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Henry Harding

TEXT-BOOK

OF

MODERN CARPENTRY;

COMPRISING

A TREATISE ON BUILDING-TIMBER,

WITH RULES AND TABLES FOR CALCULATING ITS STRENGTH, AND THE STRAINS TO WHICH EACH TIMBER OF A STRUCTURE IS SUBJECTED;

Observations on Roofs, Trusses, Bridges, &c.;

AND

A GLOSSARY,

EXPLAINING AT LENGTH THE TECHNICAL TERMS IN USE AMONG CARPENTERS.

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PREFACE.

THE following work has been prepared as a book of reference for the master-carpenter, and as a manual of instruction for the journeyman and the apprentice. The costliness of the works of Belidor, Rondelet, Tredgold, and others, places them beyond the reach of mechanics of ordinary means; and, being written with reference to scientific formulas, cannot be appreciated, or even understood, except by those versed in mathematics. Having in view the interests of the large and important class above named, we have scrupulously avoided such abstruse algebraic and mathematical formulas as would more properly belong to an encyclopædia of the science.

Works of distinguished authors have been consulted, but nothing selected which did not commend itself as of immediate practical utility; and, while the advanced student may perhaps regret the absence of the higher mathematics, it is presumed that their omission removes a great obstacle to the progress of the less learned, though not less worthy, mechanic. An extended essay on Carpentry as a science being rendered unnecessary by the comprehensive nature of the work, its place is, we think, more properly occupied by such practical suggestions as have been considered most useful. Practice and experience, those great and successful teachers of all truth, are the privilege of every mechanic; but the lessons which they convey, while perhaps sufficing for his ordinary labors, may be greatly lightened, and far more worthily directed, by a careful study of those results of the experience and science of others, which it is the aim of this work to embody and explain.

The portion of this treatise devoted to building-timber states an average of results arrived at through many experiments and much observation. The authorities on the subject are many, and the field wide. It is, however, believed that the few pages allotted to the subject comprehend nearly all that is of practical value in the works of Hutton, Barlow, Du Hamel, Perronet, and many other writers both in Europe and America.

The illustrations are intended not only to exemplify the principles of the art, but also to suggest examples for imitation; and the amount of success attending our efforts in selection — at all times a work of much difficulty — must be judged of by the reader. He will, however, bear in mind that it has been an important consideration to give a variety of each kind of work in a small compass.

The "Glossary," which forms so large a part of the text, is the result of much labor, and, it is hoped, may prove of corresponding value.

Our work is now presented to the public in the belief, that, notwithstanding its imperfections, it contains a sufficient amount of information to make it a desirable companion to the apprentice in his hours of study, as well as a ready assistant to the man of business; and, in this hope, it is respectfully dedicated to their service.

THOS. W. SILLOWAY.

BOSTON, May, 1858.

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CARPENTRY.

THE Art of Carpentry is one of the leading parts of the sciences of architecture and engineering. It has claimed and received the attention of the masters in those sciences, and must always be a subject worthy of scientific consideration. No unimportant portion of the writings of Delorme, Palladio, and even Vitruvius, is that which relates to the art under consideration. The frame of a building sustains the same relation to the whole edifice that the bones of the system do to the human body.

It is a self-evident truth, therefore, that a knowledge of carpentry, as a science, is of great importance to the builder; for no edifice can be properly constructed but in accordance with those rules and principles to which the art is subject. Walls of stone or brick may not for their construction demand this information; still, to all buildings there must be roofs, floors, and partitions, to construct which the art of carpentry will be employed.

The first and most important thing to be considered, in making or executing any design, is *the end to be attained.* If a roof is to be produced, it is not enough to know the span and the pitch, but it is quite as essential to know the material with which it is to be covered; the design best adapted for the purpose; whether the determined inclination is best for that particular covering, &c. If a floor is to be built, the carpenter is to consider the purpose for which it will generally, or may possibly, be used; if a partition is to be erected, what support it may have or may lack below, what weight may rest upon it, and to what side-strains it may be subjected.

It is, however, unnecessary to enumerate, since it is plain, that, before commencing any work, it is important to see the *end* as well as the *beginning.*

The next consideration is so to select both materials and design as to make the best possible use of the means employed. This can be done effectually only by the application of such rules as investigations have proved of value. A knowledge of the nature and properties of the kind of timber used, its strength and durability, the strains to which it will be subjected, and many other things of like nature, are of much moment in the successful practice of the art. It was a wise remark of Sir Thomas Seppings, that "the strength of a piece of framing, whatever may be the design, can never exceed that of its weakest parts; and a partial strength produces general weakness."

The third consideration is in regard to construction itself. This science, like all others in which are involved mechanical principles, has many parts, each of which is closely interwoven with the others. Most authors have divided the art into two parts. One is called *mechanical carpentry*, and treats of the nature and properties of timber; the other, *practical carpentry*, or the *use* of timber. The division is, to a good degree, warranted: yet they are mutually dependent; and, in order to make a knowledge of one useful, it is necessary to understand both.

