the square for the purpose. We will suppose the lines A and B, Fig. 73, to represent the common rafter for a curvilinear roof, let B represent the common rafter, and C the valley rafter. In plan and profile, respectively, the curves of common rafters being given, first determine the seat, or base line, of valley rafter, which in roofs of this kind is curved. To illustrate, the common rafters were cut and put up on both sides of valley strips, tacked on one side parallel with eave or ridge, and the same number of strips on the other side, tacked in the same manner and at the same vertical height; it

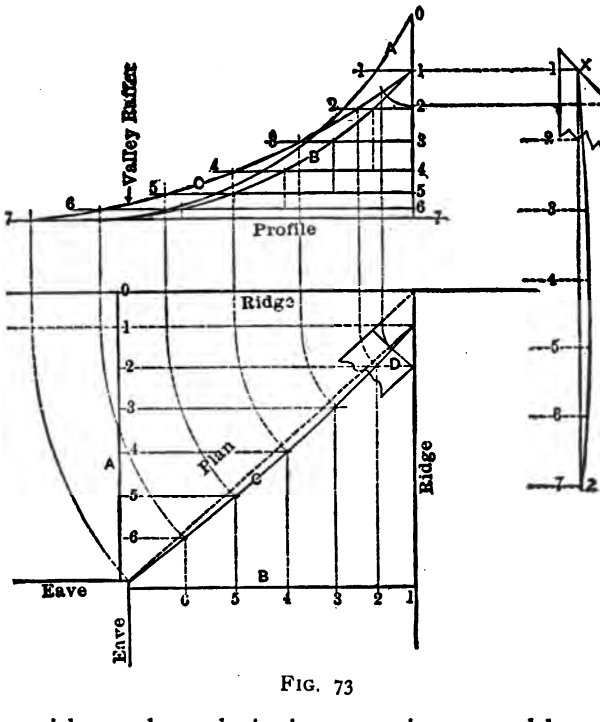

FIG. 73

is evident that their intersections would represent the line of valley. Therefore, the curves of common rafters being drawn, divide, for example, B into any convenient number of parts, and through the points thus determined draw horizontal lines. The lengths of these lines are determined by where they cut the curve of common rafter, and are set off on corresponding rafter in plan. Then draw lines parallel with eaves or ridge, as shown in the sketch, and where these lines intersect is the base line C of valley rafter. The same points of intersection project on corresponding lines of profile, giving the line of valley rafter.

To obtain the lateral curve of valley rafter, take distance on outline of valley rafter, as made by the horizontal lines already described, and draw lines, as shown, between X and Z at the right of the sketch. Draw a vertical line cutting all these lines, and set off on each corresponding line the same lateral distance as between the straight and curved base line in the plan. To find the top bevel of valley rafters, let the thickness be as shown at D in plan. Project the length of bevel by half the thickness on curved line in profile. Project the length thus found on corresponding line on upper face, as shown by XY at right of the sketch. From the two points thus determined draw a line, which will be the true bevel.

In connection with curved roofs, the following is offered as being a good method of getting the side bevels and lengths for jacks in a hipped roof: Let CB be the top line of one of the common rafters. In the diagram, Fig. 74, CBH is supposed to stand upright on rise BC. In shape all the jacks must be some part of the length of the common rafter measured from point C. On one common rafter lying on a flat surface with marked run and rise must be laid off all the jacks showing vertical cut, also long and short top edges opposite to each other. On run make CH equal to EG, long seat line of this jack. At right angles to run draw HK, the vertical cut. Then CK is the long top edge of this jack. For the opposite short top edge draw a line parallel to the vertical cut at a distance back equal to FG taken from seat of jack. On top face of jack mark the side bevel from end of long edge to end of short edge. It is evident that when jack CK stands upright over its seat its bevelled top end will fit against the hip face which stands over BC, because long top edge of jack stands over long seat line, and short top edge of jack stands over short seat line; only if ABC is an angle of 45° does FG equal thickness of jack. For

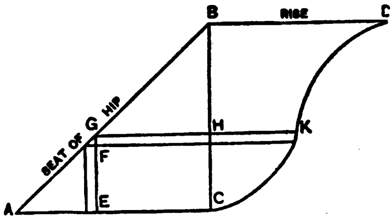

Fig. 74

each jack the side-bevel will be different, but can be obtained in this manner.

Before leaving the subject of hip, valley, and jack rafters with regard to their lengths and bevels, I think it will be in the interest of my readers to reproduce a system of lines first

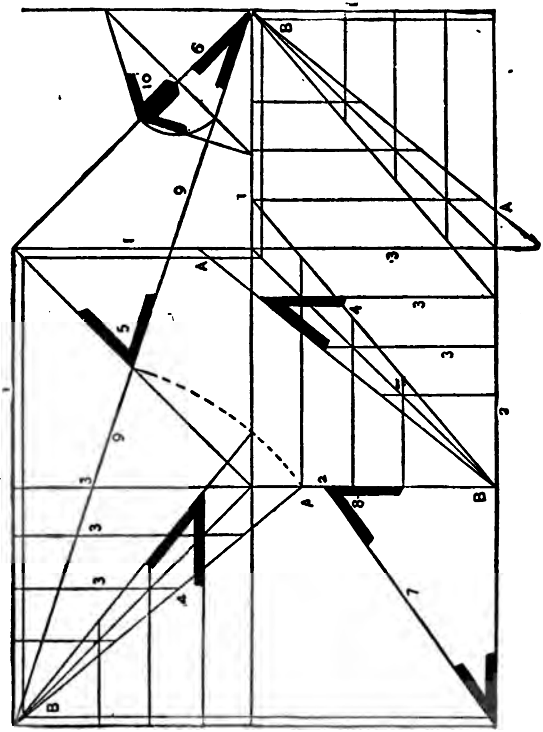

FIG. 75

invented by Peter Nicholson, and simplified by Mr. Smith and published in his "Architect," a book that at one time had a deserved popularity. While the book is now seldom spoken of, this system of lines has been made use of by nearly all the late writers on constructive carpentry, with greater or lesser elaboration. On Fig. 75, the plan 1,1,1,1,1 represents the outside plate; 2,2, the ridge line; 3,3,3,3,3,3, the jack rafters of hip and valley; 4,4, the side bevel of jacks and the length of jack from corner of plate and ridge to side of hip and valley; 5, bevel at head of hip and valley; 6, bevel at foot of hip and valley rafter; 7 is a common rafter; 8, the bevel at head of common rafter, is the down bevel for all jacks on hips and valleys; 9,9 is the length of hip and valley rafter; 10 is the method of getting the bevel of back of hip. Draw a line at right angles with base line of hip, then set one foot of the dividers where this line crosses the base line, and the other where it crosses the hip-rafter line, and set the same distance on the base line, and draw lines from that point to the plate each way, which gives the bevel for hip, and, turned the other way up, it gives the hollow for the back of the valley. Line from *a* to *b* is the length of hip and valley dropped down to get the length of jacks. Lengths and bevels of all hips and valleys the same in same roof of same pitch.

Fig. 76 is a plan for framing a valley in a roof where one side is much steeper than the other,

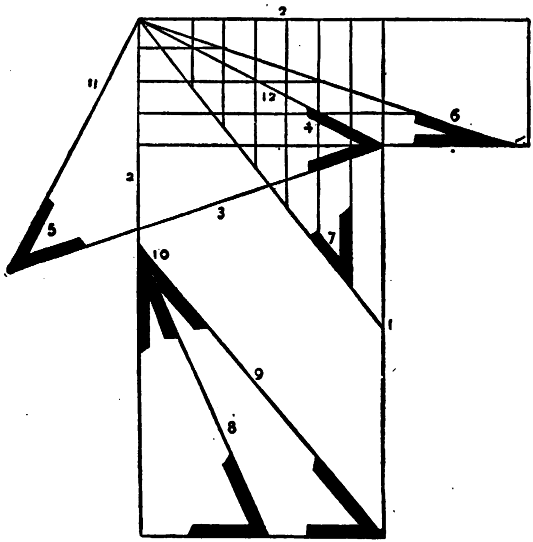

FIG. 76

as, for instance, one side rises, say, 10 feet in 8 feet. 1-1 is the wall line; 2-2 is the ridge line; 3 is the valley rafter; 4 is the bevel at the foot; 5 is the bevel at the head; 6 is the bevel of the jacks on the lowest pitch, also the length of same; 7 is the bevel of and length of jacks on the steep side; 9 is common rafter on the lower pitch; 10 is the down bevel on jacks of each side; 11 is the height of roof; 12 the base line of valley. The rafters will not match on the valley as on an equal-pitch roof, as in Fig. 75. It will be seen that it will take seven jacks on the steep side, while it requires only four on the other side, but the bevels will all fit.

BACKING HIP RAFTERS

A writer on Building Construction has said: "In America there are more hips 'backed' in books and papers than there are in houses." Unfortunately this is too true. Most workmen never think of backing a hip; they put in the timber just as it comes from the lumber yard, with the exception of cutting the bevels for point and heel of rafters. This is all wrong. All hips *should* be backed, in order to get a good strong and nearly perfect roof. When the hip is thin, being no more than two inches thick, it is not so bad, yet it ought to be backed; but when the hip is three or more inches thick, then under no circumstances should backing be omitted.

In the present volume, as well as in the former one, I have shown some rules for getting backing for hips, but in order to have the principle well understood I present a few more examples showing how the angles may be obtained.

The method shown at Fig. 77 is a quick one, and a correct one if the measurements are exactly taken. The diagram explains itself and requires no description. When the horizontal

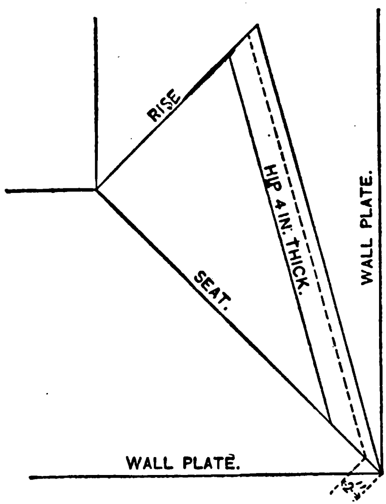

FIG. 77

or bottom cut for a hip rafter has been obtained, take one-half the thickness of the rafter and measure back from the toe or point toward the heel. This will give the point on the side of the rafter to gauge to. Then a line on the center of the top of the rafter in connection with a line gauged on the side, will give the bevel or backing.

Another example of backing and I have done. Let us suppose AB and BC, Fig. 78, to represent the plates of the building, and BD the hip rafter, BE being the seat of the rafter. Take any point of the hip, as 1. Draw a line at right angles to

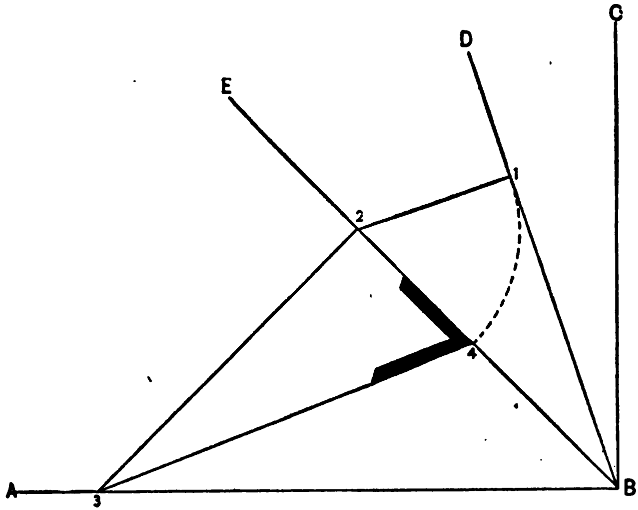

FIG. 78

this, producing it until it cuts seat BE, as shown in the point 2. From the point 2 thus established draw a line perpendicular to the seat, producing it until it cuts the line of plate AB. Transfer the distance 1-2 along the line representing the seat of the rafter, thus establishing the point 4. Draw 3 and 4; then at 4 will be given the bevel for use in backing the rafter. Fig. 79 shows the application of the bevel to the timber which will give the gauge points to work from.

These examples, with the ones on the same subject illustrated and described in previous pages, should prove quite ample and are varied enough to meet the requirements of most workmen no matter what may be their constitutional peculiarities.

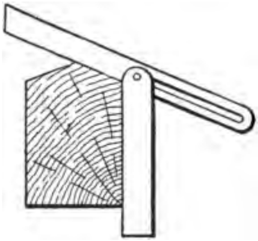

FIG. 79

FRAMING OCTAGONAL ROOFS, DOMES, BAYS AND OTHER OCTAGONAL WORK

We now enter another phase of the carpenter's art, and one in which the steel square plays, or can be made to play, an important part. I have discussed the "octagon" pretty fairly in the first volume of this work, but very much more than I have said, or can say for that matter, may be said on the construction of octagonal work; in order, however, to make this work as complete as possible I have thought it necessary to present to the reader the following illustrations and descriptions, knowing from experience they will be useful.

I have shown how the miters in polygons may be obtained by aid of the square and by other methods, and, as a sort of introduction to this chapter, I offer the following which I know will be acceptable to many of the readers of this book who have been fortunate enough to get a fair public school education: There are three kinds of angles: the right, the obtuse, and the acute. A right angle is an angle formed by two lines perpendicular to each other. An obtuse angle is greater than a right angle; an acute angle is less than a right angle. All angles of the octagon are obtuse. A right angle is equal to 90°. The angle ABC, Fig. 80, which is one of the angles of the octagon, is 45° greater than a right angle, and is equal to 90°+45°= 135°. The octagon miter is an acute angle, and is found by bisecting 135°, which is $\frac{135}{2}$=67° 30′, which is shown at ABD.

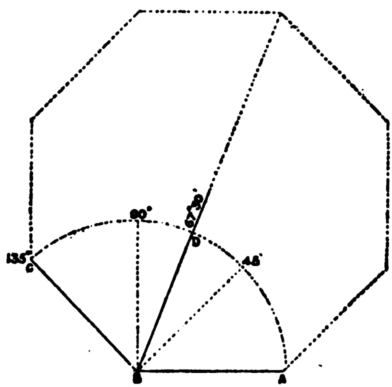

FIG. 80

I will now show the proportionate length of each line in the octagon, Fig. 81; the diameter being one, the number on each line indicates its exact length in fractional parts of one. To lay out the miter or angle, place the square as shown at ABC; take 12 inches on the blade of the square and $4\frac{31}{32}$ on the tongue; tongue gives cut. Any other number will do as well, providing the proportion of 3827 and 1585 exists between them.

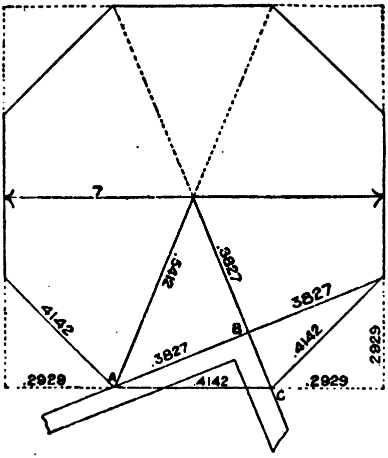

Fig. 81

This is a simple and correct method of finding the miter of an octagon, and will be found useful in solving many problems that confront the workman from time to time.

BAY WINDOWS

Often workmen are put to their "wit's end" when "laying out" an octagon bay window, owing to the surrounding conditions. The following is submitted, which shows how the faces or sides of the window or other work may be laid out with ease: First lay off a straight line DA, Fig. 82, to the length desired for one side of the window, as indicated from A to B. Then from B to C make the length $\frac{5}{12}$ of AB. The length CD is to be the same as AB. Now, with the foot of the compasses in D, and with radius DC, strike an arc as shown. Then, with the same radius

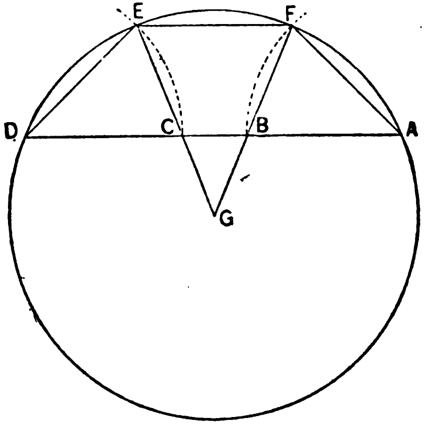

FIG. 82

from A as center, strike the second arc indicated. With the dividers set to the same distances and with C as center, strike an arc, cutting the arc struck from A, thus establishing the point F; then, in the same way, using B as center, strike an arc cutting the opposite arc, establishing the point E. Draw the lines DE, EF, and FA, the result will be three equal lengths and three equal angles. To find the center of the octagon, draw lines through the points FB and EC until they intersect in the point G; then G will be the center as required. The lines FB and EC will be the seats of hips, if any are desired. To lay off an octagon end of building, as is often done, divide the width of the building into 29 parts, and take 12 parts for each of the extreme spaces and 5 parts for the mean space, and proceed as above. If we wish to make the front side wider than the other side—for example, 2 feet wider—deduct 2 feet from the width of the building; divide the remaining space into 29 parts, take 12 parts each for the extremes and 5 parts plus 2 feet cut off for the mean space, and proceed as above, save that in crossing the arc at E we must set the compasses 5 parts from C, or at I, all as shown in Fig. 83. And in crossing at F we set 5 parts from B, or in the point H, as shown. Then we have the front side 2 feet longer than the others, and the angles the same. Three sides of any figure composed of more than four sides can be produced in the same general manner. However, the ratio between the mean part and the extremes will be different. Thus, in a figure of seven sides the mean part will be one-fourth of the extremes. Whatever the mean part is, the

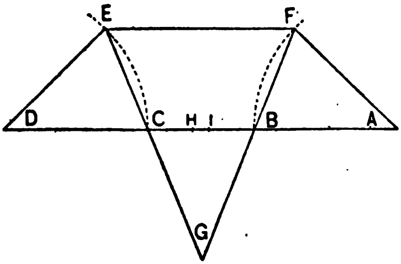

FIG. 83

sides will be equal and the angles at E and F will be the same.

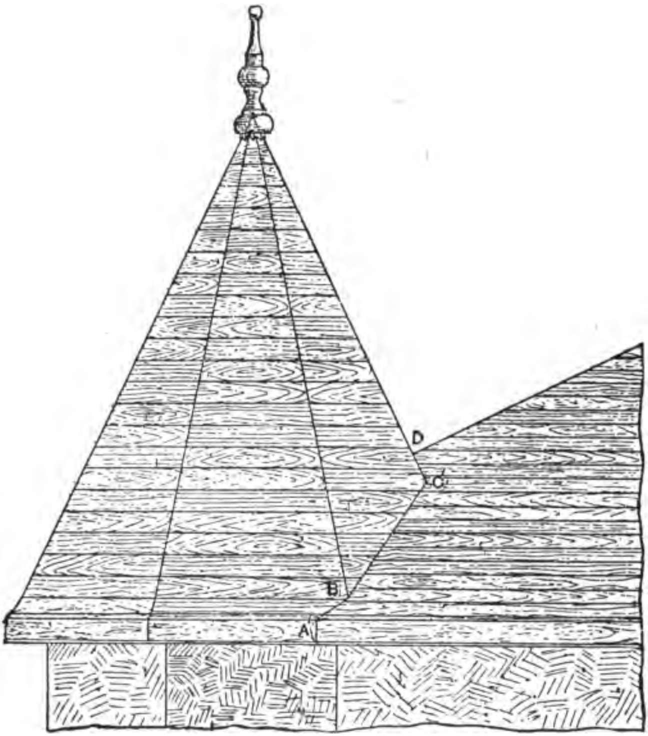

FIG. 84

OCTAGON TOWERS AND SPIRES

Now that we know how to lay out the base of an octagon and how to lay off a part of the figure for a bay window or other similar work, it will be in order to see how the framing is done for an octagonal tower, spire, or other similar structure. Suppose we have a tower to erect which is partly over another roof, as shown at Fig. 84, where the intersections occur. It will be seen that the tower intersects the hip roof, as A,B,C,D,E,F,G.

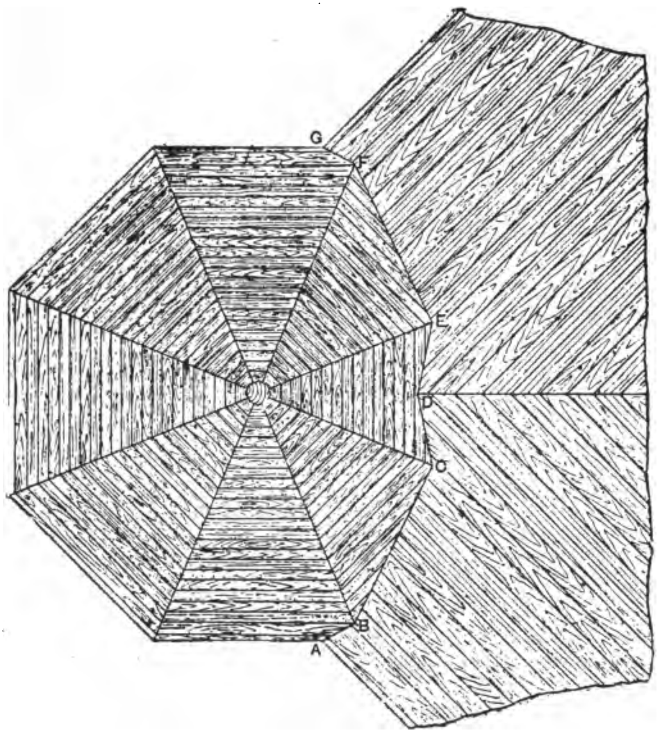

FIG. 85

Before the intersections shown by Figs. 84 and 85, and the timbers shown by Figs. 87, 88, and 89