Having determined the things suggested, and, in addition, such incidentals as may be connected with them, the next step is to execute the work. Theory must now give place to practice; and what exists but on paper, or in the imagination of the artificer, is to be produced as a thing of life. To one who has thoroughly informed himself on the principles involved in the work he is to do, this part of his labor will not be without a corresponding degree of satisfaction and entertainment: for to execute a design is, or may be, as inspiring as it was to conceive and project it; and it is a question of some nicety to determine, whether the architect and the engineer experience more real pleasure in witnessing a design as it is wrought out and produced, than the mechanic, who, by care and labor, gives to comparatively crude and unfashioned materials condition and form which endow them with a power —

> "That flings control
> Over the eye, breast, brain, and soul;
> Chaining our senses to the stone,
> Till we become
> As fixed and dumb
> As the cold form we look upon."

There are many things essential for the attainment of the desired end; but the most important of them all, and, in fact, the great and governing principle involved throughout, is, that the workman understand well every part of his work, and that he be possessed of a desire to excel in his profession. In this, as in all arts, "knowledge is power." The advice of Mr. Tredgold is apt, and to the point. He says, "Nothing will assist the artist more in forming a good design than just conceptions of the objects to be attained; and nothing will render those objects more familiar to the mind than drawing them."

To make enlarged copies of the designs published, and at the same time to study with care the rules which govern them and the principles that are involved, will insure success to any one who may be disposed to make the attempt.

NATURE AND PROPERTIES OF TIMBER.

TIMBER is the substantial substance of all trees. Woods differ in their properties; some being tough and hard, while others are brittle or soft. They are, therefore, of value proportional to the kind of work for which they are required. A great variety of opinions exists in regard to the manner in which wood is formed. All are, however, agreed, that the trunk and branches of trees are composed of three parts, — the *bark*, the *wood*, and the *pith*.

The BARK is a covering which incases the entire wood, and is composed of three distinct parts, — the *Epidermis*, the *Cellula*, and the *Liber*.

The EPIDERMIS is a thin skin, being the extreme outer covering.

The CELLULA is the organic matter next inside the Epidermis. It answers to the flesh of animals, and is formed into an infinite number of tubes.

The LIBER is the inner or newly formed bark. The Epidermis and the Liber together form what is called the *Cutis*, or outer bark, the Liber being the inner.

The WOOD is the material that exists between the pith and the bark, and is of two kinds, — the *heart-wood*, or *Duramen;* and the *sap-wood*, or *Alburnum.*

The HEART-WOOD is the hard and dark part next the pith.

The SAP-WOOD is that which is between the heart-wood and the bark.

The PITH is the soft and spongy substance which is enclosed by the heart-wood at its centre.

In all new shoots, the pith and bark are in contact, without wood between them; but, as the shoot extends, it enlarges by the deposit of a secretion called *cambium*, which lies in a cylindrical ring between the pith and the bark. The deposit thus made is of two kinds. One is formed into bark, and the other ultimately hardens into wood. A deposit of this nature is made annually; and, if the trunk of a tree be cut off across the fibres of the wood, the surface will present a series of consecutive layers or rings, so that one is enabled to determine by their number the age of the tree in which they exist.

It is unusual to find any two rings that are alike, either in regard to their whole thickness, or the proportion of the solid part to the porous; the dimensions and proportion being governed by the amount and nature of the deposit, some years being more favorable to each respectively than others.

So exact are the laws by which this is governed, that the part of the rings on the north side of trees is thinner, making the heart-wood nearer the north side. This results from the fact, that, the south side being more exposed to the action of the sun, the pores are expanded, and a larger quantity of sap is transmitted through that side.

The wood of no tree is entirely solid, but is filled with tubes, or pores; and the only substance of a solid nature that exists is that which forms the walls of the cells before named. These vessels are designed for the conveyance of a fluid called *sap*, which is absorbed by the roots, and passes up through the pores of the wood to the leaves, where it undergoes a chemical change, and is then returned through the cellula, or porous part of the bark.

Sap, when it leaves the roots, is very limpid, being nearly as thin as water: but, as it passes up through the pores, it either meets with a substance which it dissolves and carries along with it, or, when it arrives at the most distant parts, is condensed; for, on its return, it is thickened; and entirely changed in its nature.

As it passes downward through the cellula, it gradually deposits a large proportion of the material it contains; so that, when it arrives at the roots, it is as thin as when it started to pass upward.