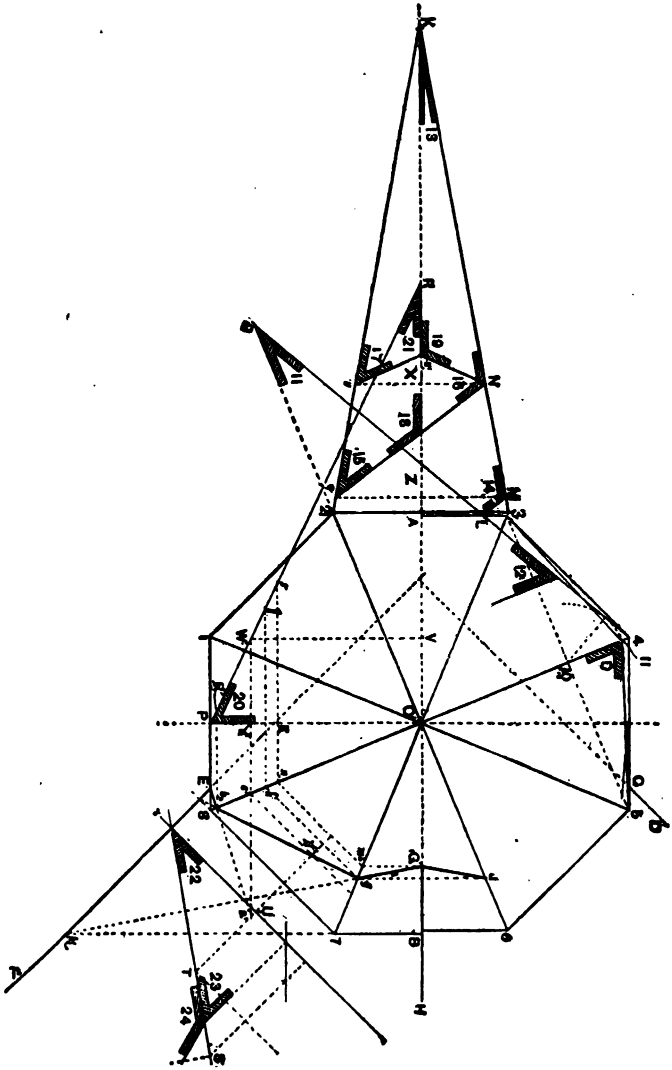

FIG. 86

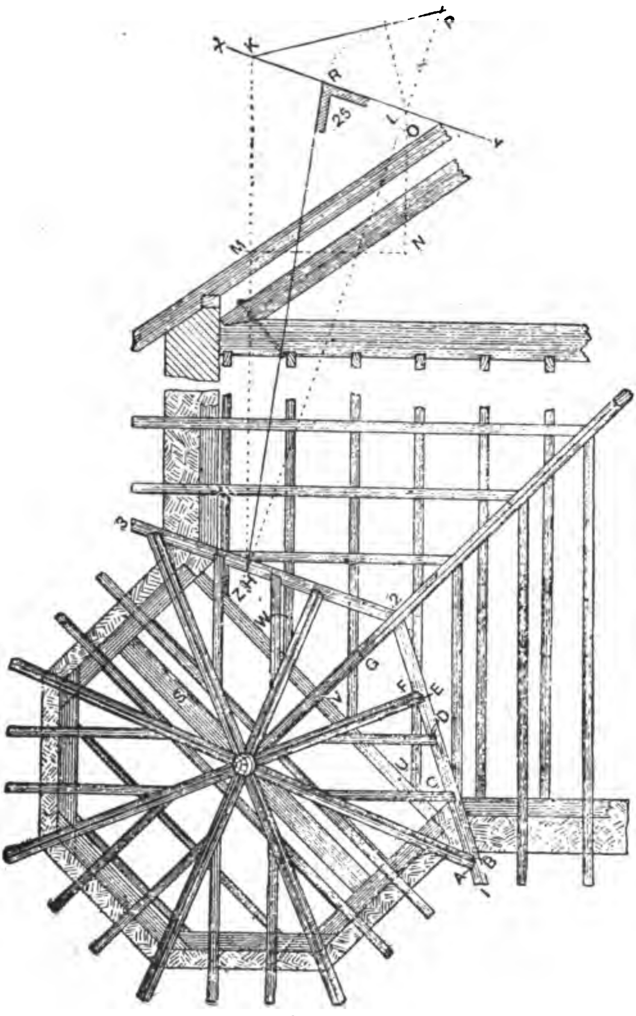

FIG. 87

can be properly set out, it will be necessary to obtain the intersections of the boarded surfaces geometrically. The method of doing this is shown by Fig. 86, and is as follows: Set out the half octagon A2187B, which is the line of board-

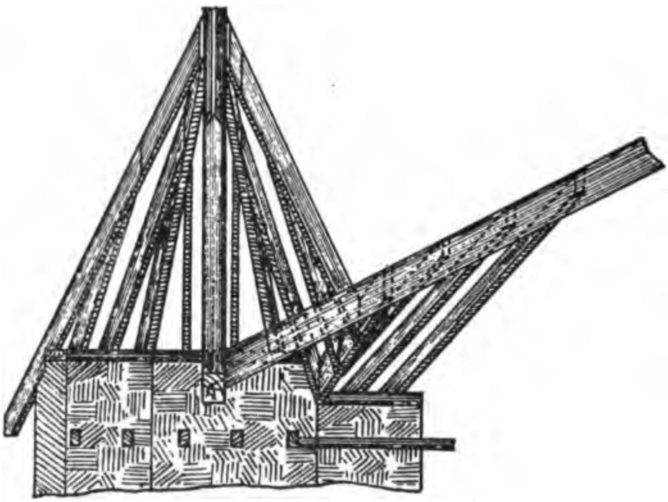

FIG. 88

ing. The other half, A3456B, it will be noticed, is a little less, this being the line of rafters. To avoid confusing the diagrams with a number of lines, several of them have been omitted; it would of course form a smaller parallel octagon to those shown. Next set out line CD, which is the line of feet of rafters, and EF, which is the line of face of the fascia board of the main roof, also the line of the main hips, as shown at GH.

At right angles to 1-8 draw OP, and at right angles to this line set up OR, making it equal to the height. Join PR, which is the true inclination of the sides of the lower roof. At any point along EF draw *xy* at right angles to it, and set up the pitch of the main roof as shown at *xs*.

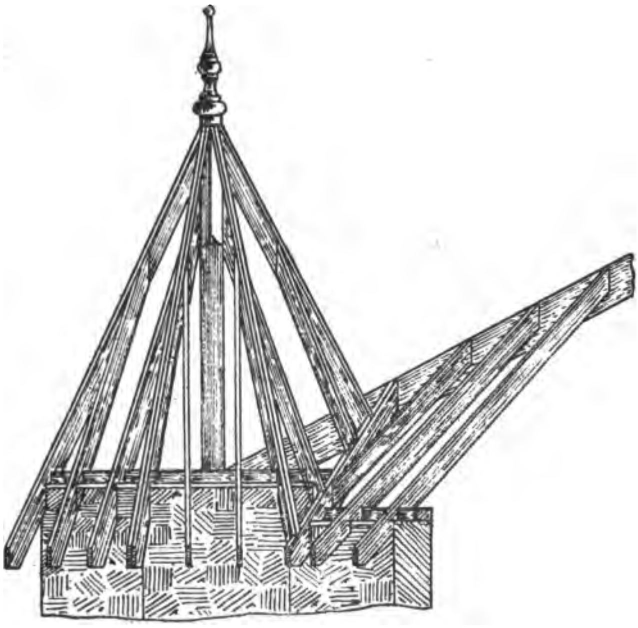

FIG. 89

Now take any point T on this pitch line, and project down at right angles to *xy*, meeting it as shown. From O mark off OV equal to the height TU. From V project across to W, parallel to 1-8, which will meet TU in *a*. Join E*a*, which will give the intersection of the surface 0-1-8, and the main roof. For the next intersection, from where W*a* cuts 0-8 in *e*, draw a line parallel to 7-8. Now produce TU, which meets the last line in *f*. Then from *b* draw through *f* to meet 0-7 in *g*. This gives the intersection of the main roof with the triangular portion, 0-7-8. The side B7 should be continued so as to meet EF in *h*. Join *hg*, and produce to G. Then *g*G is half the intersection of the surface 7-0-6. Workmen having a knowledge of geometry will see that the principle of working this has been based on a problem in horizontal projection, the specific problem being, "Given the horizontal traces and the inclinations of planes, find their intersections."

If it is desired to obtain the developments of the several surfaces, they can be obtained in the following manner: Draw PO at right angles to 1-8, and OR at right angles to OP. Measure in OR the height. Join PR, which gives the inclination and true length of the center line of the full surfaces. Bisect line 2-3, and at right angles to it draw AK, making AK the same length as PR. Join 2K and 3K, which gives the true shape of each of the full surfaces. This development can be used to show the correct shape of the surfaces which intersect the roof. From *b* project up to meet the line PR in *b′*; make AZ equal to P*b′*; then through Z draw line *g*ZM parallel to A3; next make 3L equal to E8. Then 2LMK is the true shape of the side IE*b*O. From *g* draw a line parallel to 7-8, meeting 8-0 in K; then from the point K draw a line parallel to 1-8, and continue it to meet PR, and meeting *b*. Now measure off on the line AE a distance AX equal to P*l*. Through X draw a parallel to 2-3, meeting 3K in point N. Join N*q*; then N*qk* is the true shape of the surface *gbo*. From G draw G*mns* parallel to B78P. From *s* project up to meet PR in *r*. Make A*u* equal to *r*P. Join N*u* and *uv*; then N*uv*K is the true development of the surface JG*g*O.

The method of obtaining the bevels of the several parts may now be described, the means of obtaining the backing of the hips being first shown. At right angles to 0-4 set 0-9, and make it equal to the height; join 4-9, which gives the true rake of the hips. At 11 is shown the bevel for the vertical cut of the top, and at 12 that for the foot. As will be seen, one edge of this bevel is adjacent to the pitch line; the other, being horizontal, is drawn parallel to 0-4. For the backing of the hips, join 3-5, and from where this line meets 0-4 in point 10, draw an arc tangent to the pitch line 4-9. From where the arc meets 4-10 in point 11, join to 5 and 3 as shown; then D is the bevel required.

The bevel for where the hips meet each other is shown at 13. Reference to Fig. 87 will show where this bevel will be required, and also that the upper part of the mast or central post is octagonal. This allows the upper cuts of the hips to be made square through their thickness, and therefore no bevel is required. The development of the intersection shown at 3MNK*vg*2 gives us the bevels for the feet of the hips and rafters A, B, C, D, E, F, and G, Fig. 87. The bevels 14, 15, 16, and 17, Fig. 86, are the feet of the hips A, B, E, and F, respectively, Fig. 87. These bevels are for application after the hips have been backed. The bevels to apply to the backs of the jacks at C and D, Fig. 87, are shown at 18, Fig. 86.

Whilst the bevel for the foot of G, Fig. 87, is shown at 19, Fig. 86, it will be noticed that the valley rafters shown by 1, 2, 3, Fig. 87, have their upper edges in the same plane as the main roof; therefore, it will be necessary to obtain a bevel for the preparation of these edges. The geometrical construction for this is as follows: From any point in the plan of the valley, as H, Fig. 87, draw the horizontal lines HK and HL at right angles to 2-3; then at any point on HL draw XY at right angles to it, and cutting the line HK in K. From where HK cuts the pitch of the roof, as shown at M, draw MN at right angles to HK. Then from L drop a perpendicular to MN as shown. Next project LP at right angles to XY, and make it equal in length to NO. Now join KP; then with L as a center, draw an arc tangent to KP, meeting XY in R. Join RH, which gives the bevel required as shown at 25.

The bevels for the jack are shown at 20 and 21, Fig. 86, whilst the bevel at 13 is for application to the tops of the jack rafter, or these bevels may be obtained by the steel square as shown in previous examples. The methods for obtaining the bevel for the jack rafters for the main roof may be obtained by the square, as shown by 22, 23, and 24, Fig. 86, respectively. The hip of the main roof, as will be noticed, requires supporting at the lower end. This is done by placing a dragon beam across the octagonal space, as shown at S and S, Figs. 87 and 88. Then the end of the hip should be notched, as shown at Fig. 90. The ceiling joists in the octagonal space are fastened into the wall as shown on plan, Figs. 87 and 88. Of course, as is usual, the ceil-

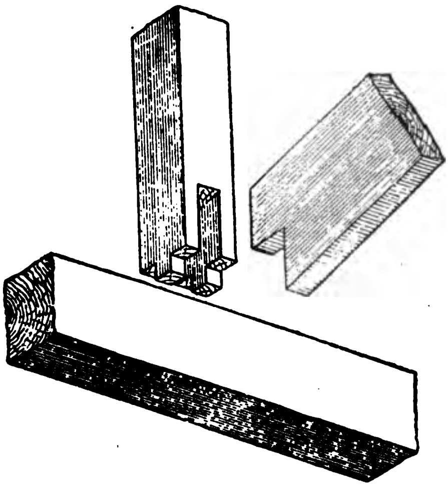

FIG. 90

ing joists should be on the same plane as the ceiling joists in the main building; the ends of four of these, U, V, W, and Z, cannot be carried to any wall, therefore a trimmer is provided of stouter scantling to carry these ends, as shown in the plan and section, Figs. 87 and 88. The boarding is clearly shown in Figs. 84 and 85, and therefore does not require further description. There are other little points which are fully shown in the illustrations, but it has not been thought necessary to enlarge upon them here.

At Figs. 88 and 89 the manner of construction is shown, including projection of rafters over eaves. It will be noticed there is a center post to which the hips or corner rafters are nailed. This post is not absolutely necessary, but when it can be used it is a great help to rapid construction, and certainly makes the work stronger.

The pitch of a tower roof may be obtained along with all the bevel lines by a proper use of the square, as shown in Fig. 91, which illustrates some unusual pitches. It is evident that if the run of one foot is 12 inches the run of two feet must be double that or 24 inches. Therefore the rise must be that proportion of 24 inches. The first inch in rise is $\frac{1}{24}$, the second $\frac{1}{12}$, and the third

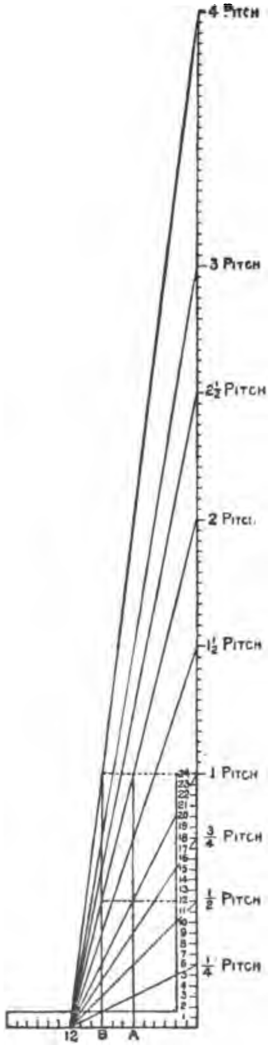

FIG. 91

⅛, the fourth ⅙, etc. The twenty-fourth inch rise being equal, the span is therefore 1 pitch. As the rise continues above this point, it is simply a repetition of the above with a 1 prefixed, thus: The twenty-fifth inch rise being $\frac{1}{2}\frac{1}{4}$ pitch, etc.; but we are now beyond the limits of the full scale as applied to the square, so we must reduce the scale.

By letting the vertical line at A represent the blade we will have reduced the scale one-half. The pitches would center at 6 on the tongue instead of 12, as in the full scale. We must now use the half inches above 12 on the blade for each inch in rise till we reach the twenty-fourth inch which will be equal to 2 pitches or 48-inch rise to the foot.

For steeper pitches it is necessary to again change the scale. If we let the blade rest at B the pitches will center at 3 on the tongue (making the scale ¼ size), and by letting the ¼ inches above 12 on the blade represent the full inches in rise will give the cuts, etc., from the forty-eighth inch rise to the ninety-sixth inch rise to the foot, or 4 pitches.

One of the methods of laying off the lines for an octagonal roof having curved rafters is given at Fig. 92, where a method of obtaining the curves is given. The plan is shown by the octagonal figure, and we will suppose it to be 20 feet

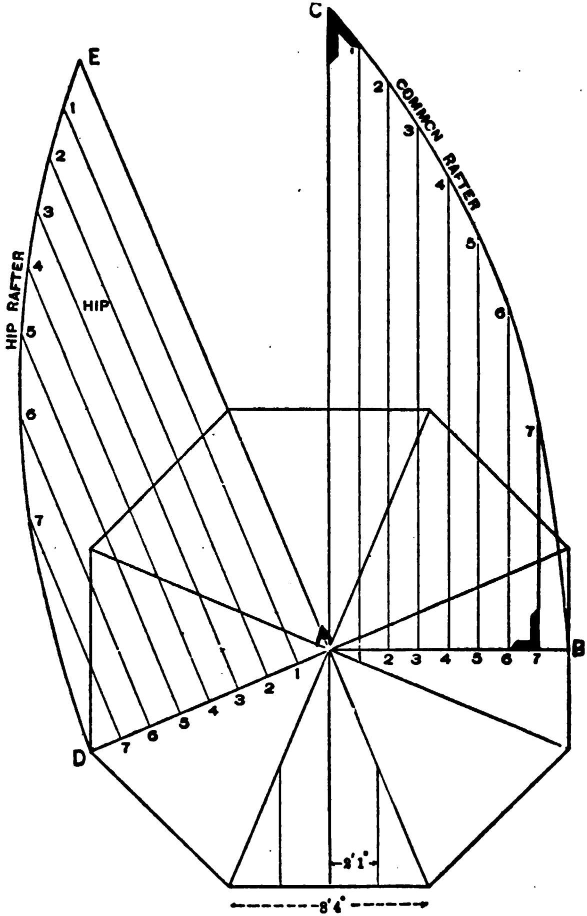

FIG. 92

in diameter and the rise of roof 25 feet. AB is the run of the common rafter and AC its rise. Divide AB into as many parts as may be necessary and square up from each of these points parallel to AC, and cutting the curved line CB, which in this case is struck with a sweep of 38 feet. Now divide the run of the rafter AD into the same number of equal parts as the run of the common rafter AB. Erect perpendiculars from each of these points at right angles to AD and set off from A to E the same distance as that from A to C on the common rafter. Next set off 11, 22, 33, etc., on the hip to correspond with 11, 22, 33, etc., on the common rafter, and connect these points. The result is the shape of the hip rafter. As for the jack rafters, their lengths depend on the number necessary. If one is sufficient, its length would be one-half that of the common rafter taken on the working line, and by making the cut for the upper end through this point, as shown at 4 where we have the proper length of the jack. The plumb and vertical cuts of the jacks are the same as those on the common rafter. The figures on the steel square which give the cuts for an octagon are 7 inches and 17 inches; the 7-inch side giving the cuts. The figures on the square which will give the cuts for common rafter in this case are 5 inches on the tongue and 12½ inches on the blade; the latter giving the upper cut and the tongue the lower cut. The figures giving the cuts for the hip rafter in this case are 5 and 5½ inches on the tongue and 12½ inches on the blade; the latter giving the plumb cut. This will be readily understood for the reason that the run of a hip rafter on an octagon is one-twelfth greater than the run of the common rafter. One method of obtaining cuts of the jack rafters is shown on the lines AB and BC. It will be seen that it will work in any case, no matter what may be the pitch of the roof or the shape of the rafter. Obtain the plumb cut of the upper end of the rafter BC, which is the same as that of the common rafter. Then square across from A to B on the upper edge. Now, as 7 inches and 17 inches on the square will give the cuts of the jacks if they are to have no rise at all, the same will work when they have a rise. Take seventeen-sevenths of the thickness of the stuff which is being worked and set it off square from the line BC to the outer edge, as CD. Then a line from A to C is the bevel of the jacks. All these cuts and lengths may be obtained by using the square, as has been shown in previous examples.

Another method of obtaining the curves for hip and jack rafters is shown at Figs. 93 and 94. The lengths and bevels will, of course, be the same as though they were to be straight, and lay them out in that way on boards wide enough to make the curve. It is best to have them planned and jointed on the back, then strike the curve of the common rafter. It may be struck with a trammel from one center, as in the sketch, or of any shape that may suit the fancy or conditions of the case. Next, divide the length of the rafter on the jointed edge of the pattern into any number of equal parts and draw the lines, as 1, 2, 3, etc., in the sketch, Fig. 94, on the same bevel as the plumb cut. Then proceed in the same

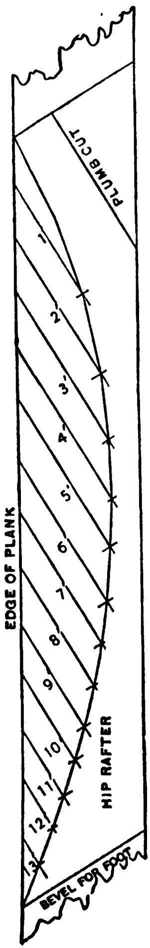

FIG. 93

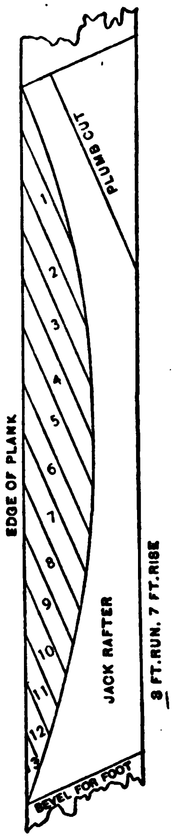

FIG. 94

manner with the board for the hip rafter, being careful to divide it into the same number of

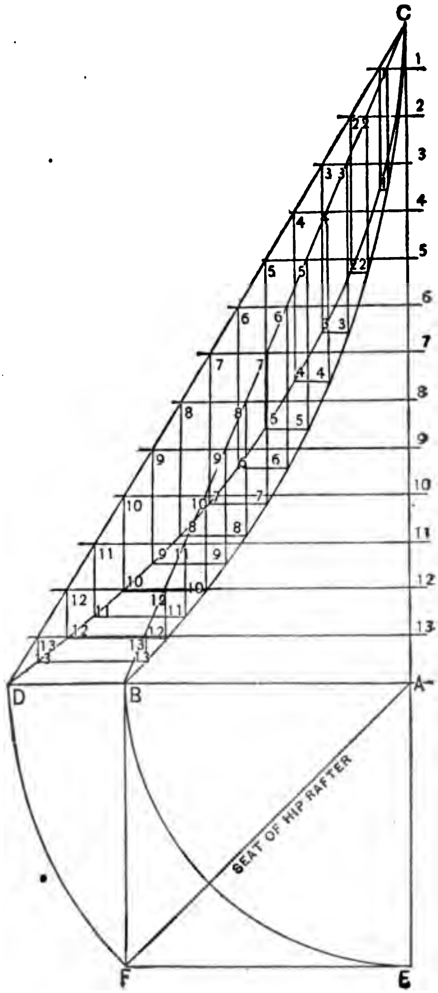

FIG. 95

equal parts, and draw the lines parallel with its plumb cuts. It will be found convenient to number the lines on the patterns the same as shown in the sketch; then, with the dividers or rule, lay off 1′ on the hip equal to 1 on the jack, 2′=2, 3′=3, etc. Then spring a light line or edging and draw through the points thus obtained. If the work is done correctly the two sides of the roof will meet exactly on that line. It will be readily seen that it makes no difference whether the hip is to be set on a square, hexagon, octagon, or at the angle of any other regular figure, providing run and length are first properly set off. Another method, which may be termed a "geometrical method," is shown at Fig. 95, and to those who have any knowledge of geometry further explanation will be unnecessary. It is given here merely as a comparison and may, perhaps, be found useful to a few readers.

The plan and elevation shown at Fig. 96 is almost self-explanatory. It simply shows the lengths and bevels of hips and jacks. The cuts in both hips and jacks are the same as would be for common rafters, except that instead of a square cut across the back of the rafter it must be at a diagonal to fit against the side of the hip, as shown by the dotted lines at A and B.

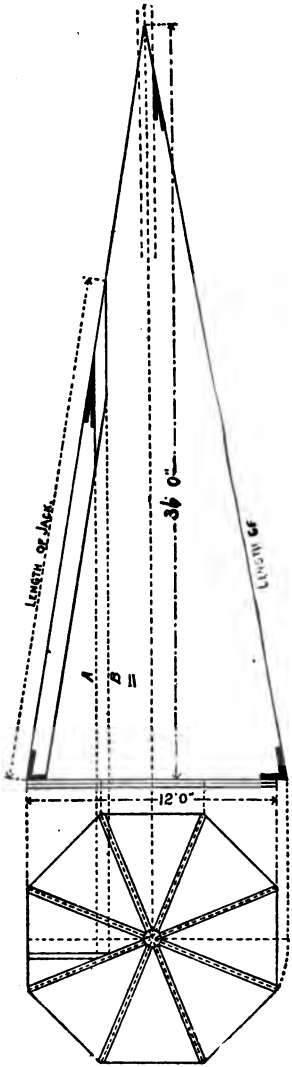

FIG. 96

These lines are always vertical and the same distance apart regardless of the pitch given. A diagonal line from A to B across the back of the jack determines the angle.

Fig. 97 illustrates this point. If there was not pitch at all then 5 and 12 would give the cut. These figures also give the starting points of lines A and B, which, since the rafters are of the same thickness, will remain at right angles the same distance apart. Thus, if the rafter be 2 inches thick, the lines A and B will be 4¾ inches apart.

The jack cut may also be found as follows: Take 5 on the tongue and the length of the common rafter for one foot run on the blade, the blade giving the cut.

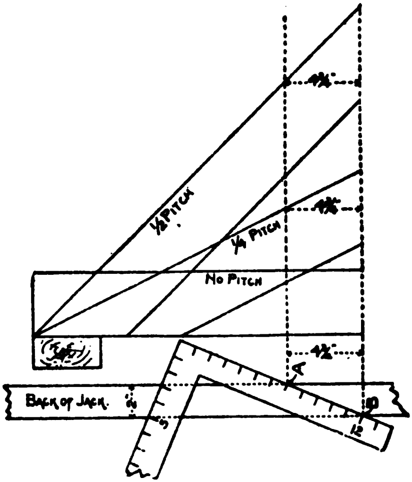

FIG. 97

Fig. 98 is a modified diagram of Fig. 96.