As soon as the leaves are developed, sap ceases to flow. The deposit gradually hardens; and thus is formed a new layer of material for wood and bark. From this period till near autumn, vegetation ceases; but, after this, the sap is again in motion, and, as it passes up, deposits along the pores of the wood the substance which the ascending sap of the next spring will dissolve and carry along for the formation of the new wood and leaves. As the tree increases in diameter, the wood at the centre is compressed by the growth of the new wood; and, becoming more solid, the pores decrease in size, and hence but little sap will flow through them. The part nearer the bark, being less compressed, is soft and porous; and, as the larger part of the sap passes through it, it takes its name *sap-wood.*

Those parts of the tree which need to be elastic and porous are continually receiving new substance of a proper nature for its replenishment; while, at the same time, those which are compressed into hard wood serve to give the requisite and additional support, or *back-bone*, to the increased tree. It has been well remarked, that the life of a tree is like that of a man, and may as properly be divided into three periods, — *infancy*, *maturity*, and *old age*.

During the whole of the first period, the tree continues to increase. Through the second, it simply maintains itself, and neither loses nor gains. As soon, however, as the heart-wood begins to decay, the second period ends, and signs of old age soon appear: and the comparison is not then inapt; for like an old man who seems to be still fresh and vigorous, but whom one storm of disease may break and sweep away, so often does a venerable and revered oak, clinging still to life, as if loath to die, put on, with each returning spring, "its youthful robes anew." But, its heart diseased, and vitality expended, being engaged in some tempestuous hour in an unequal contest, it falls to rise no more.

The timber of all trees partakes, to a greater or less degree, of the nature of the soil on which it grows. Trees grown on soft and spongy soil usually produce wood that is comparatively soft and irregular in fibre. Therefore, if oak be grown on dry and good land, the wood will be solid and tough; but, if grown on soft and wet land, it will be proportionally poor, and of less value. This fact is true of all timber-trees.

The wood of trees which stand alone, or where there are but few, and those scattered, is better than that grown in the middle of a forest, where it is not exposed to the sun and air. Hence, for building purposes, those trees which stand alone are to be first selected.

It may be well to mention here, that if the softwood trees are very large (as is often the case with some of the pines), and most of the branches are near the top, the wood near the base of the trunk is sometimes found to be *shaky.* This defect is produced by the action of heavy winds on the top of the tree, which wrenches or twists the but, and thus cleaves apart the fibres of the wood.

BUILDING-TIMBER.

There are but five kinds of wood in common use for carpentry in this country. These are *spruce*, *pine*, *oak*, *hemlock*, and *chestnut.*

Spruce (*Abies*) is indigenous to the colder parts of North America, where it grows in great abundance. For most qualities which constitute good framing-timber, it is excelled by no other wood in use.

There are two varieties, which are familiarly known as *black* or *double* (*Pinus niger*) and *white* or *single spruce* (*Pinus alba*). Of these, the black is of most value; it being much tougher than the white, and may be procured in much larger sticks. The foliage of this variety is darker and heavier. The white spruce is of a comparatively small growth; but the wood may be worked much smoother than the other variety. Spruce-wood, when seasoned, is of a clear yellowish white, the annual rings being distinctly marked by a darker tint of the same color, and having a silk-like lustre. A cubic foot, when seasoned, weighs thirty-one pounds and a half. It shrinks, in seasoning, about a seventieth part of its dimensions, and loses a fourth of its weight.

The principal defects of this wood are its liability to twisting and splitting in the sun, and its tendency to decay in all damp situations; but where due attention is paid to these points, and proper care is exercised to prevent the exposures named, little else need be done to insure the permanency of work composed of this wood.

PINE (*Pinus*) is next in value as material for a frame. Of this wood, there are many species. The family (*Conifera*) to which it belongs is large, and comprises all that ranges from the most compact and hard spruce to the softest white pine. But two kinds, however, will claim our attention; the others, as framing-timber, partaking largely of the nature of spruce. Remarks relating to that wood may be applied with nearly the same propriety to all the harder varieties of pine.

The two varieties most in use are known as *white pine* and *Carolina pine.*

WHITE PINE (*Pinus strobus*) abounds in all the northern portion of the United States, and is the tallest of our native trees. It is remarkable for the straightness of its trunk, which is often found a hundred feet high, entirely clear of limbs. The whole tree frequently attains an altitude of two hundred feet. It is the same as that known in England as *Weymouth pine.* In forests, all excepting the top branches decay early; and these, being above all other trees, make it conspicuous as far as it can be seen. Pine is of rapid growth, and, in favorable situations, increases an inch in diameter, and two feet in height, in a single year. The bark of trees which are less in diameter than fifteen inches is very smooth, and of a bottle-green; being, through the warm season, covered with an ashy gloss.

The color of the seasoned wood is a brownish white. A cubic foot weighs twenty-four pounds and three-quarters. Its decrease of dimension in seasoning is slightly more than spruce.* It has little tendency to warp or twist; and, for such parts of a frame as are liable to be exposed to dampness and continued wet, it is preferable to spruce. The wood being softer, it is more liable to indentation

* It is the generally received opinion of carpenters, that all wood is liable to *some* shrinkage in length; though, in most instances, it is hardly perceptible.

at the joints; and, being less stiff, it is not, for general purposes, entirely equal to spruce. As a whole, its average value for framing purposes may be considered as nine to ten.