OCTAGON DORMERS

I have thought fit to present to my readers a few illustrations showing how an octagonal dormer is treated in the framing of a first-class roof by architects of note. But little more is necessary than the plans, sections, and elevations showing the mode of construction to enable the reader to understand the whole arrangement.

Fig. 99 shows, in a conventional way, how the timbers are arranged and framed in order to make the dormer bay strong and effective. The

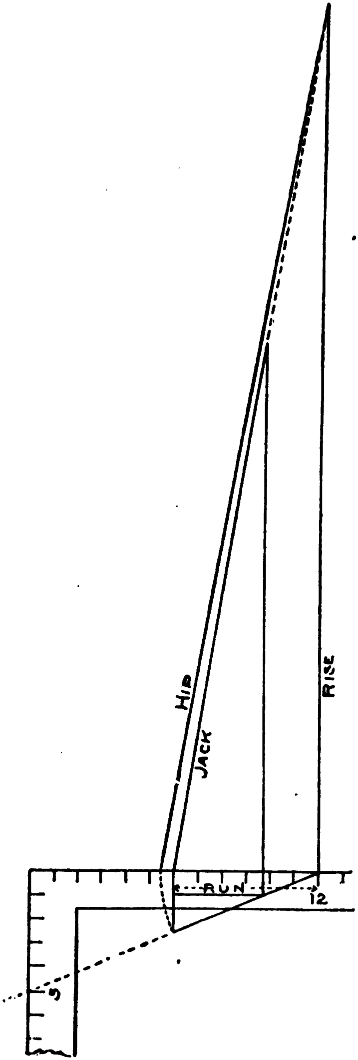

FIG. 98

sidelights in a dormer of this kind are generally fixtures, while the front sashes may be hinged and open in two leaves, or they may be so constructed as to hang with cords and weights.

Fig. 100 shows a front elevation of the framework with sashes in place; and fall-back gable of roof, rafters, and all studding are seen in position. Fig. 101 shows a plan of the whole construction, including top of brick wall, plate, and gutter. This figure requires no further explanation.

Figs. 102 and 103 show side elevations of portions of roof and dormer.

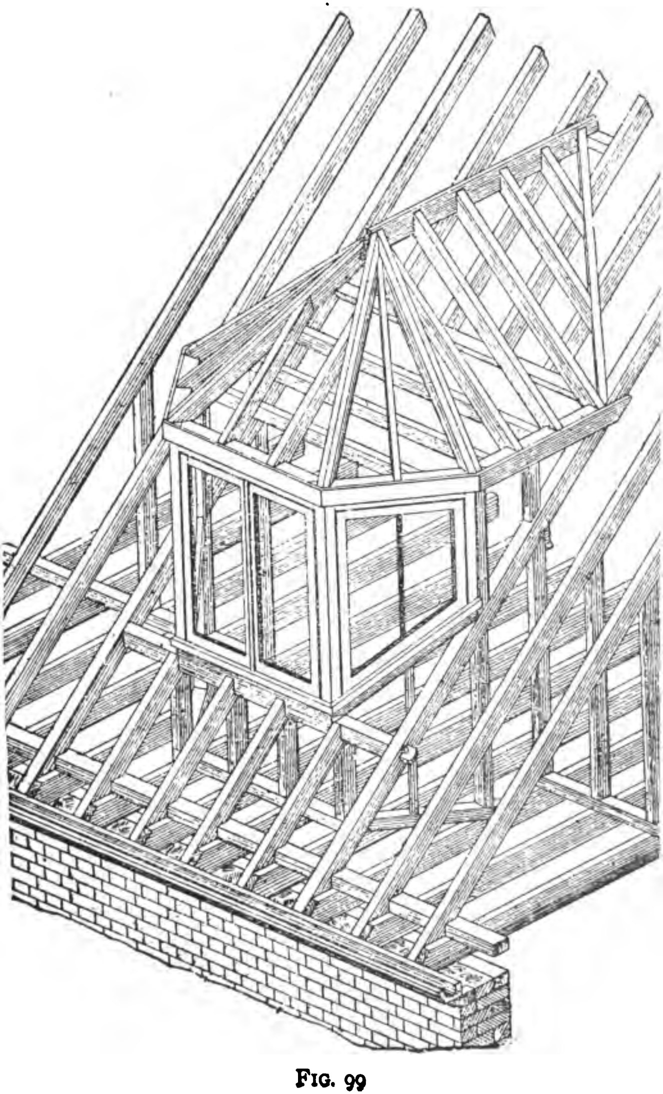

FIG. 99

At Fig. 104 a ground plan of the dormer proper is shown giving shape of corner and

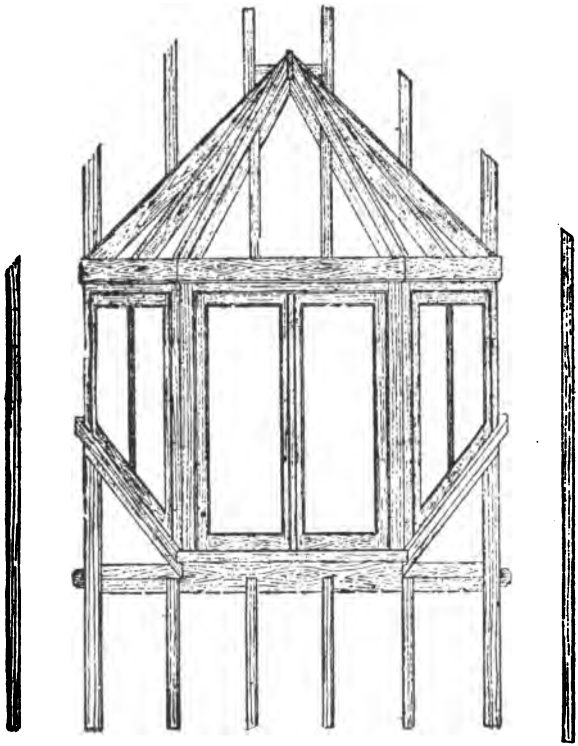

Fig. 100

angle posts. A little study of these examples will enable the reader to understand the principle of construction without further explanations. The steel square may be used to get every cut and bevel in this roof, also bevels for the window sills, as shown in Fig. 105, and which is explained as follows: Take the height of

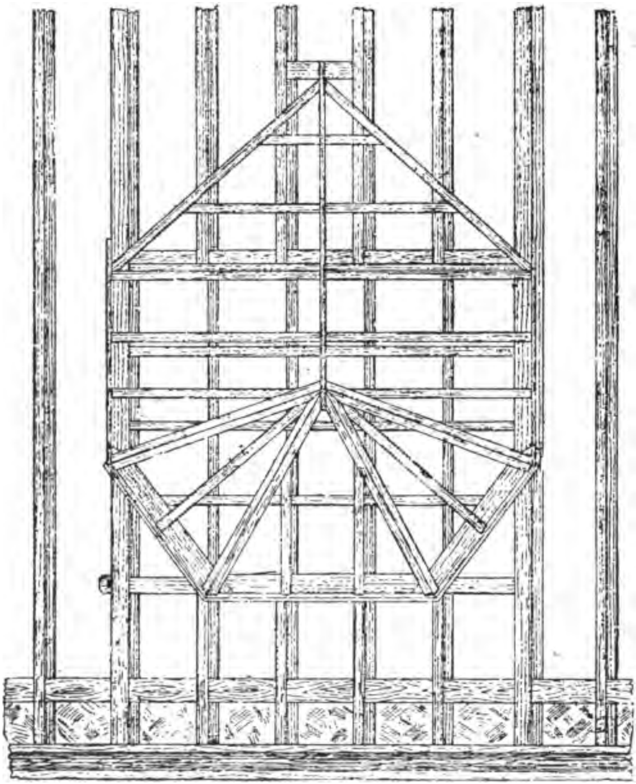

FIG. 101

rise A to A′ and set up from B to C each way. Intersect the two lines at D, one at an arc struck from O as a center, and the other from E. The line from O to D will be the bevel for face of

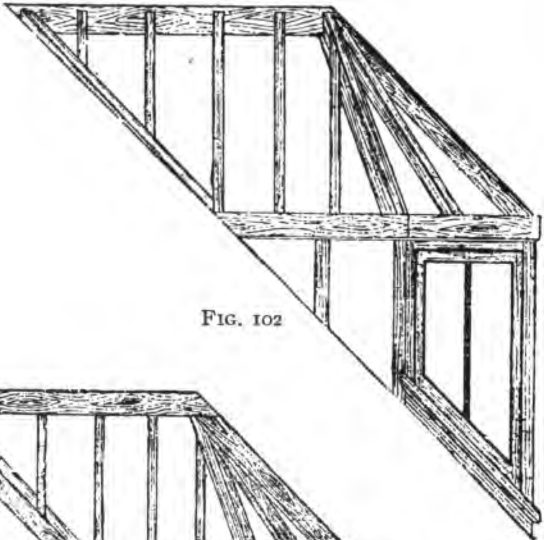

FIG. 102

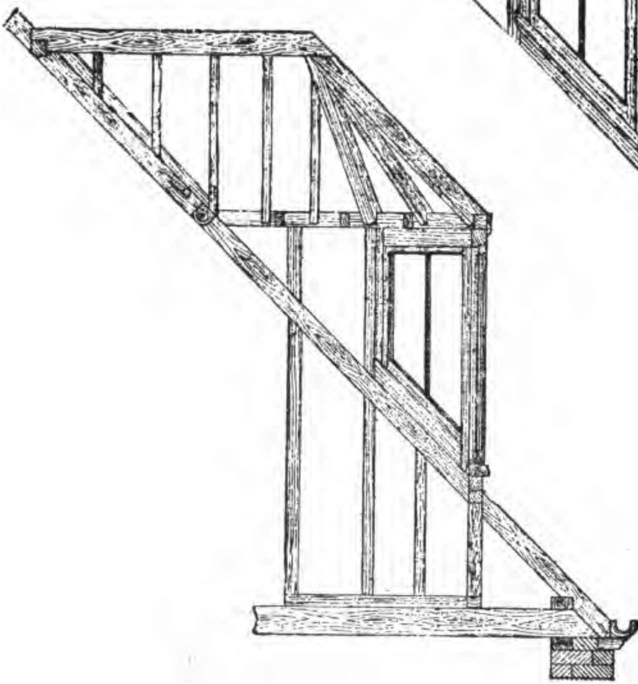

FIG. 103

sill. To obtain the down cuts, drop a line from the point of overhang of sill to the line of inter-

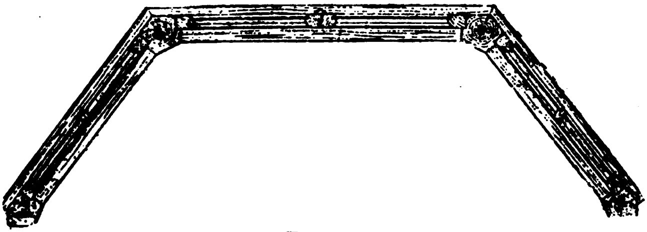

FIG. 104

section of the angle of the bay window. Set off the thickness of sill parallel to face of window.

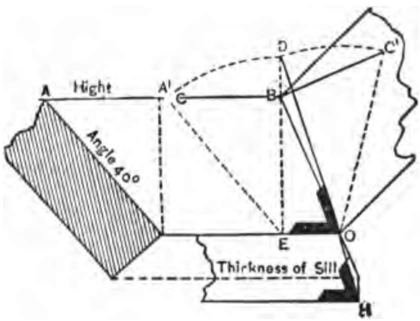

FIG. 105

Square up from where the point of overhang cuts the line of intersection of angle to the thickness of sill, and draw a line from H to O, which will be the bevel or down cut. This, of course, gives the bevels for all sides of the sills. At Fig. 106 I show an octagon tower in place, or rather the method of framing same on a balloon building over a veranda. Sizes of timbers are shown. The example may be of use.

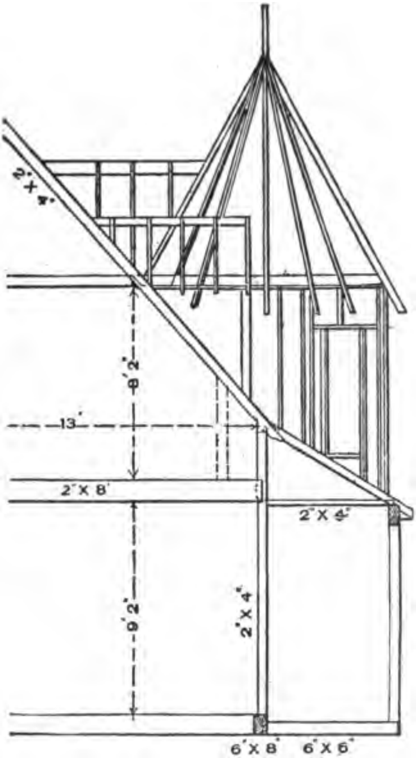

FIG. 106

Fig. 107 shows a plain octagonal tower finished. This is in connection with a two-storied frame house that is sided outside. A portion of veranda and front entrance is shown. The whole is made as plain and economical as possible. While these last two figures have no direct connection with the steel square, it is thought they may be useful as showing the work when finished.

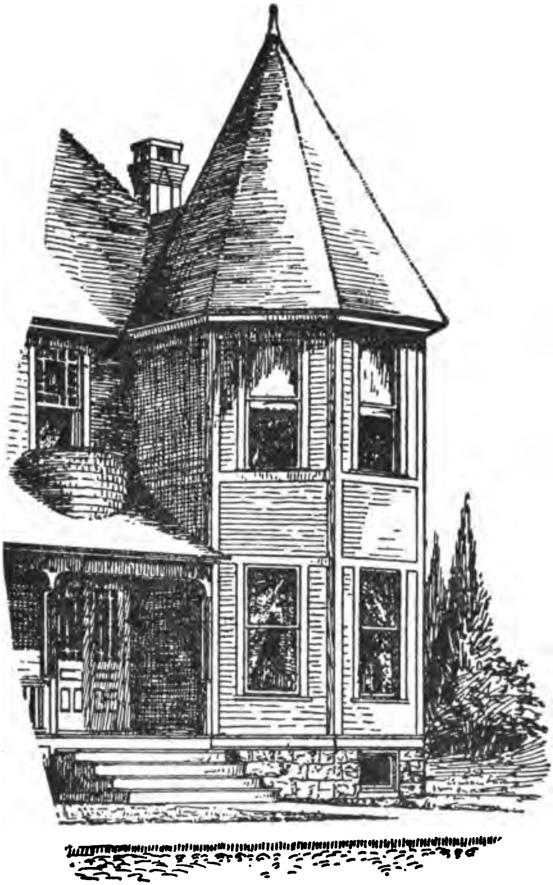

FIG. 107

HOPPERS AND HOPPER BEVELS

The question of "hopper cuts" is one that seems to puzzle nearly all young workmen—and many old ones also. Indeed, I have known many excellent workmen who could cut every timber for a complicated hip roof, on the ground, and whose work was beyond suspicion, who could not lay out the lines for the miter cuts of a hopper in a proper manner. In this chapter I will endeavor to give to the reader, in as simple manner as I know how, a number of the best methods employed by expert workmen for finding the proper lines for cutting hopper bevels, both by geometrical methods and by the use of the steel square, and to this end I have gathered up a number of methods, diagrams, and explanations from various sources—many of which have been published before.

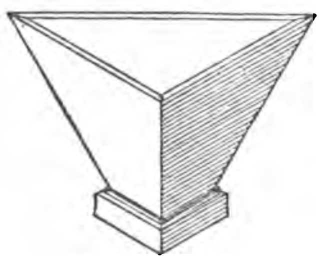

FIG. 108

The shapes of hoppers shown at Figs. 108, 109, and 110 are triangular, square, and hexagonal respectively, while Fig. 111 shows a cover or box lid, which requires a little special treatment.

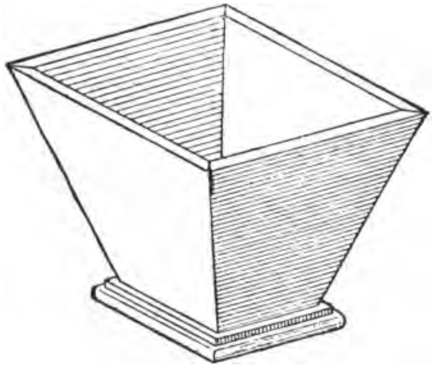

FIG. 109

I will treat all these figures in a geometrical way,

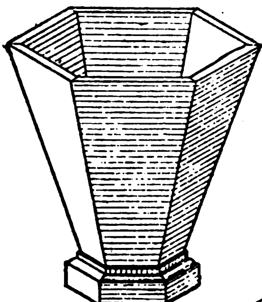

FIG. 110

so that the reader may know the "reason why" it is necessary for certain cuts to have certain lines that are at variance with certain lines in

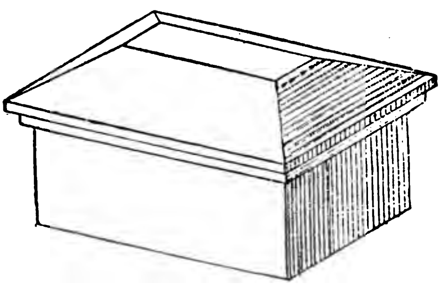

FIG. 111

apparently similar cases. The geometrical problems involved in these cases consist (1) in finding the dihedral angle between two planes; (2) in bisecting this angle, which gives the bevel; (3) in developing or obtaining the true shape of a plane surface. A geometrical problem of a very ordinary type, involving the first

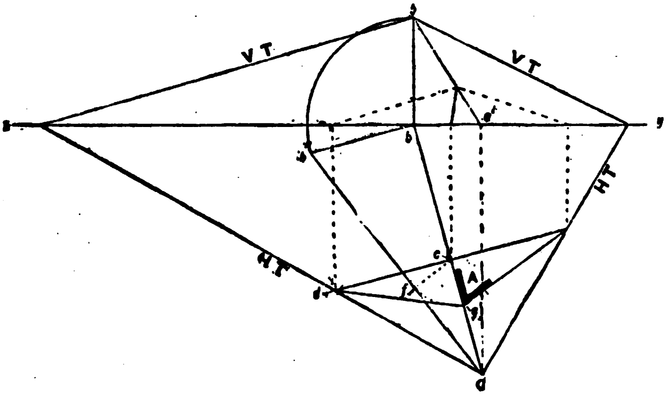

FIG. 112

two of this character, is shown by Fig. 112, where two planes are indicated by their horizontal and vertical traces. The solution is as follows: First find the plane and elevation of the intersection *ab*AB. Next obtain the true length of the intersection by rebating it into the horizontal plane as shown by *a*B. Through any point *c* on *a* draw *de* at right angles to *ab*. Then from point *c*, draw *cf* at right angles to *a*B. Then with *c* as center and *f* as radius cut *ab* in *g*. Join *eg* and *dg*; then *dge* is the dihedral angle between the two planes. Then, given two pieces of material of equal thickness meeting, and it is desired to miter-joint them, the angle for this would obviously be half the dihedral angle, as A.

Let this geometrical reasoning be applied to the case illustrated by Fig. 113, which, as will be seen, is a direct application of the problem just described, *ab* indicating the plane and *a'b'* the elevation of the line of intersection of the two adjacent plane surfaces. Draw *b''* at right angles to *ab*, and make it equal to *hb'*; then joining *a* to *b''* gives the line of intersection rebated into a horizontal plane. Then proceeding with the construction as explained at Fig. 112 (it will be

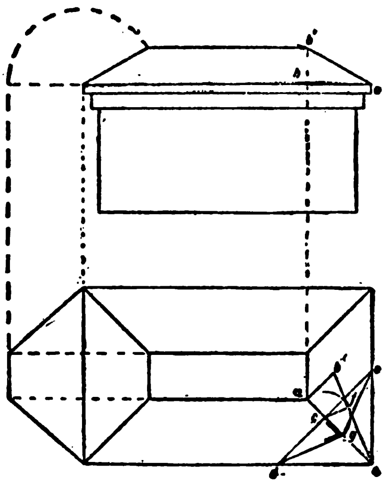

FIG. 113

seen that Fig. 113 is similarly lettered), the angle between the two surfaces of the lid is obtained. Half this angle gives the bevel required for the mitered joint as there shown.

In the cases considered the working has been

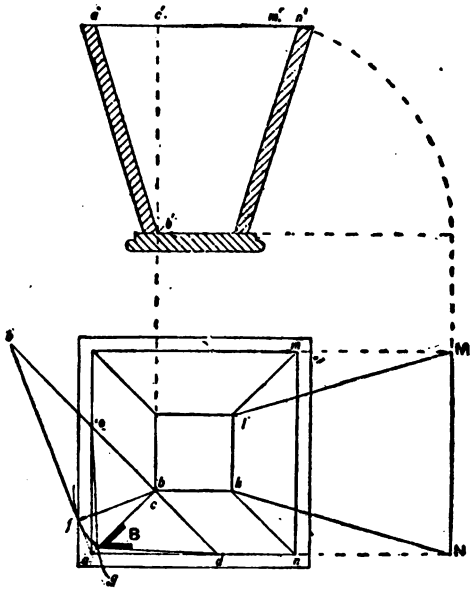

FIG. 114

in front of the vertical plane and on the horizontal plane; that is, in the first dihedral angle of the co-ordinate planes. This has been the most convenient method, because the surfaces slope up and away from the observer; whereas in the cases shown by Figs. 114 to 116 the surfaces slope upward and toward him, and therefore, for a person who has the necessary knowledge of geometry, the simplest method will be to work under the horizontal plane, but in front of the vertical, that is in the fourth dihedral angle of the co-ordinate planes. Taking the case of Fig. 114, *ab* is the plan of the intersection of the two surfaces. At right angles to this, set up the line *b*B, making it equal to BC. Join *a*B; then this line is the true length of the intersection constructed upward into the horizontal plane. Then through *c* draw *de* at right angles to *ab*—it should be noticed here that half the line *de* coincides with B, the intersecting surfaces being equally inclined. Then from *b* draw *bf* at right angles to *a*B. Next, with *c* as a center and *cf* as radius, describe the arc cutting *ab* in *g*. Then joining *dg* and *eg* gives the bevel required, as shown at B. By imagining the object at Fig. 114 turned upside down, exactly the same kind of working as that just described would apply; but perhaps the problem will be simplified by imagining that the work is in the first dihedral angle of the co-ordinate planes. To many who understand geometry this method of working this problem will commend itself as being simplest to imagine, although giving the same results. In Fig. 115 precisely the same reference letters have been adopted, and it will be seen that the same problems and principles are involved.

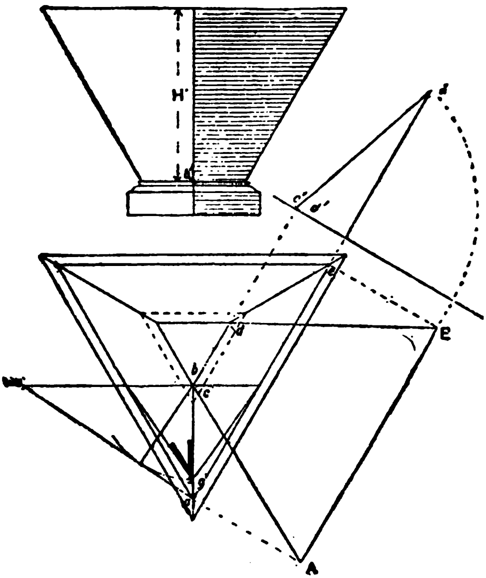

FIG. 115

The geometrical formula for finding the true shape of development of the sides is: Given the plane and inclination of a plane surface, determine its true shape. A problem of this class is shown at Fig. 117. Let *abcde* be the plan of the given figure, its side *ab* being the horizontal plane; through *ab* draw a horizontal line, at right angles to which draw *xy* as shown; next set out the angle of inclination of the figure as shown by the line VT, which may be considered

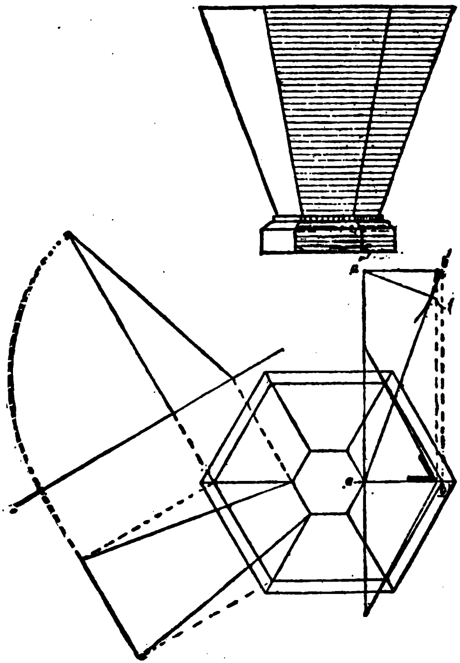

FIG. 116

as the vertical line of a singly oblique plane. From the plan set up projectors to this plane, then rebate back the figure into the horizontal plane by drawing the arc projections to *xy*; and from these, projecting at right angles to *xy*, and from *cd* and *e* parallel to *xy*, gives the points CD and E. Joining *a* to E, E to D, and D to C, and C*b* gives the true shape required.

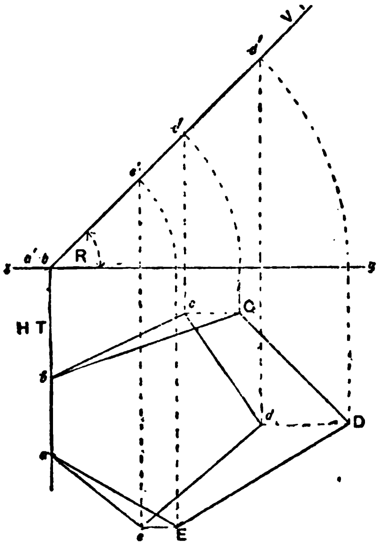

FIG. 117

If the working of this problem has been carefully followed and mastered, its direct application to cases shown at Figs. 113, 114, 115, and 116 will be readily understood.

The foregoing is meant primarily for geometricians, and secondarily for those who wish to know the "reasons why" of hopper bevels.

Having shown this much, simply to satisfy the "learned" in "theoretical" carpentry, I will now proceed to show how all the lines and cuts may be obtained for this work by aid of the square alone and in a speedier and simpler manner.

Let us suppose Fig. 118 to represent a section through a hopper; then take a board 12 inches wide, joint one edge and draw a line of the side elevation according to the refinements. From this proceed to make a draft with the square 1 inch to a foot. Take 12 inches on the blade, hold 12 at A, and by it find how many inches rise the given inclination is to a foot. Draw a line by the tongue, as shown by BV, Fig. 119. At B draw square with AC, and again square on line AB through C, as shown by CL. From VB erect a perpendicular also to C, cutting VB in the point E. By these several operations we have a complete draft by which to solve the problem. AB is the given slant, and has 9

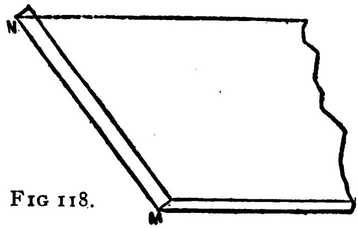

FIG 118.

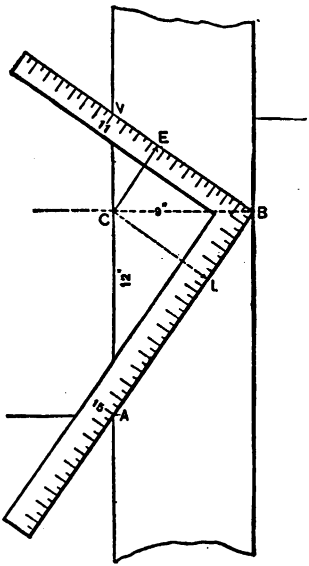

FIG. 119

inches rise to a foot. AC is 12 inches, and CB is 9 inches. The length of AB, as indicated by the figures on the square, is 15 inches. Fifteen inches, therefore, is the width of the board required to cut the hopper.

Use the foot draft of the hopper as follows:

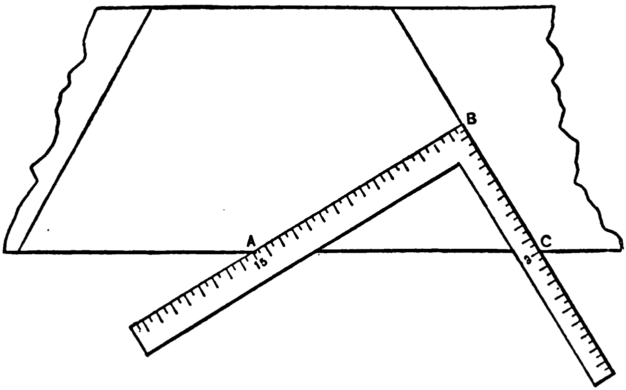

FIG. 120

Take on the blade AB, and on the tongue CB, and apply the square to the board as shown in Fig. 120. Mark on the tongue, which will give the down-cut bevel.

For a butt joint take EC on the tongue and CA on the blade and apply it as shown in Fig. 121. Mark on the square edge of the board EC.

The above principles will give the manner of backing a hip rafter. Suppose that AC, Fig. 119, were the seat of the hip rafter, and AB the length of the hip, by taking CL on the tongue and CB on the blade, marking on CL and setting

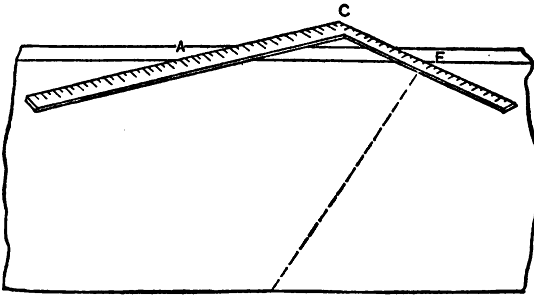

FIG. 121

the bevel by that line, the exact backing of the hip will be obtained. The handle of the bevel is to be square across the hip rafter, as shown at CL in Fig. 119.

A very good way, and one I have found to work out correct, and which I take from "Carpentry and Building," for obtaining the butt joints for hoppers, is as follows: Draw a line CD, Fig. 122, at the same angle with the straig h edge of the board AB as the sides of

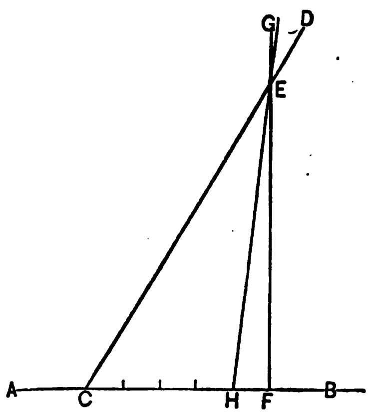

FIG. 122

the hopper are to stand. Cut this line at any point, E, with a line, FG, drawn at right angles with AB. Divide CF into five equal parts, and through the fourth point thus established draw a line as shown from H, cutting E. Then HE will be the bevel of the butt joint. This rule will work no matter what the flare of the side or width of boards used, providing always the hopper is square-cornered.

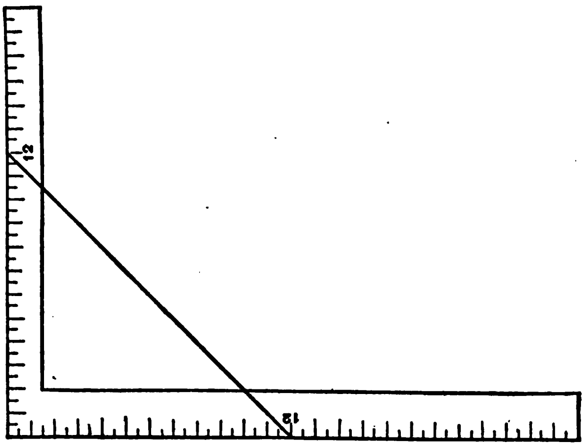

FIG. 123

A handy rule is given as follows: Let Fig. 123 represent the slant of the hopper as shown by the line running from 12 to 12 on the square. Figs. 124, 125, and 126 show the applications. Fig. 123 represents the square with a line drawn from 12 to 12; this line shows the flare of the hopper. The distance from 12 to 12 on the diagonal line is 17 inches nearly, as I have shown

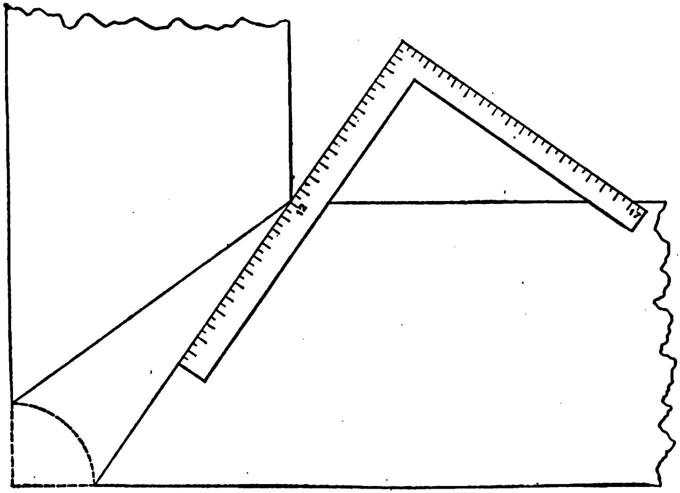

FIG. 124

previously. The angle of the miter on the hori-

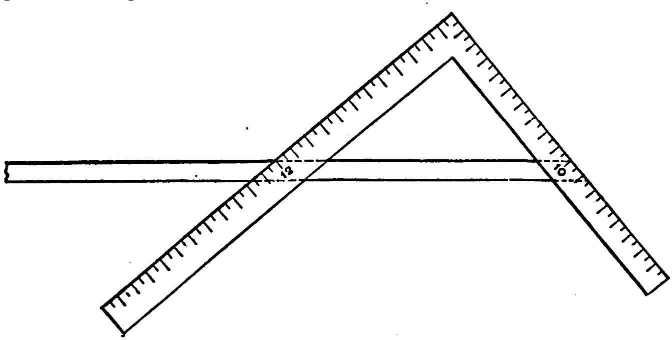

FIG. 125

zontal is 45° or a true miter. The base line from the corner of the square to 12 is 12 inches, the pitch line is 5 inches longer than the base line (the difference between 17 and 12 inches). Add 5 inches, the excess of the pitch from the base line, and we have 12 and 17 inches of bevel and miter. The application of this is shown in Figs. 124 and 125. For a butt-joint the sides slant two ways on each angle. The angle on the horizontal is a right angle. The excess of the pitch from the base line on the one side is 5 inches, and on two sides 10 inches, making an angle or-

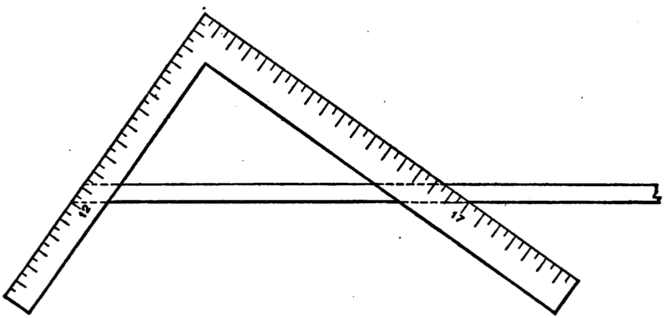

FIG. 126

joint 12 and 10, as shown in Fig. 126. The latter figure shows the application of the rule named; all the stuff being square-edged. This method when thoroughly understood is very simple and effective.

Another method, somewhat similar to the one already shown, is given herewith. To obtain the bevels of a hopper either by the square or lines, the rise to the foot of the sides being given, first ascertain the hypothenuse from 12, taken on the blade of the square, to the rise to the foot, taken on the tongue. Divide the square of 12 by the rise to the foot. Apply the square to a straight-edge, taking the hypothenuse on the blade and 12 on the tongue. This will denote the surface bevel. Again, apply the square to the straight-edge, taking the hypothenuse on the blade and the rise to the foot on the tongue. This will denote the bevel of the miter-joint, so called. For a butt-joint, take on the blade the quotient arising from the division of the square of 12 by the rise to the foot, and on the tongue take the hypothenuse. Then the blade will denote the bevel required.

Another method on the same diagram is as follows: Apply the square to a straight-edge, taking 12 on the blade, the rise to the foot on the tongue, and mark by the blade to obtain AD of Fig. 127, which represents the inclination of the sides. At random make BD perpendicular to ABC, which represents the straight-edge, taking AD on the blade and AB on the tongue. This will give the surface bevel. Again, apply the square, taking CD on the blade and BC on the tongue, which will denote the bevel for the

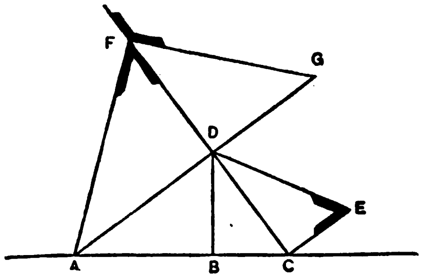

FIG. 127

miter-joints. For butt-joints apply AB taken on the blade and CD taken on the tongue. The blade will denote the bevel required. The same results may be obtained by geometrical construction, as follows: Referring to Fig. 127, make DF equal to AB, and draw AF; make DG equal to CD and draw FG; make CE perpendicular to CD and equal to BC and draw DE. The designated acute angles at F will be the angle of the surface bevel. The designated obtuse angle at F will be the bevel for the butt-joint. The angle at E is the bevel for the miter-joint.

The foregoing may be applied to roofs of one pitch over rectangular bases. Fig. 128 represents a section of cornice. That which relates to the surface bevel is applicable to the surface bevel of the boarding, the outward bevel of purlins which come in contact with each other or with hip rafters, the surface bevel of the planceer in a cornice similar to the diagram, and the edge bevel of a fascia. That concerning miter-joints is applicable to the edge bevel of the boarding, the inward or down bevel of purlins, and the surface bevel of the fascia. Applying the square to a straight-edge, according to the directions given in the first and second methods above presented for obtaining the surface bevel, and marking by the blade, we obtain the edge bevel of jack rafters. In Fig. 127, FAD denotes the edge bevel of jack rafters. In order to properly get the crown molding for a cornice similar to the drawing, lay off on the edge of a miter-box the surface bevel of the board, and on the sides the edge bevel.

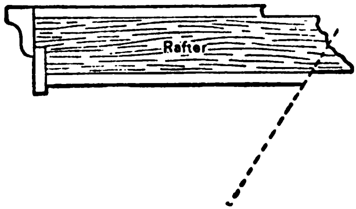

FIG. 128

Hopper cuts to a large extent are similar to the cuts required for fitting boards in or over a valley or hip roof; consequently the figures on the square that give the cuts for the roof boards must give the cut for a hopper of the same pitch.

Fig. 129 shows a hopper in different views, as follows: Beginning at the top is the top view of

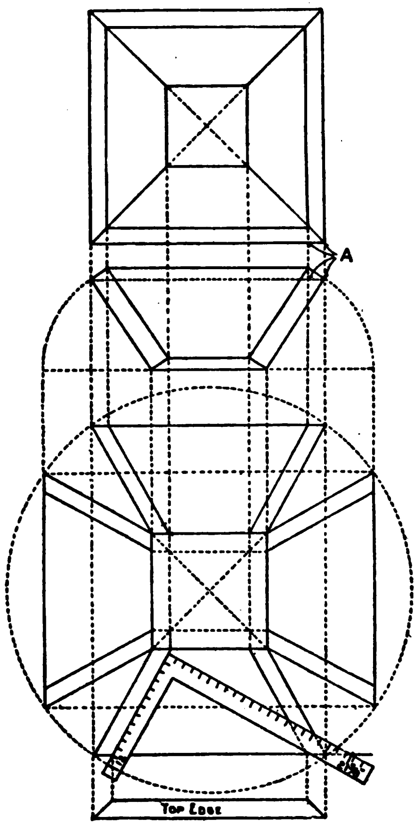

FIG. 129

the hopper. As far as this part is concerned all hoppers look alike, as there is nothing in this to distinguish the pitch. Next is the sectional or side view. In this is shown the thickness of the boards and the flare or pitch, which in this is the three-quarter pitch. Following (Fig. 129) is shown the four sides in the collapsible or ready to be put together, followed with the top view of the edge of the board.

Of course it is not necessary to lay out all of this diagram, or any of it for that matter; it is done by way of illustration. See the application of the square, which, in this case, is 12 and 21⅝. But why use these numbers? Because the flare given is the three-quarter pitch, or 12 and 18 on the square, and the hypothenuse of these numbers is 21⅝, the tongue giving the side bevel. When working full scale it is always 12 on the tongue.

For the miter bevel, the top edges should be first beveled so as to be level when in position. The miter would be at an angle of 45°, and any of the equal numbers on the square gives this cut; but if the edges are to be left square with the sides, as shown, the above will not work.

To accomplish this, however, a very simple way is shown in diagram at A, or in Fig. 130 as follows: Lay off the base and the desired pitch, and on the latter measure the thickness of the board as at AB. From B draw a plumb line to base. BC is the width apart; the side bevels should be along the edge of the board.

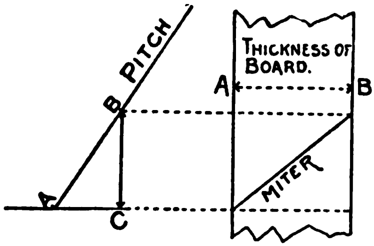

FIG. 130

In case of large hoppers to be built to suit some particular place, or regardless of pitch, it is better to use the one-inch scale as illustrated in Fig. 131. The figures 7½ and 17⅞ give the side cut, while the section gives the miter.

This diagram is all that is necessary to find the cuts for any size hopper, and were it not for the miter even this is unnecessary.

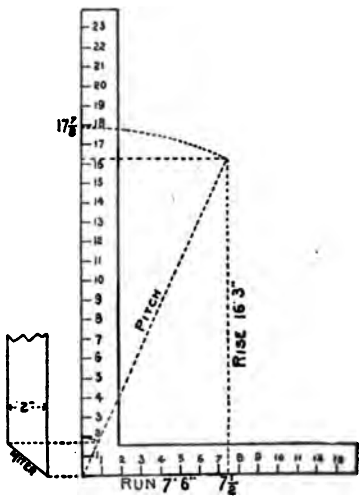

FIG. 131

Another method is here offered which is taken from the old "American Builder," and which many of the older workmen will recognize, as it was at one time in great favor. The lines E, D, H, A, and

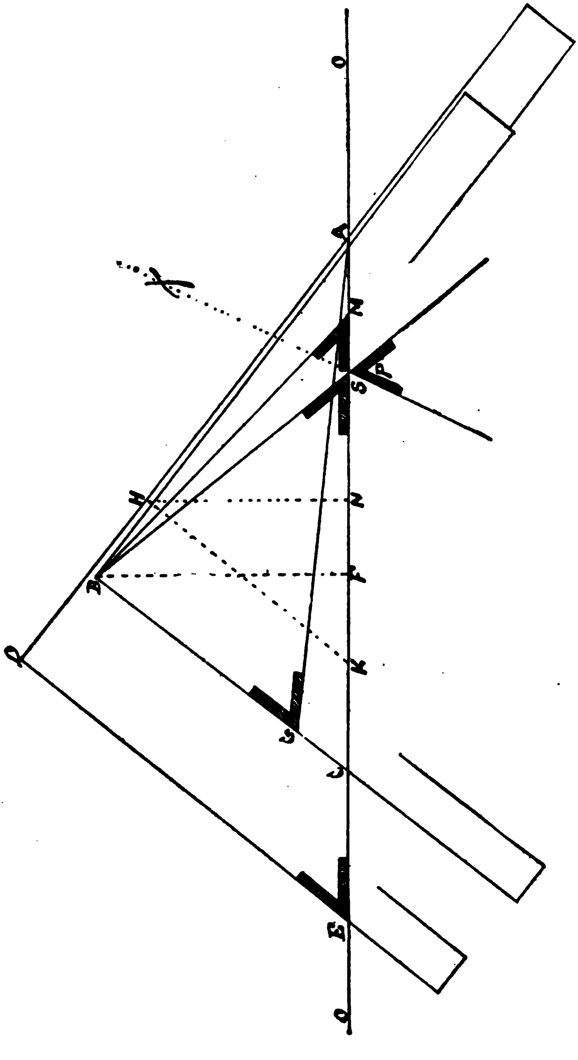

FIG. 132

C, G, B, Fig. 132, show the outside edges of the steel square, or squares; OO is the edge of the board. Half the width of the width of the top less half the discharge hole on the blade AB. The depth on the tongue BC gives the diagonal AC, the width of the side. Make AD on the blade equal AC, and DE on the tongue equal AB, and E is the bevel for face of stuff. Make GB equal FB; connect GA, and G is the miter cut for edge of stuff. Square a line from OO, cutting AB. To save extra lines use FB. Make AH (on AD) equal AF. HK square from AD, and FM equal HK; connect MB, and M is the bevel for straight cut (to nail on, as we nail a box together, square instead of miter), the long point inside. If we make the line cutting at H square from AE instead of AD, as NH and FS equal NH, connect SB, and S is the trying bevel for straight cut. Bisect BSO; draw the miter line and it gives P the trying bevel for miter cut; the lines are extended and bevel P placed below the line for want of room above.

And yet another method: Suppose ABCD, Fig. 133, to represent the elevation of a box, the sides of which have a slope of 45°. Take C as a center and CB as radius, and describe the semicircle under the line AB, as shown by BEJ.

From C let fall a perpendicular through the line AB, intersecting the semicircle in the point E. Through the point E thus established draw a horizontal line or a line parallel to AB, making it in length equal to AB. From

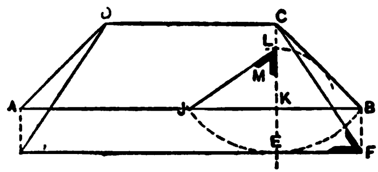

FIG. 133

the point F thus established draw FC. Then the bevel at F will be the bevel to be used for the sides of the box or hopper. To find the bevel of miters at the corners with K as center and radius equal to the distance from K to the line CB, describe an arc cutting the line KC, thus establishing the point L. From L draw the line LJ, cut-

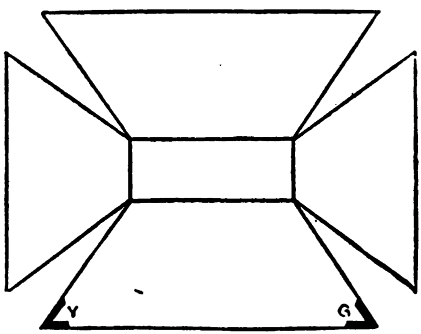

FIG. 134

ting the line AB at the point J, which represents the intersection of the arc first drawn with the AB. Then the bevel at L is the bevel of the line join it and E, and four times this line DE will be equal to the circumference of the circle. This may be proven as follows: Join B, E, then draw E parallel with the diameter cutting the perpendicular in J; draw through R parallel with JE cutting in F and H; join J, D, and we have AB, which divided the circumference into six equal parts; i.e., DC7, BE8, FH9, AC10, KJ11, NP12, BL13, PR14, and BC into 16 parts. This diagram also gives the lengths of chords which divide the circle into equal parts and proves the accuracy of the line DE, as four times this line will be the circumference.