For *finishing-lumber*, it excels all others, and sustains the same relation to *joinery* that spruce does to *carpentry*. None is better calculated to withstand the effects of the sun and weather than this; for with the exercise of proper care in seasoning, and reasonable protection afterwards, it will retain its natural strength and vigor as long as the best of oak.

Carolina Pine (*Pinus australis*) is, in most respects, entirely unlike the wood last described; being very compact, and thoroughly saturated with a resin, or pitch, which is remarkable for its intense fragrance. It grows in great luxuriance in all our States south of Virginia, and is familiarly known at the north as *southern pine*. Timber of almost any reasonable length and dimensions may be easily obtained. This wood is seldom cut up into small joists; but, when not sawed into large framing-timber, it is used for planks and floor-boards; the solidity of the wood, and the fineness of its grain, making it of great value for the purpose last named.

In all dry situations, it is exceedingly durable; but, in wet or even damp places, it loses its vigor, and soon moulds and decays. Its tensive strength, compared with oak, is nearly equal; while its weight is much less. This quality, added to its peculiar stiffness and resilience, has of late years made it a rival of oak, where a lighter yet solid wood is required. It is, however, very brittle, and liable to fracture by a sudden blow or concussion; making it inferior to oak, where toughness is needed.

This wood, when newly planed, is a rich yellow; the resinous parts giving it a finely variegated appearance. The average weight of a cubic foot, when seasoned, is not far from thirty-eight pounds and a quarter. It decreases a fifth of its weight in seasoning, and a sixty-fifth of its dimensions; shrinking something more in the direction of its length than either of the other woods in common use.

Oak (*Quercus*) is a wood, like all others, existing in many species. Only two, however, — those commonly known as *white oak* and *yellow oak*, — are in general use for building purposes. It is a native of temperate climates, and is found in great perfection and vigor in the United States, — from Virginia (the northern limit of the growth of Carolina pine) to the Canada line. The wood is very durable, when kept immersed in water; and, while remaining in a perfectly dry situation, it has lasted more than a thousand years. When subjected alternately to the action of water and air, together with more than ordinary warmth, it is subject to early decay. Oak-wood is hard, yet elastic and tough. Its texture is alternately porous and solid; the porous sections being the lighter colored portion of the annual ring. The wood of young trees is much tougher than that of old ones, and is more difficult to work. That of old ones is often quite brittle; while at the same time, in most other respects, it appears to retain its natural qualities. It is the case with oak as with all trees, — that the wood, taken from the body and large limbs, is stronger than that taken from the small branches. The sap is possessed of a peculiar odor and taste. It contains gallic acid; and, in consequence, turns black or purple, when brought in contact with iron.

The color of the wood is a whitish brown in the *white* species, and a yellowish brown in the *yellow*. A cubic foot, when dry, weighs forty-eight pounds. It shrinks, in seasoning, a thirty-sixth part of its dimensions, and loses a third of its weight.

For many purposes, — such as *strengthening-pieces*, *keys*, *treenails*, &c., — oak is indispensable; though of late years, as a general framing-timber, it has been little used. For the first two centuries after the settlement of this country, it was employed almost to the entire exclusion of other wood; but spruce and pine have gradually supplanted it, till now a new piece of oak-framing is but seldom seen. When used to any great extent, it is for open timber-roofs of churches, or something of the kind. The natural beauty of its selected wood for a rich *finish-lumber*, and its great strength and durability as a framing-timber, insure the usefulness and value of the "monarch of the forest."

In addition to the foregoing, the two next in value are those familiarly known as the *black oak* and the *live oak*. The former is nearly allied to the yellow oak; and is, in many respects, of equal value. *Live oak* is principally used in ship-building. The wood is nearly identical with white oak; but the nature and habits of the tree tend to produce only small and very crooked timber. For the various purposes, however, for which the timber is used, it is an important member of the *Quercus* family.

Hemlock (*Canadensis*) is often used in the cheaper kinds of carpentry. It is indigenous to nearly all places which are favorable to the production of spruce and the light pines. In dry situations, when the wood has been properly seasoned, and is carefully protected from the action of the sun, it may be considered as a fourth-rate wood. Its peculiar structure, tending to twistish or cleftish grain, makes it entirely unreliable for large timbers where either tensile or compressive strain is required. It decays quickly in damp situations; and, if exposed while in an unseasoned state, its heart-wood cleaves from the surrounding wood by the action of either sun or wind.

Considering these tendencies (existing even in the best specimens), it is usually cut into small studding-joists or common boards. Hemlock possesses one quality in common with oak and the other hard woods; viz., the tenacity with which it adheres to a nail. An ordinary tenpenny cut nail, if driven into the wood half its length, will part before it can be drawn out. This quality is one of its first recommendations for common or rough boarding, as it firmly holds the nails of shingling, slating, clapboarding, &c.