Now comes in the steel square, where these dimensions may be worked out without drawing a line. Looking at Fig. 149 we find that the lines DJ and DR form an angle in which is a bevel marked X which plays an important part in the next illustration.

Let EB on the blade of the square, shown at Fig. 150, be the radius of the circle; lay a straight-edge across the square, keeping one edge on the point E, then apply the bevel X, as shown, to the blade of the square so that the blade of the bevel will align with the edge of the straight-edge; then the distance BR on the blade will be twice the length of DE, Fig. 149, and consequently equal to half the circumference of the circle.

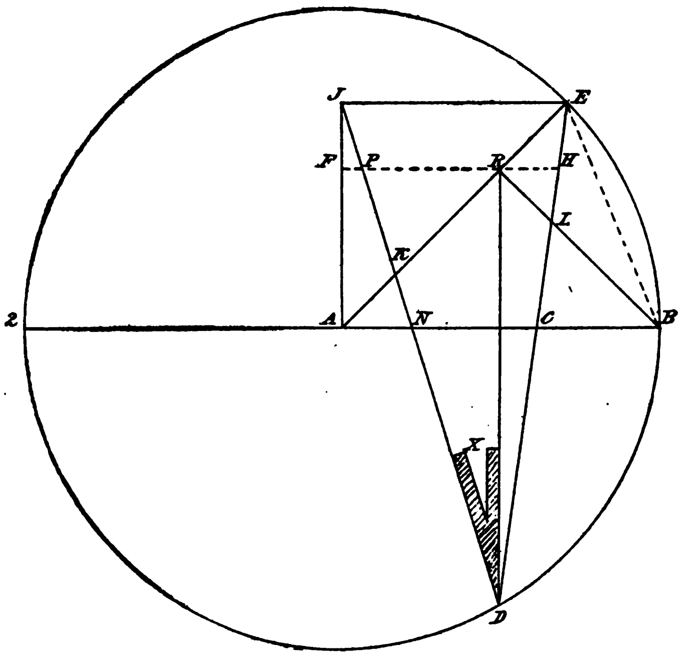

FIG. 149

To find the figures on the square that shall give an angle equal to that of DJE, Fig. 149, in which is seen that bevel X, lay a straight-edge across the square, keeping the edge to the mark 9½ on the blade and 3 on the tongue; then the angles thus formed by the straight-edge and the square will be found to exactly agree with that of bevel X, which was obtained by the geomet-

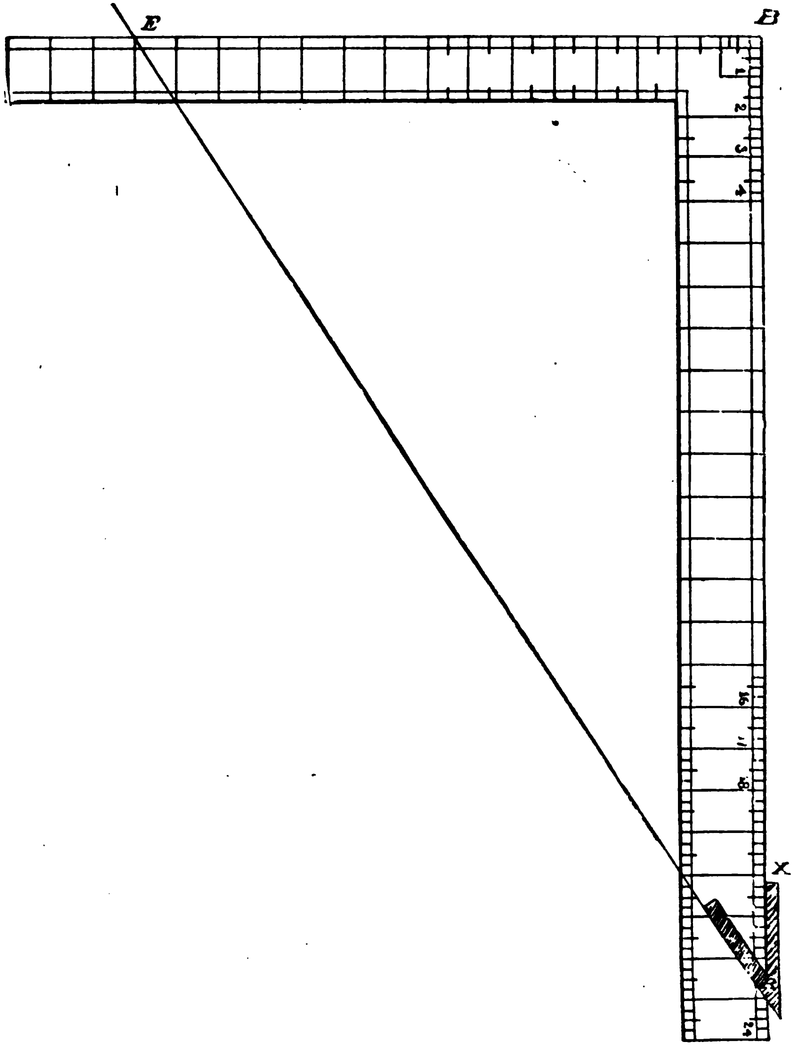

FIG. 150

rical construction of Fig. 149. This is a useful problem and may often be put to practical use.

To divide a line of any length into any number of equal parts by the steel square, we proceed as follows: The heel, or external angle of the square, is shown at A, Fig. 151. Take line No. 1, which may be made to half-inch scale, and we find it will measure 17 feet 6 inches, which is required to be divided into thirteen parts. To do this, let AB on tongue of square equal AB on the right; make A5 on blade of square measure 6½ inches, or thirteen halves, which are equal to the number of parts required. Draw line 5B; make 5L equal one-half inch; from L square over a line cutting in N; then LN divides line No. 1 into thirteen parts, length of each 1′4″.

Take line No. 2. This measures, by a quarter-inch scale, 31 feet 5 inches. It is required to be divided into 22 parts. To do this, let AC on tongue of square equal AC No. 2, on the right, and A4 on blade of square measure 5½ inches or 22 quarters, which is equal to the number of parts required. Draw line 4C; make 4R equal ¼ inch; from R square over a line cutting in K. This gives RK, which will divide line No. 2 into 22 parts as required. Length of each 1′5″.

No. 3 on the right. This line measures, by a quarter-inch scale, 26 feet 6 inches. It is

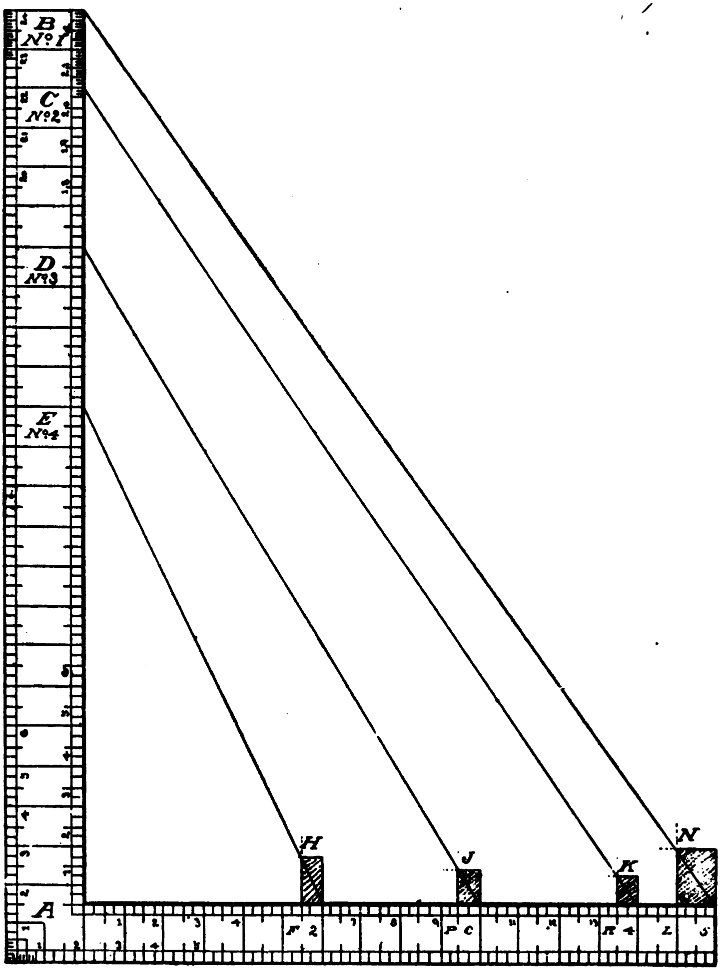

FIG. 151

required to be divided into 17 parts. To do this, make AD on tongue of square equal AD, No. 3 on the right, and A3 on the blade of square to measure 4¼ inches or 17 quarters; that being the number of parts required. Draw line 3D; make 3P equal ¼ inch; from P square over a line cutting in J; then PJ divides line No. 3 into 17 parts. Length of each 1'7".

No. 4 on the right. This line measures, by a quarter-inch scale, 23 feet, and it is required to be divided into 11 parts. This is done by making AE on tongue of square equal AE, No. 4 on the right. Let A2 on blade of square measure 11 quarter inches, that being the number of parts required; draw line 2E; make 2F equal ¼ inch; from F square over a line cutting in H; then FH divides lines No. 4 into 11 parts. Length of each 2' 1$\frac{1}{11}$".

In dividing a space of any great extent, the quarter-inch scale will be found most convenient. To give a practical illustration: Suppose a line to be 96 feet long, and it is required to be divided into 48 parts. Begin in a systematic way by squaring over a line on the surface of a board, and from its edge mark one foot on the line; one foot being equal to 48 inches. Next, measure two feet from the line along the edge of board, two feet being equal to 96 quarter inches. Now proceed to find one part that will divide 96 feet into 48 parts. The answer is given by the method just explained.

A little thought will enable the student to use any scale that is divisible by the divisions and subdivisions laid down on the steel square, a matter that will enable him to divide lines of almost any length.

When we know the side of a square we can readily find its diagonal by the steel square as follows: Suppose AB, Fig. 152, be the side of a square which measures, by a quarter-inch scale, 6 feet 10 inches. To find its diagonal, draw the line BC to the angle 45°; take A as center and strike an arc touching line BC, cutting in V. Join V, C. This gives bevel W; let it be applied to the square, Fig. 153, and at the distance AB, which is equal to the side of given square, lay a straight-edge against the blade of bevel and the line made by it cuts in mark C on the square, giving AC for the diagonal, which measures 9 feet 7 inches. This agrees exactly with line PR or BC, Fig. 152.

Now let it be required to give the diagonal of a square, the sides of which are equal to A2, and measure 10 feet 6 inches; find its diagonal at

Fig. 153 by making A2 equal the side of square; let bevel W and the straight-edge be applied as

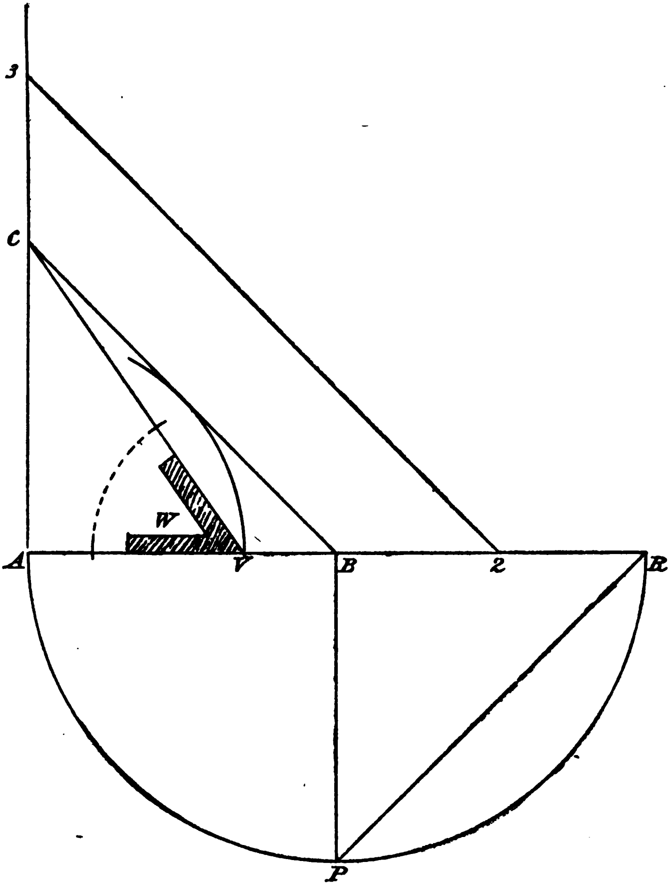

FIG. 152

before; then the line from 2 cuts mark J on the square, giving AJ for the diagonal, which measures 14 feet 8 inches; this agrees with diagonal 2-3, Fig. 152.

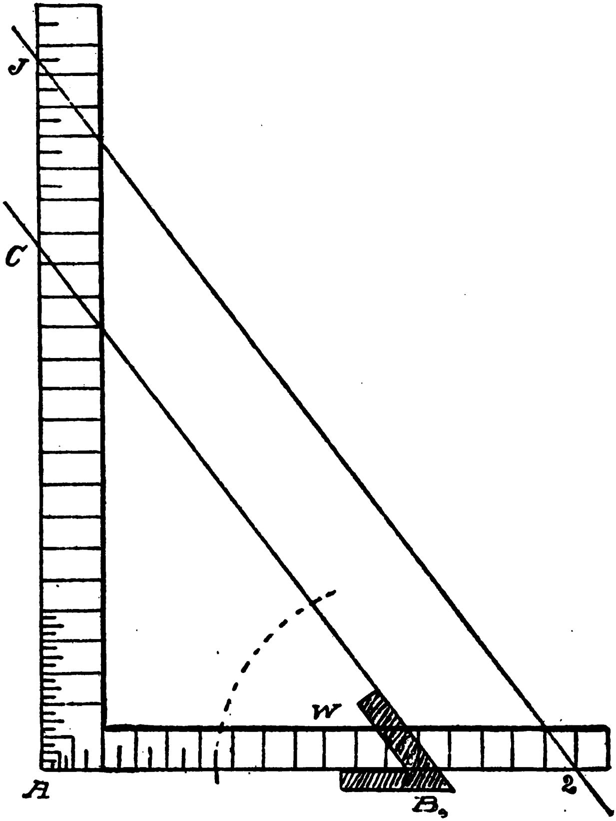

FIG. 153

Similar results may be obtained without any drawing by merely finding the numbers on the blade and tongue of a square that will agree or equal the angle in bevel W; then let the bevel as now set be applied to the square, and we find that the blade of bevel agrees with mark 4″⅞″ on tongue of square and 6″⅞″ on the blade; so that the diagonal of any square being required, it is easily obtained by setting a bevel in the manner stated. The answer will be correct by the angle in the bevel being accurate.

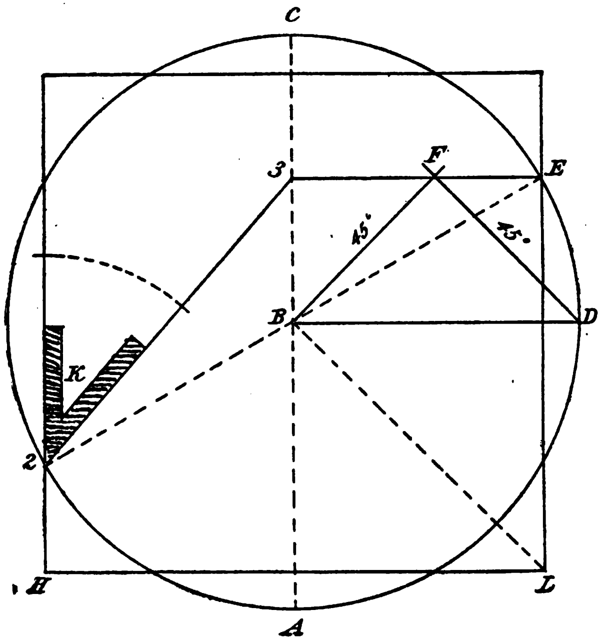

FIG. 154

Fig. 154 shows a construction which might be called an attempt at squaring the circle. Its solution has been thought an impossibility, and with all due regard to the opinion of others on this point, we think it quite possible to solve this difficult problem by a new and simple method of construction, which is here given.

The diameter of the circle measures 12 feet. From center B draw line BD at right angles with the diameter; draw from B and D, with the angle 45°, intersecting in F; through F draw 3E parallel with BD; draw through E parallel with the diameter, and from center B draw parallel with FB cutting line from E in L; and from L draw parallel with BD; also from E draw through center B, cutting in 2; draw through 2 parallel with the diameter cutting line from L in H, and we have now three sides of a square; the fourth, being made equal to one of these, completes a square, the area of which will be found equal to that of the circle; its diameter being 12 feet, and one ,side of the square 10 feet 5 inches.

To remove all doubt as to the correctness of this solution, let us prove it in another way, by a right angle, or the steel square, shown at Fig. 155. Here make the distance AC equal the diameter of the circle; lay a straight-edge across the square, keeping its edge on point C. Take bevel K in the angle HAC and apply it to point C; bring the straight-edge against the blade of bevel, and we find a line cutting the

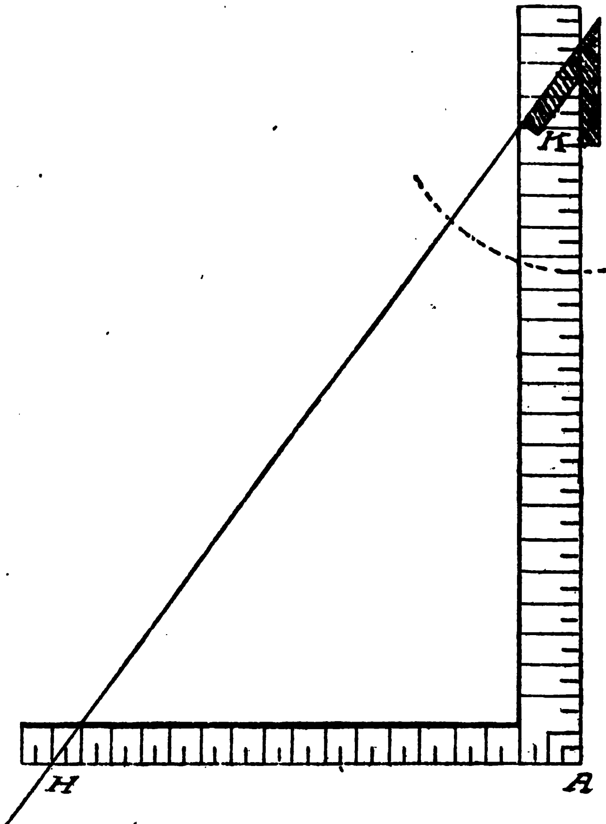

FIG. 155

right angle at point H, giving the distance HA, which exactly equals one side of the square HL, Fig. 154, thus giving the same result by two different methods.

The utility of the steel square is now evident; by it the measurement of any surface may be instantly given, and by the same means we can find the capacity of anything round or square. All that is necessary is to set the bevel to a certain number of parts or inches on the blade and tongue of the square. To explain this point, take bevel K as now set, and apply its stock against the blade of square; move the bevel until the blade cuts some members on the square that will correspond with the angle of the bevel; its blade agrees with marks 5″⅞″ and 5″⅛″, or 6″¾″ and 5″⅛″; either of these numbers will answer. The bevel being set in the manner stated, will not require any alteration, let the diameter of the circle be what it may.

In a previous diagram I explained how this problem might be worked out by a different method. Both are correct, and the reader may adopt either one or the other.

I will now endeavor to show how the square may be used in getting certain dimensions without much effort. Suppose we wish to find the superficial contents of a board or other material that is not more than one inch thick, we proceed as follows: Let Fig. 156 represent the square. The blade and tongue may be divided into any number of parts by scale. We may call a $\frac{1}{16}$, or an ⅛ or a ¼, etc., a foot, just as we wish to

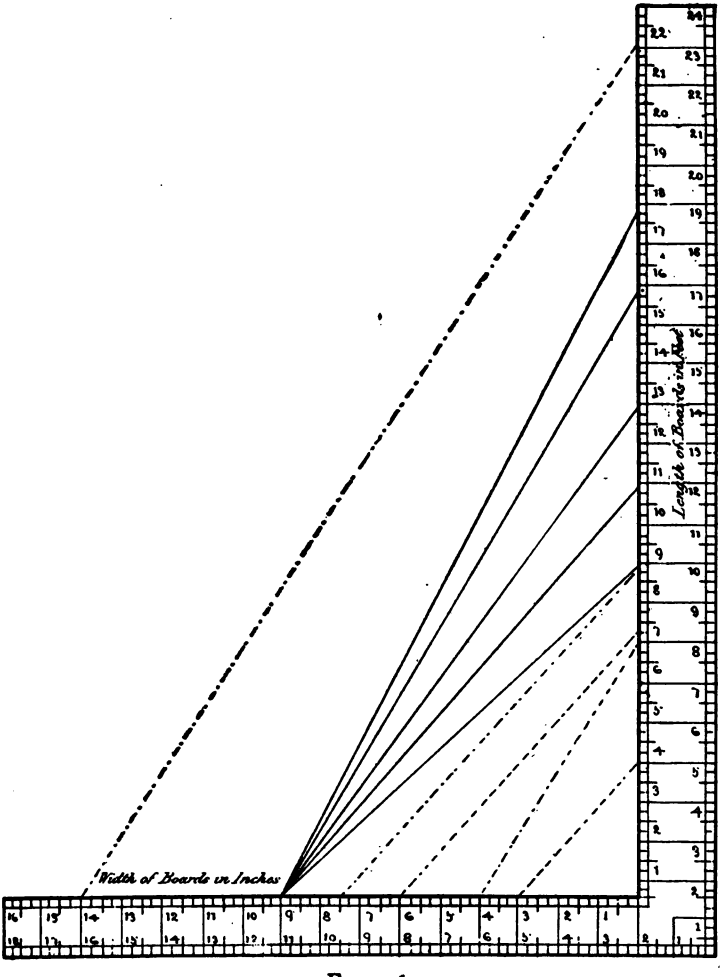

Fig. 156

meet the condition. Let the point 12 or 6, where the lines most converge, be a fixed point. Now assume a board to be 26 feet long and 6 inches wide. We know that the surface measurement of it is exactly 12 feet. The same result is given by the right angle. For example, draw the line 12-26, and parallel to it draw from the 6-inch mark. The line cuts in 13 feet, which is the answer.

Find the measurement of a board 21 feet long and 19 inches wide. Draw the line 12-21, and parallel to it draw from the 19-inch mark. The line cuts in $33\frac{3}{10}$ feet, which is the answer.

Give the measurement of a board 18 feet long and 10½ inches wide. Draw the line 12-18, and parallel to it draw the 10½-inch mark. The line cuts in $15\frac{7}{10}$ feet, which is the answer.

Find the measurement of a board 18 feet long and 9 inches wide. The line 12-18 being already given, draw parallel to it from the 9-inch mark; and this line cuts in 13 feet 6 inches, which is the answer.

What is the surface measurement of a board 29 feet long and 4 inches wide? Draw the line 12-29, and parallel to it draw from the 4-inch mark. The line cuts in 10 feet, which is the answer.

In the foregoing it will be seen that the scale used is less than one inch; but whatever the scale, it must be made to represent an inch in the end; thus, if we use ½ inch, then we must multiply the result by 2 to make it into inches, and if we use a quarter-inch scale, then multiply by 4, and so on, in order to make the result into feet and inches.

To reduce surface measure to square yards by aid of the square, we proceed as follows: There are 9 square feet in 1 square yard, as shown in Fig. 157, so we make 9 a constant number in this problem. Let us suppose any of the regular divisions of the square 1 yard in length; be it a ¼-inch, 1-inch, or any other division. To designate the sides, call the perpendicular *blade* of square, and lower line *tongue* of square, and A the internal angle. Let 9B, Fig. 158, be the fixed point, and from it draw the perpendicular, which divide into any number of parts, each to equal those on the right angle.