The sap is possessed of an intense and somewhat unpleasant odor. It is unfit for use while in an unseasoned state, as it corrodes iron immediately at the part where it begins to project from the wood. The color of the wood is a light brown; and a cubic foot, when dry, weighs twenty-seven pounds. It shrinks, in seasoning, a little less than spruce, and loses one-fourth of its weight.

CHESTNUT (*Castana*) is a wood of great value, and is in most respects nearly identical with oak, which it resembles in color, toughness, and solidity. It is a native of temperate regions, and is usually found growing side by side with its rival. For most purposes for which oak is used, chestnut is of equal value. While exceedingly durable in damp situations, it is equally so in those which are dry; and, in places partaking at times of both, it is preferable to oak. For posts set in the ground, it may be considered good for a service of forty years. Like oak, the grain of the wood is compact; and that of young trees is very tough and flexible: but old wood is liable to brittleness, appearing sound and healthy without, while within it is decayed and rotten. Chestnut contains one valuable quality not possessed by either of the other woods; namely, when once seasoned, it is but slightly susceptible of shrinking or swelling. The weight of a cubic foot of the wood, when perfectly seasoned, is forty-one pounds.

FOREIGN TIMBER.

As many scientific experiments have been made in Europe on woods which are, in their general properties and strength, nearly identical with those in common use in America, a brief synopsis of these will be given, that the carpenter may avail himself of the experiments by applying the results to our corresponding timber.

ACACIA (*Robina*), — a wood commonly known in America as *locust*. A cubic foot, when seasoned, weighs forty-eight pounds. It is slightly stronger than oak.

CHRISTIANA DEAL (*Pinus abies*), — a wood nearly allied to the spruce of North America. It is somewhat heavier and tougher. It will bear one-fifth more strain, and is also one-fifth stiffer.

COWRIE (*Dammara australis*), — a New-Zealand tree, the wood of which answers well to the *pitch* or *yellow pine* growing in the New-England States. A cubic foot, when seasoned, weighs forty pounds. Its general strength is that of our spruce.

Dantzic Oak is of the same stiffness as our white oak, but is tougher and stronger.

English Oak (*Quercus robur*) is one-tenth lighter, and one-seventh stronger, than our white oak; and, while it is one-fourth tougher, it is not as stiff by one-seventh.

Mar-Forest Fir (*Pinus sylvestris*), — a wood which, in New England, would be considered as a cross between spruce and northern pitch-pine. A cubic foot, when dry, weighs thirty-eight pounds. It is of the same tensile strength as our spruce, but less elastic.

Memel Fir, — a wood nearly identical with that from Mar Forest. It answers well to the red and yellow pines of New England, but partakes of the nature of spruce, in being stiffer than the pines named.

Norway Spruce (*Pinus abies*) is, in many respects, like our black spruce. It is harder, and has more pitch. When seasoned, it weighs thirty-four pounds to a cubic foot.

Riga Oak is one-seventh stronger than our white oak, but is one-seventh less stiff. It is one of the *toughest* varieties of oak in use.

SCOTCH FIR is nearly identical with our New-England red and yellow pine.

WEYMOUTH PINE (*Pinus strobus*) is a wood identical with the white pine of New England.

FELLING TIMBER.

The felling of timber was looked upon by ancient architects as a matter of much moment. Vitruvius was so minute in giving advice on this subject, as to urge that timber should never be felled but in the decrease of the moon; and we find good Isaac Ware saying of the suggestion (it being what he termed the opinion of the "Roman oracle"), "This has been laughed at, and supposed to be an imaginary advantage. . . . There may be good in following the practice; there can be no harm: and therefore, when I am to depend upon my timber, I will observe it." Sir John Evelyn quaintly says, "It should be in the vigor and perfection of trees that a felling should be celebrated."

The end to be attained in the management of timber-trees is to produce, from a given number, the largest possible amount of sound and durable wood.

To accomplish this requires not only attention in felling the timber, but in caring for it afterwards. The first, and perhaps most important, advice is to fell a tree as near the time of its maturity as possible: for, if it be cut earlier, the sap-wood predominates; and, the heart-wood being comparatively soft, the timber cannot possess great strength or much durability. If permitted to stand long after this, it declines in quality; the wood by degrees losing its elasticity, and becoming brittle.

It is somewhat difficult to decide just when a tree is at maturity. From the investigations of naturalists, however, it may be safe to consider, that hard-wood trees, as oak and chestnut, should never be cut before they are sixty years old; the average age for felling being a hundred years. For the soft woods, — as spruce and pine, — the proper age is seventy years. It should be remembered, that the times mentioned are by no means arbitrary; for situation, soil, &c., have much to do with it.

When a tree, under conditions favorable to its growth, entirely ceases increasing the diameter of its trunk, and loses its foliage earlier in the autumn than it is wont to do, these facts may be considered as indications of decline, and that the tree is of sufficient age to be felled.