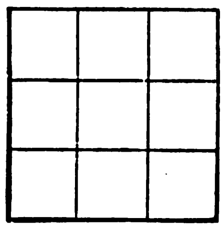

FIG. 157

It is now required to give the number of square yards in a floor 22 feet long and 15 wide. Draw the line 9-22-H, and parallel to it draw from mark 15E cutting in H. This gives 14⅔, to which add

22, making 36⅔ square yards of floor, which is the answer.

How many square yards of carpet will cover a floor 18 feet long and 13 wide? Draw the line 9-18-L, and parallel to it draw from mark 13-D cutting in F. This gives 8, to which add 18, making 26 square yards of carpet, which is the answer.

To find the number of square yards in a floor which is 15 feet long and 11 wide. Draw the line 9-15-K, and parallel to it draw from mark 11-C cutting N. This gives 3⅓, to which add 15, making 18⅓ square yards in the floor; this is the answer.

Now give the number of square yards on the surface of a counter which is 10 feet long and 7½ wide. Draw the line 9-10-R, and parallel to it, draw from mark 7½-P cutting in J. This gives 8½ square yards on the surface of counter, which is the answer.

It is now evident that the steel square may be made to give many other useful and practical ideas, besides those which have been shown.

THE SQUARE IN HANDRAILING

For over 25 years I have felt certain that some genius will arise and show the world how all kinds of handrailing may be "laid out" by the use of the steel square alone. I have wrestled with the subject often and long, but it has so far eluded me, though in a hazy way I have been able to get a glimpse of the relation between the square, the rise and tread, and an oblique cut cylinder. I know that a relation exists, and that relation and its perfect rendering will be discovered some of these days by a steel square expert; and a fortune awaits the man who makes the discovery and gives it to the public.

This may seem heretical to the old time handrailer who has waded through the mazy paths as marked down by the old master-hands of the science, and they may well be forgiven if they turn up their scientific noses at what I have said in this matter, and sneeringly call it so much "bosh." If thirty years ago any person had predicted that the steel square could be made to accomplish what it now can in good hands, the prophet would have been set down as a foolish fellow, and his predictions "all bosh." Yet we see what has been done, and knowing what I do regarding the capabilities of the square, I do not hesitate for a moment regarding my reputation as a prophet when predicting that all circular and elliptical handrails will be laid out altogether by aid of the steel square and a piece of string before the end of the first quarter of

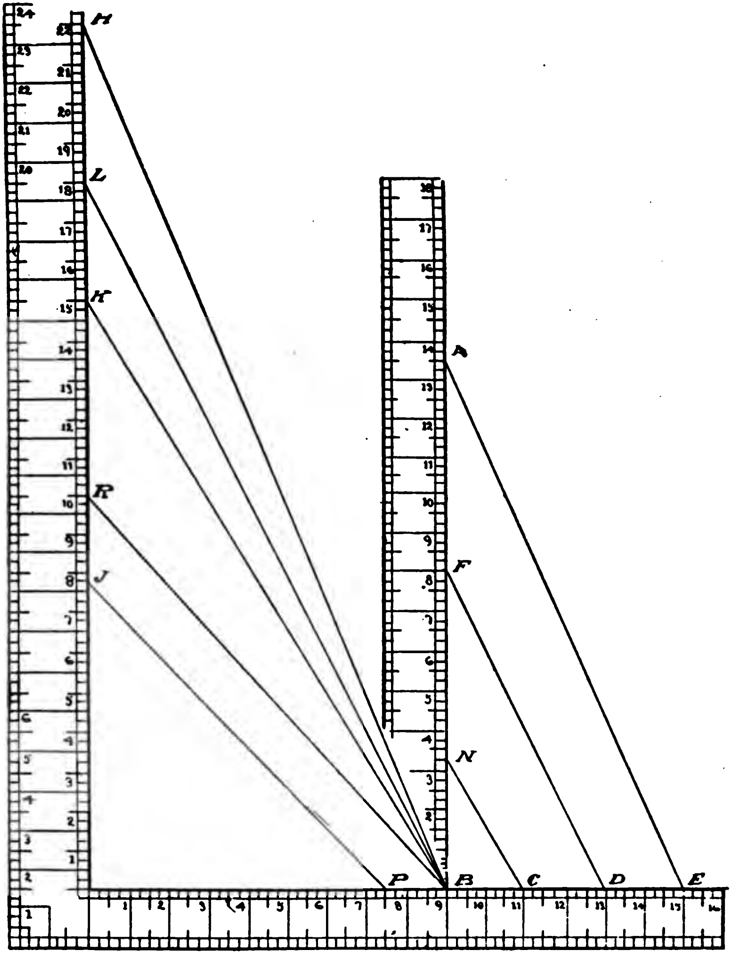

FIG. 158

the twentieth century. With this certainty before me, I urge all young men, and old ones too, to sometimes try and find the method I refer to. That it exists in the unseen land I am as confident as I am of penning these lines, and to the man who makes the discovery fame and wealth will be the reward.

As an item in this direction, I give the following, which is by Mr. Penrose of England, and which was sent me for publication in this work. I had reached this point myself some years ago, but described it a little differently; but think on the whole, Mr. Penrose's way of putting it is perhaps better than mine, so give it as it came to me.

In getting out face molds it has generally been considered necessary first to unfold the tangents and get the heights, and by construction get the bevels. This method is somewhat different, though results are the same, but are produced more expeditiously,—a steel square, a pencil, and a pair of compasses being used. Take, for illustration, a side wreath mitered into the newel cap. The distance the newel stands out of line with the straight rail is usually governed by the width of the hall, but where there is plenty of room it is a matter of taste. The distance the easement runs back is also a matter of choice. The method will apply no matter where the newel is placed, or whether the easement is less or more than the one step of the example illustrated. What is meant by one step is, that the tangent of the straight rail continues

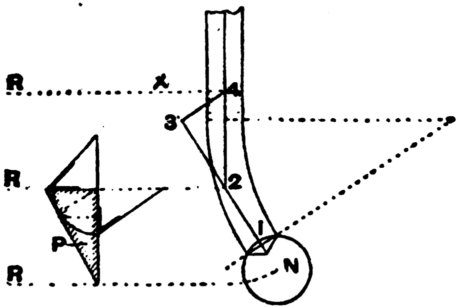

FIG. 159

to the point 2, Fig. 159. The tangent 2-1 is level.

To produce the face mold, lay the steel square in the position indicated by the lines 1, 2, 3, 4, not the figure on the square at the points numbered, and transfer them to a piece of thin stuff, Fig. 160. Line 3-4 in Fig. 160 is indefinite. Now take the length of the long edge of the pitch board in the compasses, and with point 2, Fig. 160, as a center, cut the line 3-4 in 4 and draw 2-4.

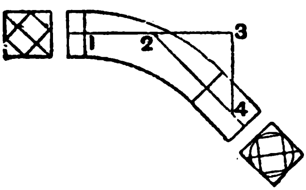

FIG. 160

Now 1-2 is the level, and 2-4 is the pitch tangent on the face mold.

To get the bevels and width of the face mold at both ends, take the distance 3-4 on the blade of the square, and the height of a riser on the tongue of the square, apply to the edge of a board and mark by the tongue; this gives the bevel for the lower end of the wreath. Mark the width of the rail on the bevel; this gives the width of the mold at the lower end.

Next take the distance 4-x on the blade of the square, and the distance shown on the pitch board by the line squared from its top edge to the corner, on the tongue of the square; apply to the edge of a board and mark by the tongue; this gives the bevel for the top end of the wreath. Mark the width of the rail on the bevel, and this gives the width of the mold at the top end. An allowance of 6 inches is made at the top end to joint to the straight rail, and 2 inches at the bottom end to form the miter into the newel cap. The springing line is taken from the pitch board.

Fig. 159, in which are shown the bevels and the pitch board will help to make clear the method used. The bevel at the back of the pitch board is for the bottom end of the wreath. The triangle has for its base the line 3-4, and for its height one riser. The hypothenuse is the length of 3-4, Fig. 160, and Fig. 160 stands over Fig. 159, level on the line 1-2-3, and inclined from it in this cast at an angle of nearly 45°.

The top end bevel is shown below the pitch board. The angle has for its base the distance 4-x, and for its height not one riser but the length of a line, from the corner of the pitch board squared from its top edge. This bevel will be understood better by placing the pitch board on the line 2-4 and applying the small triangle to it with its base on the line 4-x, and its point even with the top edge of the pitch board. It will then be at right angles to the top edge of the pitch board.

In practice, a parallel mold is generally used, and the wreath piece is cut out; both thickness of plank and width of molding being equal to the diameter of a circle that will contain a section of finished rail.

This is a good beginning, and if this much can be accomplished by the square, why not more on the same lines?

In the earlier part of this work I have shown how the square may be employed in laying out strings for stairs, step ladders and similar work, and if a method or system for setting out handrails for circular and elliptical stairs by the square can be evolved, then nearly the whole science of carpentry and joinery may be developed and explained by aid of that wonderful instrument, the American steel square.

TABLES

In the following tables are all the cuts necessary for obtaining the proper bevels to cut common rafters, hips, jacks, valleys and purlins, either by degrees or by the use of the steel square, for six different pitches, namely, quarter-pitch, one-third pitch, three-quarter pitch, half-pitch, one and a quarter-pitch, and one and a half-pitch.

The figures to be employed on the square to get the proper bevels, are in the last column, right hand side of the tables.

TABLE I

QUARTER-PITCH ROOF

27 Degrees, or 6-inch Rise to 12-inch Run

DESCRIPTION.	Pitch in Inches.	Pitch in Degrees.	Vertical cut in Degrees.	Horizontal cut in Degrees.	Horizontal cut in Inches.	Vertical cut in Inches.
Common Rafter..	12×6	27	60	27	12×6	Sq. of 12×6
Hips............	12×4½	18¾	71¼	18¾	12×4⅛	" 12×4⅛
Jacks............	12×6	27	60	42	12×10¾	" 12×6
Valleys...........	12×4½	18¾	71¼	18¾	12×4½	" 12×4½
Purlins Vertical ..	....	...	45	90	Square	" 12×12
Purlins to Plane of Roof	....	...	65⅛	134	12×13	" 12×5⅛

TABLE 2

ONE-THIRD PITCH ROOF

34 Degrees, or 8-inch Rise to 12-inch Run

Description.	Pitch in Inches.	Pitch in Degrees.	Vertical cut in Degrees.	Horizontal cut in Degrees.	Horizontal cut in Inches.	Vertical cut in Inches.
Common Rafter..	12×8	34	56	34	12×8	Sq. of 12×8
Hips..............	12×5⅝	25	65	25	12×5⅝	" 12×5⅝
Jacks	12×8	34	56	40	12×10	" 12×8
Valleys...........	12×5⅝	25	65	25	12×5⅝	" 12×5⅝
Purlins Vertical..	....	...	45	90	Square	" 12×12
Purlins to Plane of Roof	....	...	60½	132	12×14⅛	" 12×6½

TABLE 3

THREE-QUARTER PITCH ROOF

37 Degrees, or 9-inch Rise to 12-inch Run

Description.	Pitch in Inches.	Pitch in Degrees.	Vertical cut in Degrees.	Horizontal cut in Degrees.	Horizontal cut in Inches.	Vertical cut in Inches.
Common Rafter..	12×9	37	53	37	12×9	Sq. of 12×9
Hips	12×6¼	27¼	62¾	27¼	12×6¼	" 12×6¼
Jacks	12×9	37	53	39	12×9⅝	" 12×9
Valleys...........	12×6¼	27¼	62¾	27¼	12×6¼	" 12×6¼
Purlins Vertical..	....	...	45	90	Square	" 12×12
Purlins to Plane of Roof	....	...	58½	130½	12×14⅞	" 12×7⅛

TABLE 4

ONE-HALF PITCH ROOF

45 Degrees, or 12-inch Rise to 12-inch Run

Description.	Pitch in Inches.	Pitch in Degrees.	Vertical cut in Degrees.	Horizontal cut in Degrees.	Horizontal cut in Inches.	Vertical cut in Inches.
Common Rafter..	12×12	45	45	45	12×12	Sq. of 12×12
Hips	12×8½	34½	55	34½	12×8½	" 12×8½
Jacks	12×12	45	45	36	12×8½	" 12×12
Valleys...........	22×8½	34½	55	34½	12×8½	" 12×8½
Purlins Vertical..	....	...	45	90	Square	" 12×12
Purlins to Plane of Roof	....	...	54	127	12×16½	" 12+8½

TABLE 5

ONE AND ONE-THIRD PITCH ROOF

54 Degrees, or 16-inch Rise to 12-inch Run

Description.	Pitch in Inches.	Pitch in Degrees.	Vertical cut in Degrees.	Horizontal cut in Degrees.	Horizontal cut in Inches.	Vertical cut in Inches.
Common Rafter..	12×16	54	36	54	12×16	Sq. of 12×16
Hips	12×11⅜	44	44	44	12×11⅜	" 12×11⅜
Jacks	12×16	54	36	32	12×7½	" 12×16
Valleys	12×11⅜	44	44	44	12×11⅜	" 12×11⅜
Purlins Vertical ..	....	...	45	90	Square	" 12×12
Purlins to Plane of Roof	....	...	51	132½	12×19½	" 12×9⅜

TABLE 6

ONE AND ONE-HALF PITCH ROOF

57 Degrees, or 18-inch Rise to 12-inch Run

DESCRIPTION.	Pitch in Inches.	Pitch in Degrees.	Vertical cut in Degrees.	Horizontal cut in Degrees.	Horizontal cut in Inches.	Vertical cut in Inches.
Common Rafter ..	12×18	57	33	57	12×18	Sq. of 12×18
Hips	12×12⅝	46	44	46	12×12⅝	" 12×12⅝
Jacks	12×18	57	33	30	12×6⅝	" 12×18
Valleys..........	12×12⅝	46	44	46	12×12⅝	" 12×12⅝
Purlins Vertical ..	....	...	45	90	Square	" 12×12
Purlins to Plane of Roof	....	...	50	120	12×21	" 12×10

I have given the pitches of those roofs which are more generally used than any other, though the same rules which obtained the above figures could be continued indefinitely. It has been thought, however, that the foregoing examples were quite sufficient for all ordinary purposes.

In these tables it will be seen that the bevels for purlin cuts have been given, both when the purlin is square or plumb with the horizon, and when it sits with one of its sides against the rafters, or inclined with the roof. The square is made to produce all these bevels.

FOR ESTIMATING CONTENTS OF RAFTERS

In the earlier pages of this work, I promised to publish a table wherein the contents of rafters might be estimated without being obliged to take actual measurements of the timbers, and to this end the annexed table, No. 7, is presented.

In the lengths given, there is no provision made for projections over eaves, or for ridge poles. The measurements are from the face of the plate to the point of ridge. The length of any rafter is given for roofs having a pitch of one-quarter to one-half, and a span of from 8 feet to 50 feet. No provision is made for fractions of feet in width of building.

The length of the rafter being obtained, and its sectional area being known, the contents may readily be found: Thus, suppose width of building to be 34 feet, rafters to be 2x6 inches, sectional area; pitch 9-inch rise; then we have length of rafter by table, is 21 feet 3 inches, and as each foot in length of a rafter 2x6 inches contains one foot board measure, we have 21 feet 3 inches as the amount of material in each rafter, board measure. So with all the other dimensions in the table. The lengths of rafters are given. Determine the sectional areas of rafters, and the contents may easily be found:

TABLE 7

LENGTH OF RAFTERS

In Feet, Inches and Fractions of an Inch

Width of Building in Feet.	Run of Rafters.	6-Inch Rise.		7-Inch Rise.		8-Inch Rise.		9-Inch Rise.		10-Inch Rise.		11-Inch Rise.		12-Inch Rise.		13-Inch Rise.		14-Inch Rise.		15-Inch Rise.		16-Inch Rise.	
	ft.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.	ft.	in.
8	4	4	5 5/8	4	7 1/2	4	9 3/4	5		5	2 1/2	5	5 1/8	5	7 7/8	5	10 3/4	6	1 3/4	6	4 7/8	6	8
10	5	5	7 1/8	5	9 1/2	6	0 1/8	6	3	6	6 1/8	6	9 3/8	7	0 7/8	7	4 1/2	7	8 1/4	8		8	4
12	6	6	8 1/2	6	11 3/8	7	2 1/2	7	6	7	9 3/4	8	1 5/8	8	5 7/8	8	10 1/8	9	2 5/8	9	7 1/4	10	
14	7	7	10	8	1 1/4	8	6	8	9	9	1 3/8	9	6	9	10 3/4	10	3 7/8	10	9 1/8	11	2 1/2	11	8
16	8	8	11 3/8	9	3 1/8	9	7 3/8	10		10	5	10	10 1/4	11	3 3/4	11	9 1/2	12	3 1/2	12	9 5/8	13	4
18	9	10	0 3/4	10	5	10	9 3/4	11	3	11	8 5/8	12	2 1/2	12	8 3/4	13	3 1/4	13	10	14	4 7/8	15	
20	10	11	2 1/8	11	7	12	0 1/4	12	6	13	0 1/4	13	6 3/4	14	1 3/4	14	9	15	4 3/8	16		16	8
22	11	12	3 5/8	12	8 7/8	13	2 5/8	13	9	14	3 7/8	14	11	15	6 5/8	16	2 5/8	16	10 7/8	17	7 1/4	18	4
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26	13	14	6 1/2	15	0 5/8	15	7 1/2	16	3	16	11	17	7 5/8	18	4 5/8	19	2	19	11 3/4	20	9 3/4	21	8
28	14	15	7 7/8	16	2 1/2	16	10	17	6	18	2 3/4	19		19	9 5/8	20	7 3/4	21	6 1/8	22	5	23	4
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34	17	19		19	8 1/8	20	5 1/8	21	3	22	1 1/2	23	0 3/4	24	0 5/8	25	0 3/4	26	1 1/2	27	2 1/2	28	4
36	18	20	1 5/8	20	10	21	7 5/8	22	6	23	5 1/8	24	5	25	5 1/2	26	6 1/2	27	7 7/8	28	9 3/4	30	
38	19	21	2 7/8	22		22	10	23	9	24	8 3/4	25	9 1/4	26	10 1/2	28	0 1/8	29	2 3/8	30	5	31	8
40	20	22	4 3/8	23	1 7/8	24	0 1/2	25		26	0 3/8	27	1 5/8	28	3 1/2	29	5 7/8	30	8 3/4	32	0 1/4	33	4
42	21	23	5 3/4	24	3 3/4	25	2 7/8	26	3	27	4	28	5 7/8	29	8 3/8	30	11 1/4	32	3 3/4	33	7 3/8	35	
44	22	24	7 1/8	25	5 5/8	26	5 1/4	27		28	7 5/8	29	10 1/8	31	1 3/8	32	5 1/2	33	9 5/8	35	2 5/8	36	8
46	23	25	8 5/8	26	7 1/2	27	7 3/4	28	9	29	11 1/4	31	2 1/2	32	6 3/8	33	11	35	4 1/8	36	9 7/8	38	4
48	24	26	10	27	9 3/8	28	10 1/8	30		31	2 7/8	32	6 3/4	33	11 1/4	35	4 5/8	36	10 1/2	38	5	40	
50	25	27	11 3/8	28	11 1/4	30	0 1/2	31	3	32	6 1/2	33	11	35	4 1/4	36	10 1/4	38	5	40	0 1/4	41	8

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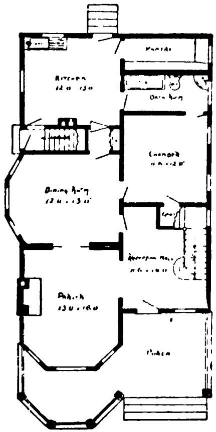
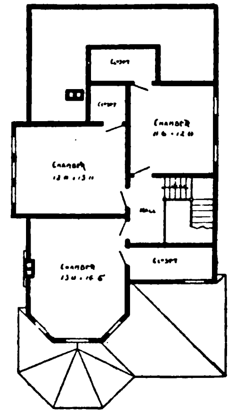


FIRST FLOOR PLAN

SIZE

Width, 28 feet.
Length, 46 feet,
exclusive of porch.



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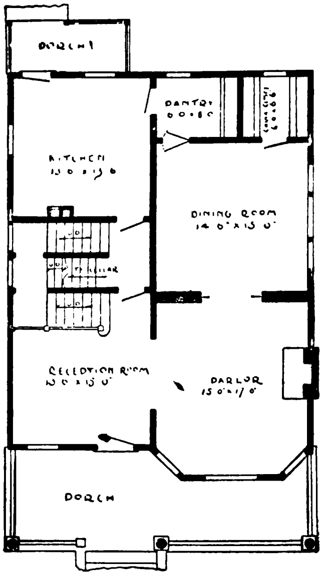


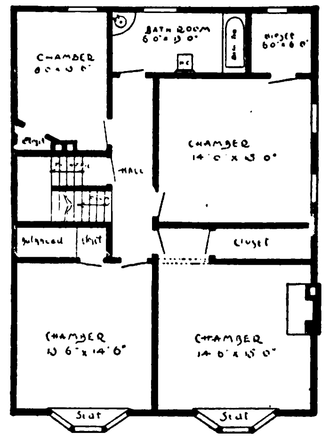
FIRST FLOOR PLAN

SIZE

Width, 30 feet.

Length, 40 feet,

exclusive of porches.



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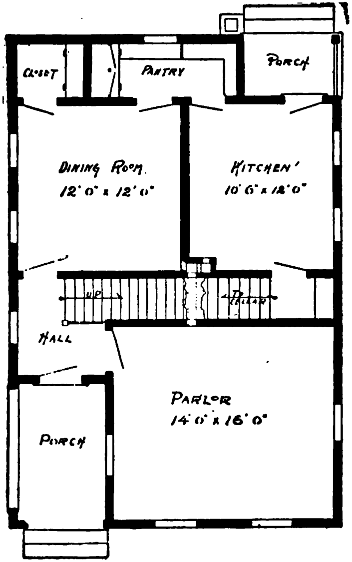
No. 1009

PRICE
of Plans and
Specifications
$5.00

House Design No. 1009

Full and complete working plans and specifications of this house will be furnished for $5.00.
Cost of this house is from $2500 to $2750, according to the locality in which it is built.

FLOOR PLANS OF DESIGN No. 1092

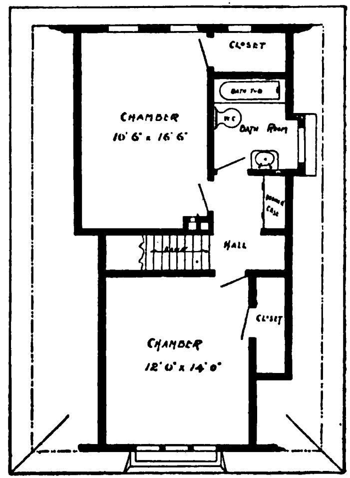


FIRST FLOOR PLAN

SIZE

Width, 24 feet.

Length, 36 feet.



SECOND FLOOR PLAN

Blue prints consist of cellar and foundation plan; first and second floor plans; front, rear, two side elevations; wall sections and all necessary interior details.

Specifications consist of about fifteen pages of typewritten matter.

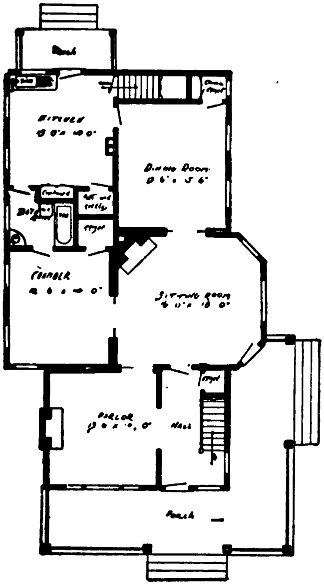
No. 1092

PRICE
of Plans and
Specifications
$5.00

HOUSE DESIGN No. 1092

Full and complete working plans and specifications of this house will be furnished for $5.00. Cost of this house is from $850 to $1000, according to the locality in which it is built.