The next consideration is the season of the year most favorable for the work. All investigations tend to prove that the only proper time is that at which the tree contains the least sap. As stated in another article, there are two seasons in each year when the vessels are filled. One is in the spring, when the fluid is in motion to supply nutriment to the leaves, and deposit material for new wood: the other is in the early part of the autumn, when, after the stagnation which gives the new wood time to dry and harden, it again flows to make the vegetable deposits in the vessels of the wood. At neither of these times should trees be felled; for, if the pores be full of vegetable juices, — which, being acted upon by heat and moisture, may ferment, — the wood will decay.

In the New-England States, August is, for this purpose, the best month in the year; for, at that time, most of the fluids and vegetable matter having been exhausted in the formation of leaves and wood, and the watery parts evaporated, the wood is dryest. Next to this is the month of January; for then, as in August, there is but little sap in the tree.

The age at which trees should be felled, and the most suitable time for the work, having been determined, there are two other things which claim attention.

The first of these is the removal of the bark from the trunk and principal branches of the trees. This practice has, from time immemorial, been considered of inestimable value: for, by it, the *sap-wood* is rendered as strong and durable as the *heart-wood;* and, in some particular instances, experiments have shown it to be four times as strong as other wood, in all respects similar, and grown on the same soil, but felled with the bark on, and dried in sheds.* Buffon, Du Hamel, and, in fact, most naturalists, have earnestly recommended the practice. The venerable Evelyn, in his "Sylvia," says, "To make excellent boards and planks, it is the advice of some, that you should bark your trees in a fit season, and so let them stand naked a full year before felling."

In regard to the time that should elapse between the removal of the bark and the felling of a tree, a variety of opinions exists. It was the usual custom of early architects to remove the bark in the spring, and fell the trees the succeeding winter.

* Emerson's "Trees and Shrubs of Massachusetts," p. 33.

Later investigations have proved that it is better to perform this work three, or even four, years in advance, instead of one. Trees will, in most situations, continue to expand and leaf out for several seasons after the bark has been removed. The sap remaining in the wood gradually becomes hardened into woody substance; thereby closing the sap-vessels, and making it more solid. As bark separates freely from the wood in spring, while the sap is in motion, it should be taken off at that period.

The second suggestion is to cut into and around the entire trunk of the tree, near the roots, so that the sap may be discharged; for, in this manner, it will be done more easily than it can be by evaporation after the tree is felled. In addition to this, if it be permitted to run out at the incision, a large portion of the new and fermentable matter will pass out with it, which would remain in the wood if only such material is removed as would pass off by evaporation.

This cutting should be made in the winter previous to the August in which the tree is to be felled; and the incision should be made as deep into the heart-wood as possible, without inducing a premature fall of the tree.

Many suggestions might be made as regards the mechanical operation in felling trees: but, as these are familiar to all intelligent workmen, we will mention only one; namely, the value of removing from the side of the tree such branches as will strike the ground when it falls, and, by wrenching, cleave the grain of the wood, and thereby injure the timber. Such defects, which are often found after the timber has become seasoned, could not be discovered when it left the mill.

SEASONING TIMBER.

Nothing contributes more to increase the value of timber than thorough and judicious seasoning. The principal objects to be attained are, first, to remove the saccharine or loose vegetable matter, which by heat and moisture may ferment, and thereby cause the wood to decay; and, second, to remove all *moisture*, in order that the wood may shrink to its smallest dimensions, and thus be enabled to retain its shape and place after it has been wrought. To attain this, many methods have been used; but, fortunately, the most simple and practical of them all is of most value. If timber be properly subjected to the action of water and air, it may, by this means, be perfectly seasoned, and at small expense.

As soon as it has been felled, timber should be immediately removed to the mill, and sawed. If this is impracticable, and the bark has not been removed, it should be taken off, and the logs put into the river or some running stream, there to remain till they can be taken to the mill.

If no stream is near, they should be placed on some dry spot, be well blocked up from the ground, and covered with boughs of trees to keep from them the action of the hot sun or of strong currents of wind.

After the lumber has been sawed, it should be put into the water, and chained down beneath its surface, for at least two weeks, when the vegetable matter will be dissolved, and pass out into the water. After remaining submerged for the time named, it should be taken out, and piled in a dry place, where it may be covered with boards to protect it from the direct action of both sun and wind.

It is not well to attempt to dry it too quickly; for, if it be subjected to great heat, a large portion of the carbon will pass off, and thereby weaken the timber. And, further, if it be dried by heat, the outside will become hardened, and the pores closed; so that moisture, instead of passing out, will be retained within. Timber, too suddenly dried, cracks badly, and is thus materially injured.

In piling it, the sleepers on which the first pieces are laid should be perfectly level and "out of wind," and so firm and solid throughout, that they will remain in their original position; for timber, if bent or made to wind before it is seasoned, will generally retain the same form when dried. Pieces of wood should be put between the sticks, and each piece directly over the other, so that air may freely pass through the whole pile; for, while it is necessary to shield timber from strong draughts of wind and the direct action of the hot sun, a free circulation of air and moderate warmth are equally essential.

More costly methods of seasoning — such as smoking, steaming, exhausting the sap by an air-pump, &c. — are not sufficiently valuable to compensate for the trouble and expense.

The length of time requisite for seasoning timber depends entirely upon the size of the stick, the kind of wood, its situation, &c., while drying. The carpenter should exercise his own judgment; always remembering that a large stick is *never* so dry that it will not season, and consequently shrink still more, if sawed into smaller pieces, and new surfaces be exposed to the action of the air.

THE PRESERVATION OF TIMBER.

To preserve timber is next in importance to obtaining it; for, unless properly cared for, however good may be the material, all previous precautions avail but little. Wood is liable at any time to change its nature, and part with its most valuable properties. In all timber, even if well seasoned, there remains a certain quantity of sap and vegetable matter, which, when the piece is shut up in stagnant air liable to be heated in summer, will mould or ferment, and an acid be formed, decomposing the wood.

In no instance should a piece of framing be so enclosed that fresh air cannot at all times come in contact with it. To every roof, church-spire, dome, &c., there should be air-holes at such points above and below as will insure a continual circulation of air about the wood.

The next consideration is to protect it from the action of alternate moisture and dryness. If a stick of timber be exposed to a continued heat,—as, for instance, over a baker's oven,—it will in time lose its elastic power, and become brittle. If, on the other hand, a piece of the same timber, in all respects identical in properties and nature, be immersed in water, and remain submerged, it will retain the larger part of its properties for centuries. In fact, if not injured by insects or acids in the water, it may be considered as almost indestructible; but the reverse of this is the case if it be subjected to the alternate action of water and air.

As soon as a piece of wood is exposed to the action of moisture, the vegetable and saccharine matter begins to dissolve; and a slimy coating is formed wherever the solution exists. When exposed to the air, this slime ferments; and from it grows a sort of fungus, which lives on the vital parts of the wood itself. A continual series of exposures of this kind soon induces a visible decay, which ends in the entire destruction of the timber.

Every part of a frame should in some way be protected. No work should, therefore, be placed on or very near the ground, where earth can in any way come into immediate contact with it; nor should any be subjected to the direct action of steam or vapor, without being in some way shielded. The artificial methods of preserving timber are numerous. Covering the work with boards is in many instances effectual. Sometimes, however, this is no protection, but, on the contrary, serves to retain moisture that would evapoporate if left exposed, as is often the case with the sills of buildings, timber-bridges, &c.

In every instance where the timber *must* be covered, but is necessarily exposed to moisture, also when it is exposed to the action of the weather without a covering, artificial means for preservation must be resorted to.

The first step to be taken is to season the timber thoroughly. When this has been done, the whole of the exposed surfaces should be covered with some preparation that will strike into the wood, and, as much as possible, harden the outside. Thus, by closing the pores, the piece is made impervious to the weather.

A valuable practice for the preservation of timber is to heat it by burning charcoal, or something of like nature, beneath; and, while it is in a heated state, applying a hot solution of an ounce and a half of corrosive sublimate, or one of aqua fortis (nitric acid), in a gallon of water. After this is done, and the work well dried, it should be painted with the best quality of white lead and oil.

A thin solution of hot coal-tar and whale-oil is of great benefit to all timber that is to be placed near the ground. If this operation be repeated two or three times, and finely pulverized clinkers from a blacksmith's forge, or the dust made from the scales of iron which lie about an anvil, be sifted upon the timber while the tar is newly put on, it will possess great durability, since wood prepared in this manner is scarcely susceptible of decay.

Pyroligneous acid, or the liquor that drips from stove-pipes in which vapor condenses, also strong decoctions of soot applied hot, are recommended as good preservative agents. In all framing exposed to the weather, every mortise that can hold water, and their tenons, together with all the wood about them, should have a good coating of one of the preparations first named, before the work is put together.

It not unfrequently occurs that the wood at the lower end of posts, rafters, &c., of church-steeples, is found to be entirely decayed, while other parts of the structure are perfectly sound. In almost all such cases, some part of the work, being imperfect, has admitted water, which, following down the post to its end, has filled the mortise, and thus rotted the wood.

When a piece of framing is to be permanently exposed to the weather, it should be treated with one of the solutions first described, and then thoroughly painted and sanded. Wood in a proper condition when felled, afterwards thoroughly seasoned, well saturated with diluted corrosive sublimate, and, finally, kept properly painted and sanded, is as durable as it ever can be.

One caution it would be well to remember; namely, to refrain from applying paint or any preparation to wood before it is thoroughly seasoned: for, should the outside be coated so as effectually to prevent impenetration from without, evaporation will also be prevented from within; therefore, all moisture that may be in the wood will be retained, and rot the piece.