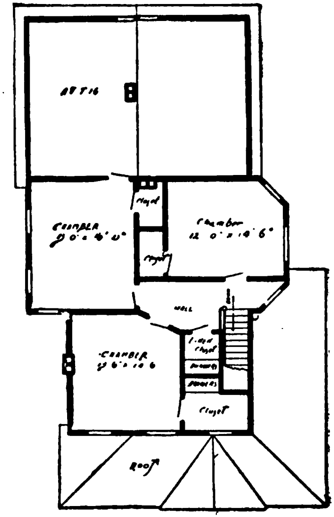
FLOOR PLANS OF DESIGN No. 1019



FIRST FLOOR PLAN

SIZE

Width, 32 feet.
Length, 52 feet,
exclusive of porches.



SECOND FLOOR PLAN

Blue prints consist of cellar and foundation plan; first and second floor plans; front, rear, two side elevations; wall sections and all necessary interior details. Specifications consist of about twenty pages of typewritten matter.

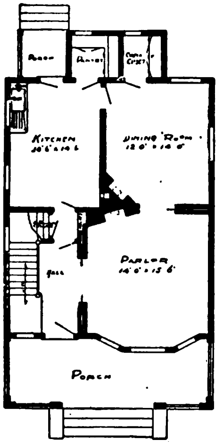
No. 1019

P R I C E
of Plans and
Specifications
$5.00

House Design No. 1019

Full and complete working plans and specifications of this house will be furnished for $5.00
Cost of this house is from $1900 to $2100, according to the locality in which it is built.

FLOOR PLANS OF DESIGN No. 1037

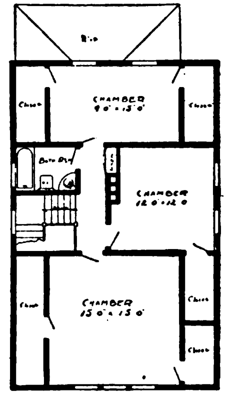


FIRST FLOOR PLAN

SIZE

Width, 24 feet.

Length, 38 feet.



SECOND FLOOR PLAN

Blue prints consist of cellar and foundation plan; first and second floor plans; front, rear, two side elevations; wall sections and all necessary interior details.

Specifications consist of about fifteen pages of typewritten matter.

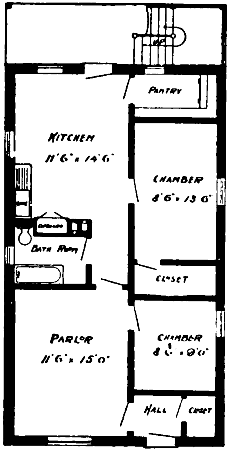
No. 1037

PRICE
of Plans and
Specifications
$5.00

House Design No. 1037

Full and complete working plans and specifications of this house will be furnished for $5.00. Cost of this house is from $1800 to $1950, according to the locality in which it is built.

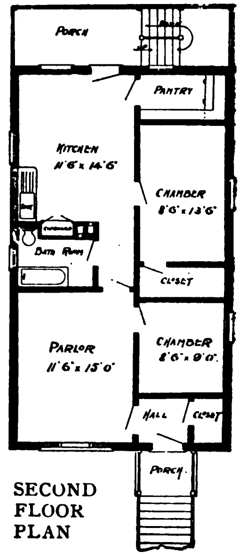
FLOOR PLANS OF DESIGN No. 1089



FIRST FLOOR PLAN

SIZE

Width, 22 feet.
Length, 38 feet,
exclusive of porches.



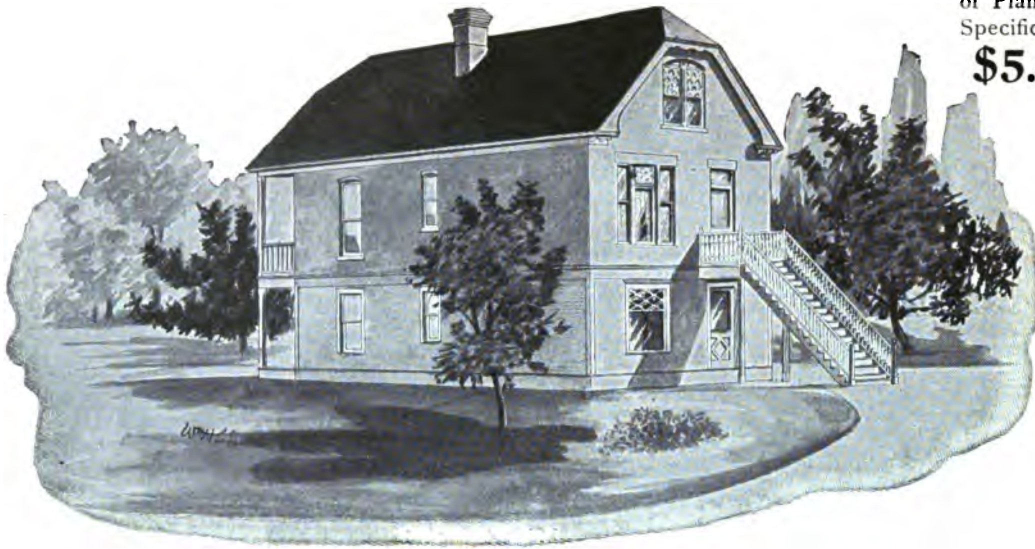
SECOND FLOOR PLAN

Blue prints consist of foundation first and second plan; floor plans; front, rear, two side elevations; wall sections and all necessary interior details.

Specifications consist of about fifteen pages of typewritten matter.

No. 1089

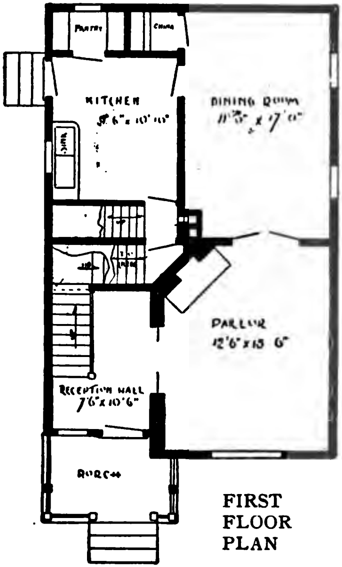
PRICE
of Plans and
Specifications
$5.00



HOUSE DESIGN No. 1089

Full and complete working plans and specifications of this house will be furnished for $5.00. Cost of this house is from $1500 to $1650, according to the locality in which it is built.

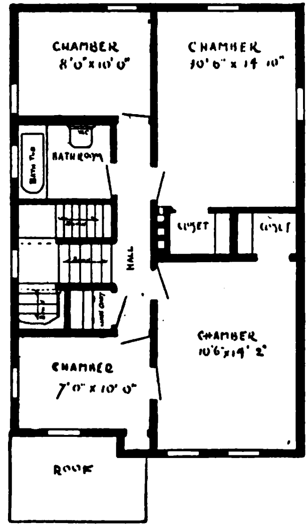
FLOOR PLANS OF DESIGN
No. 1008



FIRST FLOOR PLAN

SIZE

Width, 22 feet.
Length, 34 feet,
exclusive of porch.



SECOND FLOOR PLAN

Blue prints consist of cellar and foundation plan; first and second floor plans; front, rear, two side elevations; wall sections and all necessary interior details.

Specifications consist of about twenty pages of typewritten matter.

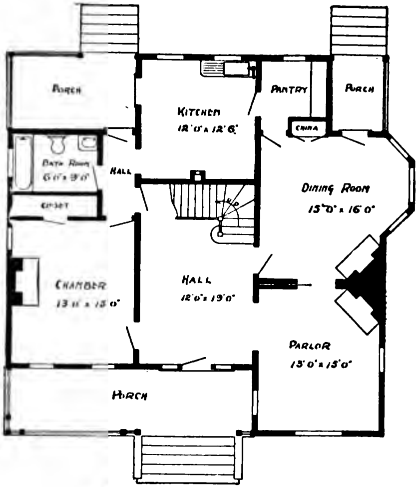
No. 1008

P R I C E
of Plans and
Specifications
$5.00

HOUSE DESIGN No. 1008

Full and complete working plans and specifications of this house will be furnished for $5.00. Cost of this house is from $1350 to $1500, according to the locality in which it is built.

FLOOR PLANS OF DESIGN No. 1086

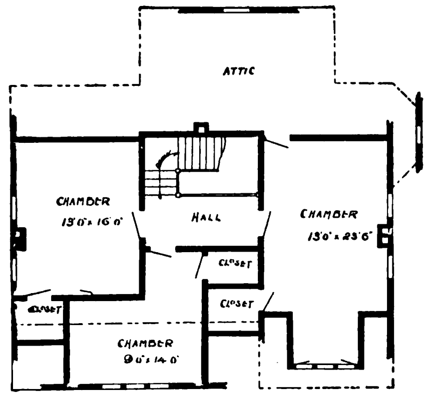


FIRST FLOOR PLAN

SIZE

Width, 40 feet.

Length, 40 feet.



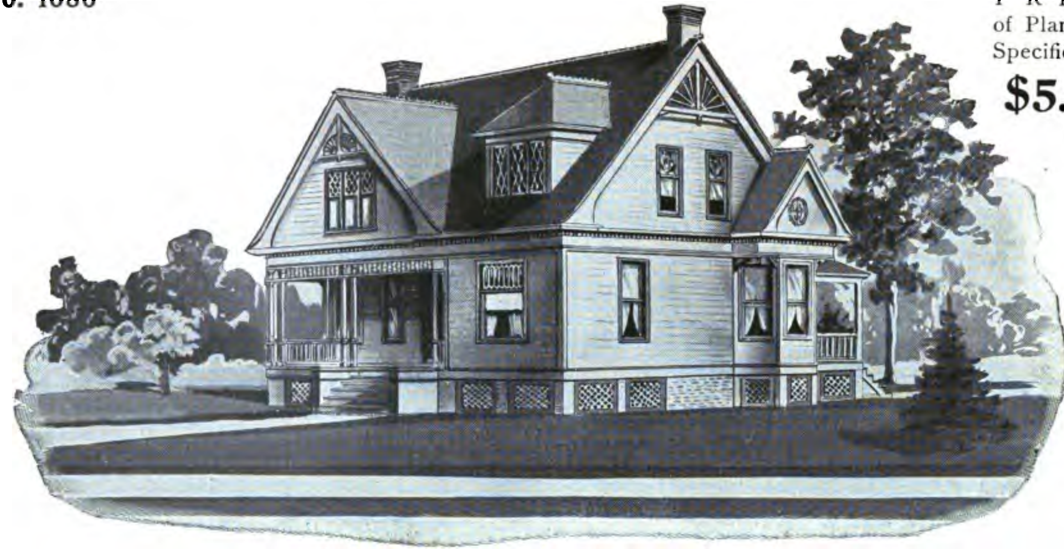
SECOND FLOOR PLAN

Blue prints consist of foundation plan; first and second floor plans; front, rear, two side elevations; wall sections and all necessary interior details.

Specifications consist of about twenty pages of typewritten matter.

No. 1086

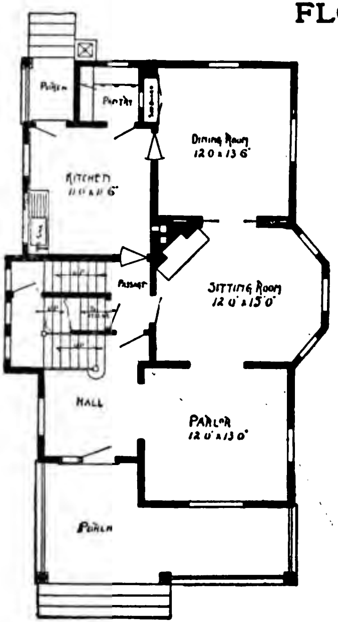
PRICE
of Plans and
Specifications
$5.00



HOUSE DESIGN NO. 1086

Full and complete working plans and specifications of this house will be furnished for $5.00. Cost of this house is from $1500 to $1700, according to the locality in which it is built.

FLOOR PLANS OF DESIGN No. 1054



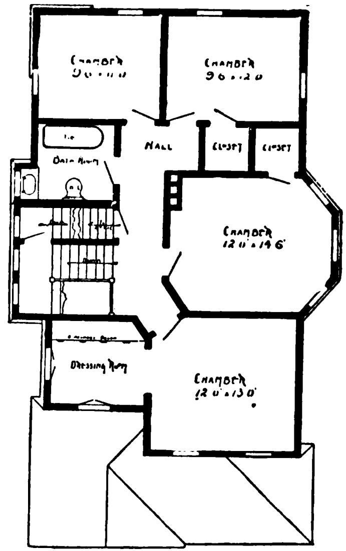
FIRST FLOOR PLAN

SIZE

Width, 28 feet.
Length, 40 feet,
exclusive of porch.

Blue prints consist of cellar and foundation plan; first and second floor plans; roof plan; front, rear, two side elevations; wall sections and all necessary interior details.

Specifications consist of about twenty pages of typewritten matter.



SECOND FLOOR PLAN

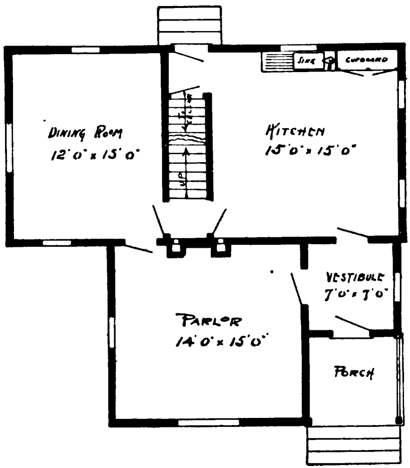
No. 1054

PRICE
of Plans and
Specifications
$5.00

HOUSE DESIGN NO. 1054

Full and complete working plans and specifications of this house will be furnished for $5.00. Cost of this house is from $2250 to $2400, according to the locality in which it is built.

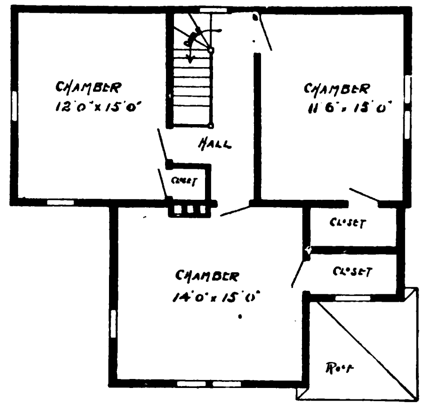
FLOOR PLANS OF DESIGN No. 1093



FIRST FLOOR PLAN

SIZE

Width, 32 feet.
Length, 31 feet,
exclusive of porch.



SECOND FLOOR PLAN

Blue prints consist of cellar and foundation plan; first and second floor plans; front, rear, two side elevations; wall sections and all necessary interior details.

Specifications consist of about fifteen pages of typewritten matter.

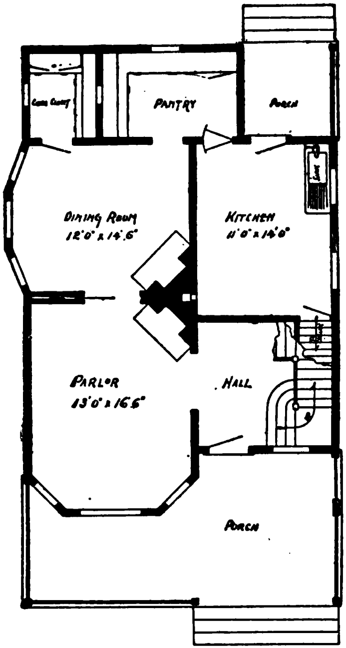
No. 1093

P R I C E
of Plans and
Specifications
$5.00

HOUSE DESIGN NO. 1093

Full and complete working plans and specifications of this house will be furnished for $5.00. Cost of this house is from $1250 to $1400, according to the locality in which it is built.

FLOOR PLANS OF DESIGN No. 1057



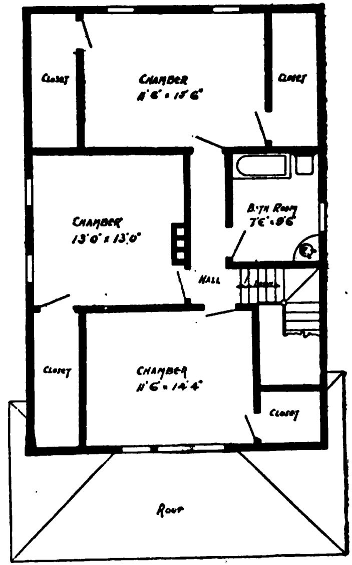
FIRST FLOOR PLAN

SIZE

Width, 27 feet,
Length, 38 feet,
exclusive of porches.

Blue prints consist of cellar and foundation plan; first and second floor plans; front, rear, two side elevations; wall sections and all necessary interior details.

Specifications consist of about fifteen pages of typewritten matter.



SECOND FLOOR PLAN

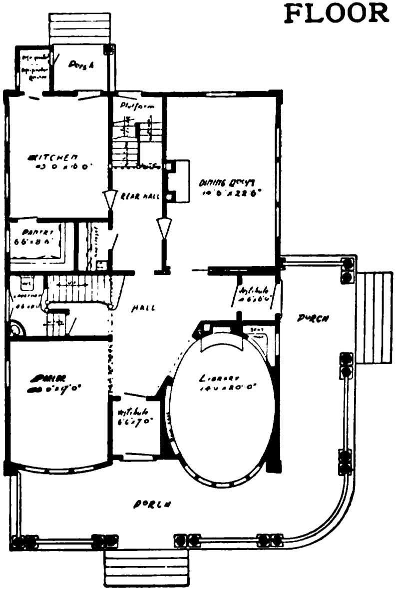
No. 1057

PRICE
of Plans and
Specifications
$5.00

HOUSE DESIGN NO. 1057

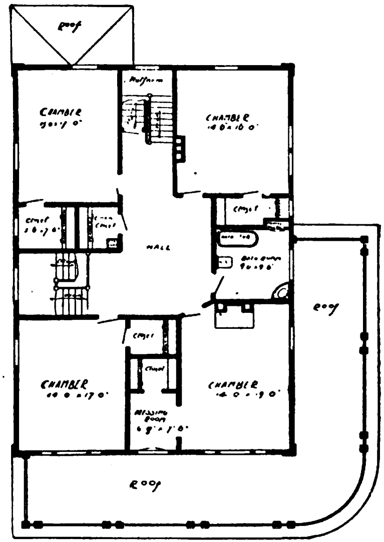
Full and complete working plans and specifications of this house will be furnished for $5.00. Cost of this house is from $1500 to $1650, according to the locality in which it is built.

FLOOR PLANS OF DESIGN No. 1007



SIZE

Width, 36 feet.
Length, 50 feet,
exclusive of porches.



FIRST FLOOR PLAN

SECOND FLOOR PLAN

Blue prints consist of cellar and foundation plan; first and second floor plans; front, rear, two side elevations; wall sections and all necessary interior details.

Specifications consist of about twenty-five pages of typewritten matter.

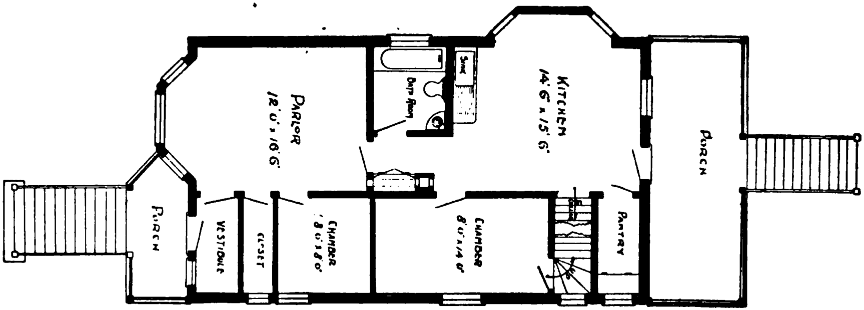
No. 1007

PRICE
of Plans and
Specifications
$25.00

HOUSE DESIGN NO. 1007.

Full and complete working plans and specifications of this house will be furnished for $25.00. Cost of this house is from $6500 to $6750, according to the locality in which it is built.

FLOOR PLAN OF DESIGN No. 1079



SIZE

Width, 22 feet. Length, 40 feet, exclusive of porches.

Blue prints consist of foundation plan; floor plan; front, rear, two side elevations; wall sections, and all necessary interior details.

Specifications consist of about fifteen pages of typewritten matter.

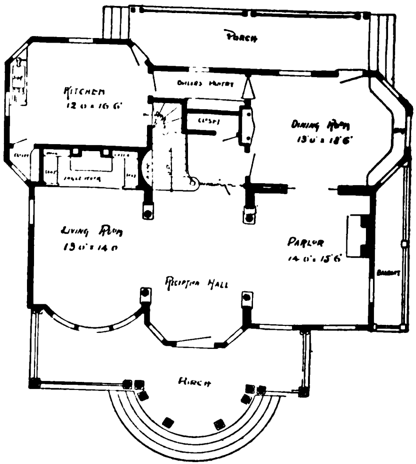
No. 1079

PRICE of Plans and Specifications **$5.00**

HOUSE DESIGN NO. 1079

Full and complete working plans and specifications of this house will be furnished for $5.00. Cost of this house is from $1500 to $1650, according to the locality in which it is built.

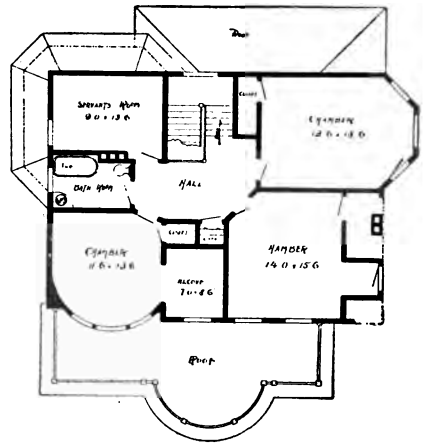
FLOOR PLANS OF DESIGN No. 1091



FIRST FLOOR PLAN

SIZE

Width, 48 feet,
Length, 36 feet,
exclusive of porches.



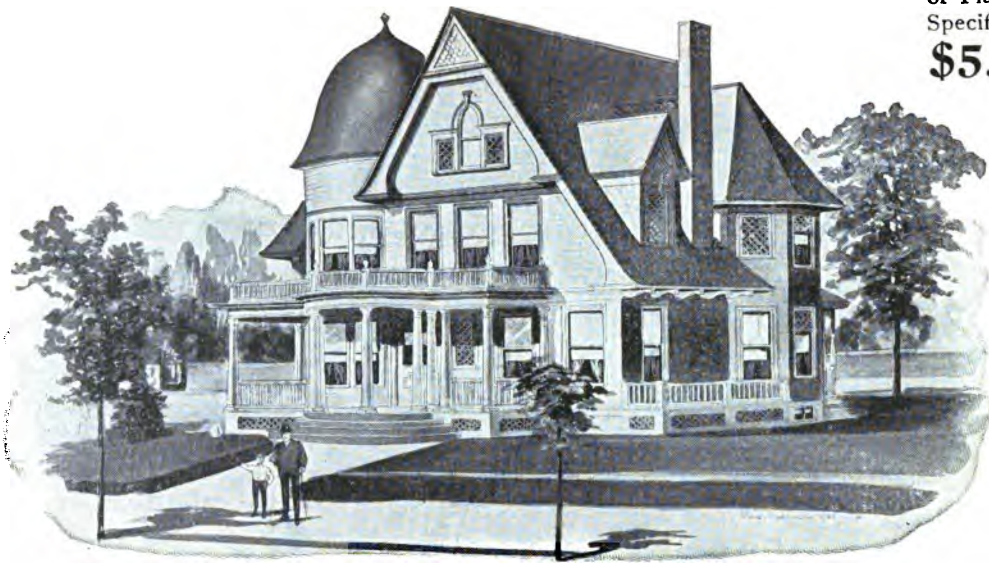
SECOND FLOOR PLAN

Blue prints consist of cellar and foundation plan; first and second floor plans; front, rear, two side elevations; wall sections, and all necessary interior details.

Specifications consist of about twenty pages of typewritten matter.

No. 1091

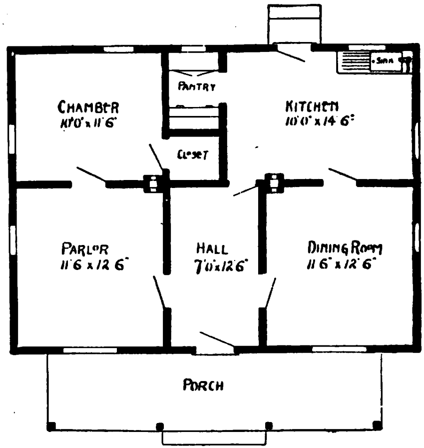
PRICE
of Plans and
Specifications
$5.00



House Design No. 1091

Full and complete working plans and specifications of this house will be furnished for $5.00. Cost of this house is from $3150 to $3300, according to the locality in which it is built.

FLOOR PLAN OF DESIGN No. 1048



FLOOR PLAN

SIZE. Width, 32 feet. Length, 24 feet, exclusive of porch.

Blue prints consist of foundation plan; floor plan; front, rear, two side elevations; wall sections, and all necessary interior details.

Specifications consist of about fifteen pages of typewritten matter.

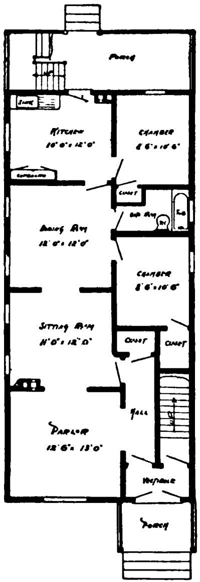
No. 1048

PRICE
of Plans and
Specifications
$5.00

HOUSE DESIGN NO. 1048

Full and complete working plans and specifications of this house will be furnished for $5.00. Cost of this house is from $600 to $700, according to the locality in which it is built.

FLOOR PLANS OF DESIGN No. 1094

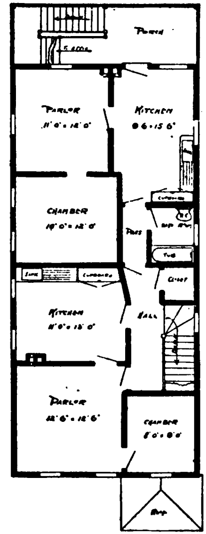


FIRST FLOOR PLAN

SIZE

Width, 22 feet.

Length, 48 feet, exclusive of porches.



SECOND FLOOR PLAN

Blue prints consist of cellar and foundation plan; first and second floor plans; front, rear, two side elevations; wall sections, and all necessary interior details.

Specifications consist of about twenty pages of typewritten matter.

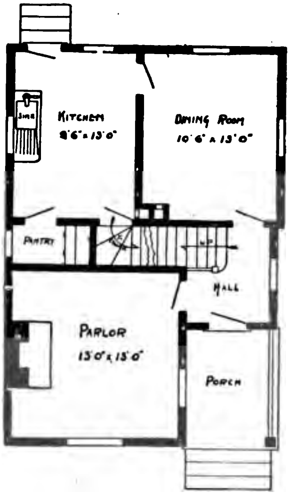
No. 1094

PRICE
of Plans and
Specifications
$5.00

HOUSE DESIGN NO. 1094

Full and complete working plans and specifications of this house will be furnished for $5.00. Cost of this house is from $2000 to $2250, according to the locality in which it is built.

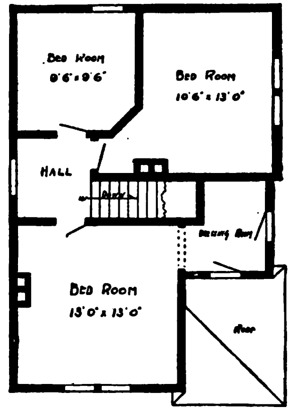
FLOOR PLANS OF DESIGN No. 1103



FIRST FLOOR PLAN

SIZE

Width, 20 feet.
Length, 28 feet,
exclusive of porches.



SECOND FLOOR PLAN

Blue prints consist of cellar and foundation plan; first and second floor plans; front, rear, two side elevations; wall sections, and all necessary interior details.

Specifications consist of about fifteen pages of typewritten matter.

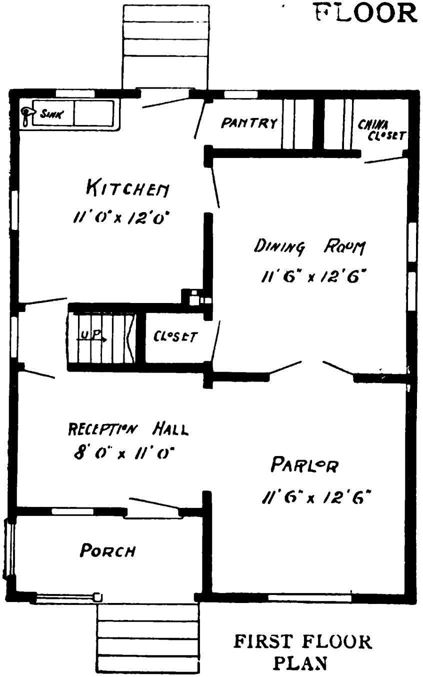
No. 1103

PRICE
of plans and
Specifications
$5.00

HOUSE DESIGN NO. 1103

Full and complete working plans and specifications of this house will be furnished for $5.00. Cost of this house is from $950 to $1100, according to the locality in which it is built.

FLOOR PLANS OF DESIGN No. 1090



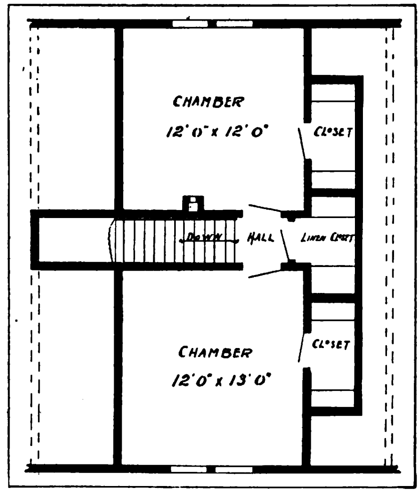
FIRST FLOOR PLAN

SIZE

Width, 21 feet.
Length, 30 feet,
exclusive of porches.

Blue prints consist of cellar and foundation plan; first and second floor plans; front, rear, two side elevations; wall sections and all necessary interior details.

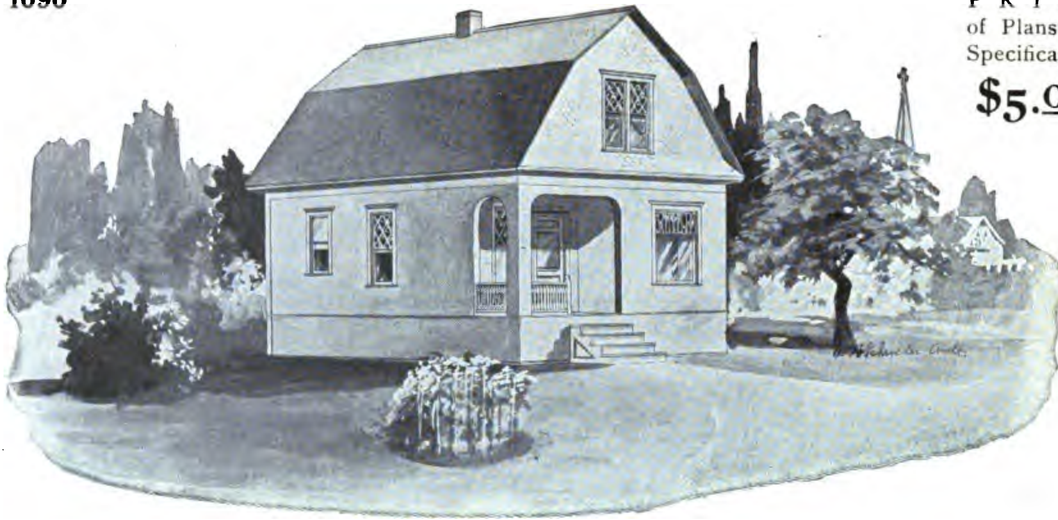
Specifications consist of about fifteen pages of typewritten matter.



SECOND FLOOR PLAN

No. 1090

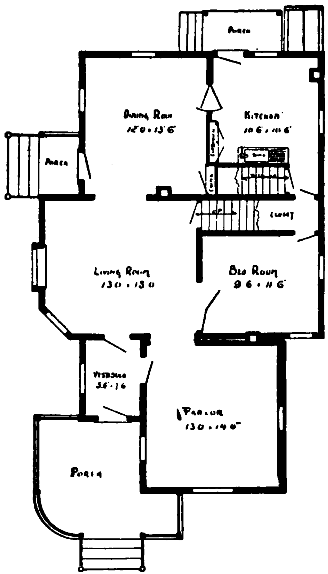
PRICE
of Plans and
Specifications
$5.00



HOUSE DESIGN NO. 1090

Full and complete working plans and specifications of this house will be furnished for $5.00. Cost of this house is from $850 to $1000, according to the locality in which it is built.

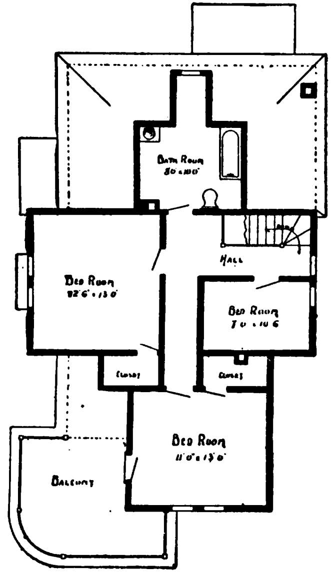
FLOOR PLANS OF DESIGN
No. 1108



FIRST FLOOR PLAN

SIZE

Width, 28 feet.
Length, 43 feet,
exclusive of porches.



SECOND FLOOR PLAN

Blue prints consist of cellar and foundation plan; first and second floor plans; front, rear, two side elevations; wall sections and all necessary interior details.

Specifications consist of about twenty pages of typewritten matter.

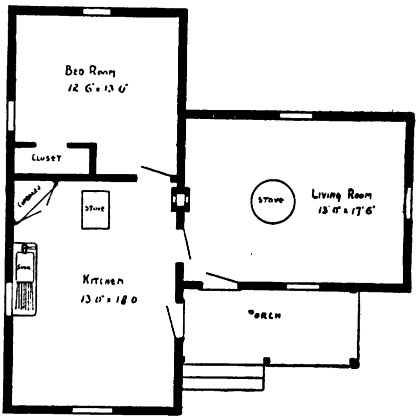
No. 1108

PRICE
of Plans and
Specifications
$5.00

HOUSE DESIGN NO. 1108

Full and complete working plans and specifications of this house will be furnished for $5.00. Cost of this house is from $1600 to $1800, according to the locality in which it is built.

FLOOR PLAN OF DESIGN No. 1063



SIZE

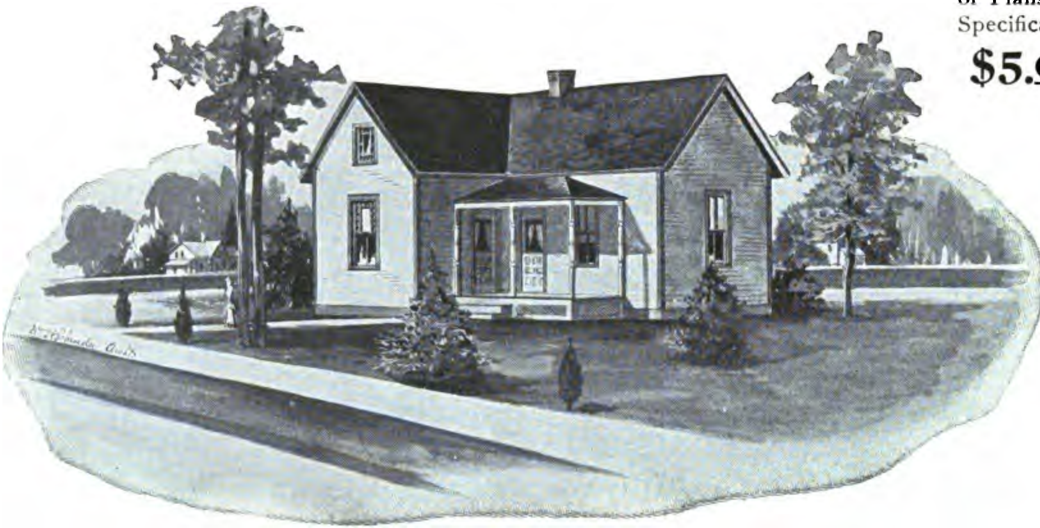
Width, 32 feet. Length, 32 feet.

Blue prints consist of foundation plan; floor plan; front, rear, two side elevations; wall sections and all necessary interior details.

Specifications consist of about fifteen pages of typewritten matter.

No. 1063

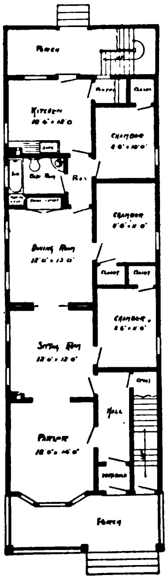
PRICE
of Plans and
Specifications
$5.00



House Design No. 1063

Full and complete working plans and specifications of this house will be furnished for $5.00. Cost of this house is from $500 to $600, according to the locality in which it is built.

FLOOR PLANS OF DESIGN No. 1101



FIRST FLOOR PLAN

SIZE

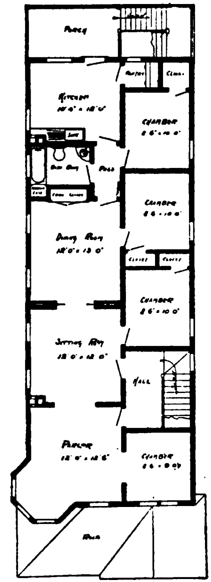
Width, 22 feet.

Length, 60 feet,

exclusive of porches.

Blue prints consist of foundation plan; first and second floor plans; front, rear, two side elevations; wall sections and all necessary interior details.

Specifications consist of about twenty pages of typewritten matter.



SECOND FLOOR PLAN

No. 1101

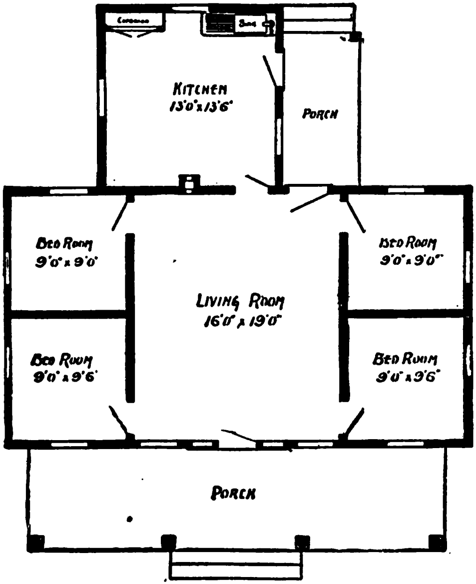
PRICE
of Plans and
Specifications

$5.00

HOUSE DESIGN NO. 1101

Full and complete working plans and specifications of this house will be furnished for $5.00. Cost of this house is from $2250 to $2500, according to the locality in which it is built.

FLOOR PLAN OF DESIGN No. 1055



FLOOR PLAN

SIZE

Width, 36 feet.
Length, 34 feet,
exclusive of porches.

Blue prints consist of foundation plan; floor plan; front, rear, two side elevations; wall sections and all necessary interior details.

Specifications consist of about fifteen pages of typewritten matter.

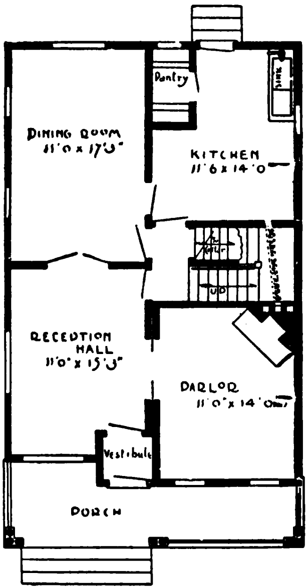
No. 1055

PRICE
of Plans and
Specifications
$5.00

HOUSE DESIGN NO. 1055

Full and complete working plans and specifications of this house will be furnished for $5.00. Cost of this house is from $550 to $700, according to the locality in which it is built.

FLOOR PLANS OF DESIGN No. 1010

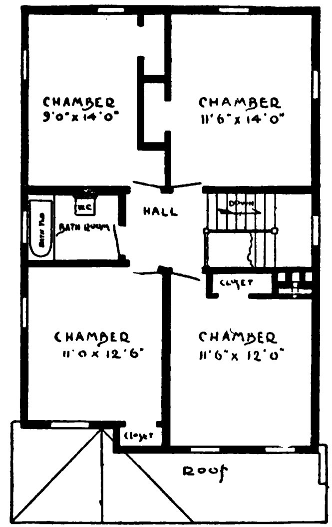


FIRST FLOOR PLAN

SIZE

Width, 24 feet.

Length, 36 feet, exclusive of porch.



SECOND FLOOR PLAN

Blue prints consist of cellar and foundation plan; first and second floor plans; front, rear, two side elevations; wall sections and all necessary interior details.

Specifications consist of about fifteen pages of typewritten matter.

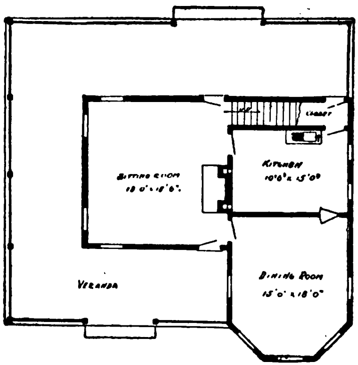
No. 1010

PRICE
of Plans and
Specifications
$5.00

HOUSE DESIGN No. 1010

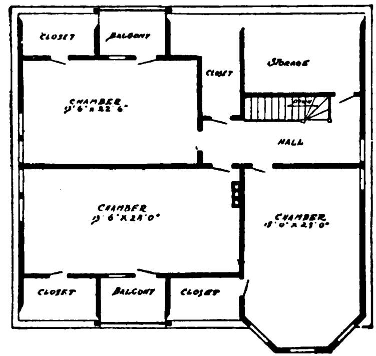
Full and complete working plans and specifications of this house will be furnished for $5.00. Cost of this house is from $1500 to $1700, according to the locality in which it is built.

FLOOR PLANS OF DESIGN No. 1027



FIRST FLOOR PLAN

SIZE
Width, 44 feet.
Length, 34 feet.



SECOND FLOOR PLAN

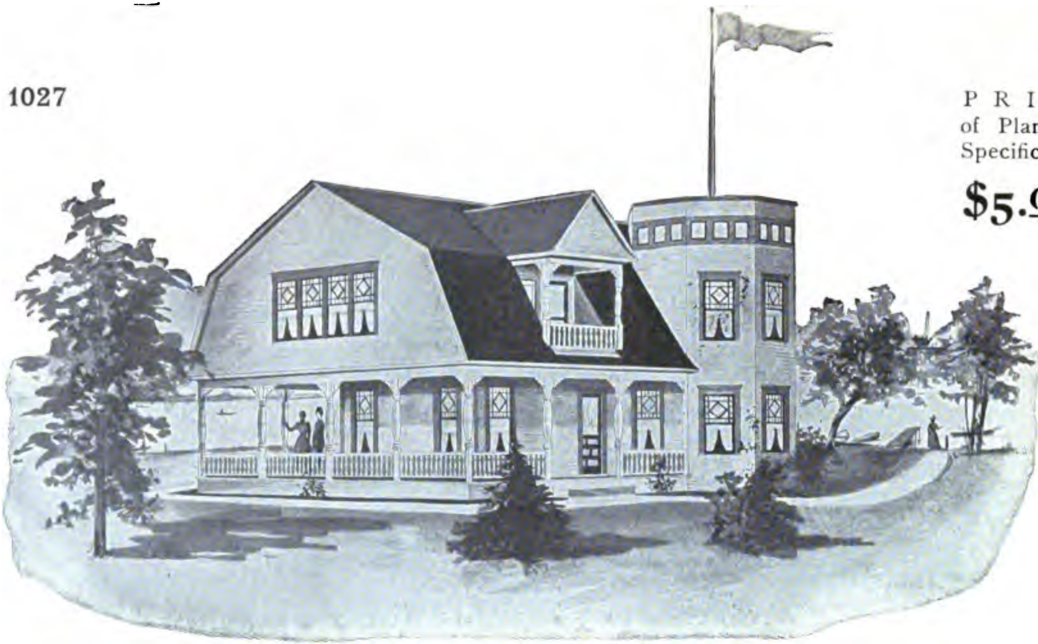
Blue prints consist of foundation plan, first and second floor plans; front, rear, two side elevations; wall sections and all necessary interior details.

Specifications consist of about fifteen pages of typewritten matter.

No. 1027

PRICE of Plans and Specifications

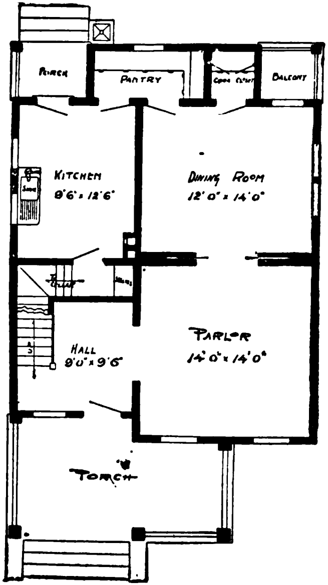
$5.00



HOUSE DESIGN NO. 1027

Full and complete working plans and specifications of this house will be furnished for $5.00. Cost of this house is from $1500 to $1700. according to the locality in which it is built.

FLOOR PLANS OF DESIGN No. 1095



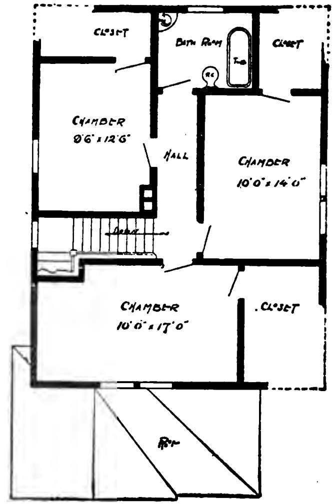
FIRST FLOOR PLAN

SIZE

Width, 25 feet.

Length, 32 feet,

exclusive of porches.



SECOND FLOOR PLAN

Blue prints consist of cellar and foundation plan; first and second floor plans; front, rear, two side elevations; wall sections and all necessary interior details.

Specifications consist of about fifteen pages of typewritten matter.

No. 1095

PRICE
of Plans and
Specifications
$5.00

HOUSE DESIGN NO. 1095

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Cost of this house is from $1250 to $1400, according to the locality in which it is built.

Remember

We can mail out the same day we receive the order any complete set of working plans and specifications we illustrate in this book.

Remember also

That, if you are going to build, complete working plans and specifications always

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We do not claim to be able to do it.

The estimated cost of the houses we illustrate is based on the most favorable conditions in all respects and does not include Plumbing and Heating.

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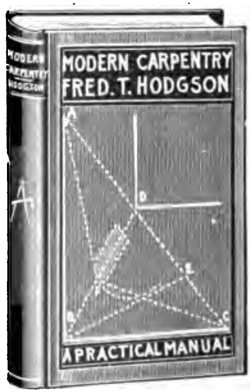

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