Another suggestion is to use timbers as small as the nature of the work will permit. It is a mistake to suppose that large timbers will continue good longer than small ones. We may see an exemplification of this at any New-England farmhouse. The light spokes of a wheel will remain sound and strong for years after the tongue of the cart to which they belonged has entirely decayed.

If a timber is sufficiently strong when first used (the requisite allowance being made for permanent strain), all has been done that prudence would dictate, since no increase of the dimensions of the piece will insure its longer duration. And, finally, it should be scrupulously remembered, that timber will not certainly remain sound because a large portion, or even most of it, is in proper condition, and well cared for. Only so much as is actually protected will retain its qualities; and any part so exposed as to injure the whole stick will as surely injure or destroy the unprotected part. Therefore, the ends of timbers which are built into walls, also all surfaces in contact, — as where the side or edge of one stick rests upon another, tenons in mortises, &c., — should be supplied with air, kept dry, and in every way properly protected.

DURABILITY OF TIMBER.

The durability of timber is almost incredible. The following are a few examples for illustration, being vouched for by Buffon, Du Hamel, Rondelet, and others : —

The piles of a bridge built by Trajan, after having been driven more than sixteen hundred years, were found to be petrified four inches ; the rest of the wood being in its ordinary condition.

The elm-piles under the piers of London Bridge have been in use more than seven hundred years, and are not yet materially decayed.

Beneath the foundation of Savoy Place, London, oak, elm, beach, and chestnut piles and planks were found in a state of perfect preservation, after having been there for six hundred and fifty years.

While taking down the old walls of Tunbridge Castle, Kent, there was found, in the middle of a thick stone wall, a timber-curb, which had been enclosed for seven hundred years.

Some timbers of an old bridge were discovered, while digging for the foundations of a house at Ditton Park, Windsor, which ancient records incline us to believe were placed there prior to the year 1396.

The durability of timber out of the ground is even greater still. The roof of the basilica of St. Paul, at Rome, was framed in the year 816 ; and now, after more than a thousand years, it is still sound : and the original cypress-wood doors of the same building, after being in use more than six hundred years, were, when replaced by others of brass, perfectly free from rot or decay; the wood retaining its original odor. The timber-dome of St. Mark, at Venice, is still good, though more than eight hundred and fifty years old. The roof of the Jacobin Convent at Paris, which is of fir, was executed more than four hundred and fifty years ago.

The age of our country's settlement does not enable us to refer to examples of like antiquity; but no good reason appears to exist why timber may not be as durable in America as in Europe. Many old white-pine cornices here exist, which, having been kept properly painted, have been exposed to the storms of more than a hundred and fifty years. The wood is still sound, and the arrises are as good as when they were made; while freestone, in the same neighborhoods, has decayed badly in less than fifty years.

STRENGTH OF TIMBER.

To discover rules which will in all cases determine the exact strength of timber has for many years been an object of interest with scientific men. Mr. Tredgold, an eminent writer on the science of carpentry, has laid down at length the results of the best investigations made by himself and others; but, in summing up, he speaks as follows: "The age of trees at the time of cutting; the natural defects, such as knots, shakes, &c.; also the mode of seasoning, or the comparative dryness, — are the cause of some difference in the strength and stiffness of timber. All these things considered, it is impossible to calculate correctly its strength and stiffness." After reminding the reader that the "precision which is so essential to the philosopher is not absolutely necessary to the architect and engineer," he says, "They content themselves with approximations that are simple and easy to be obtained; and, provided that the limits which cannot be passed with safety be pointed out, these approximations are sufficient to direct their practice." *

Mr. Peter Nicholson (from whose works subsequent authors have borrowed *ad libitum*) remarks as follows: "On that subtile subject,—the proportional strength of timber, on which I gave some observations and calculations in my 'Carpenter's Guide,'—I was in hopes that I should have been able to reduce the theory of scantlings to an arithmetical rule of consequences certain, and of general application. I have to lament that all my endeadors, assisted by several gentlemen well versed in mathematics, have hitherto been unsuccessful." †

Experiments on the strength of timber have, until a late day, tended but little to reform the science of carpentry. Probably more has been done by bold, and perhaps rash, experiments than by all the works which have been written. It remains a fact, however, that the strength of any piece of timber may be determined with sufficient accuracy for all practical purposes. In the ex-

* Tredgold's "Elementary Principles of Carpentry," art. 68, p. 29.

† "Carpenter and Joiner's Assistant," pp. vi. and vii. (Preface).

amples of framing published in this work, such dimensions for the several timbers are given as experience has approved; and these examples comprise all that any carpenter can need. But, that he may be fully informed in regard to the strength of the various kinds in common use, tables and rules will be given, exhibiting the principles involved. These tables have been prepared expressly for this work, and are founded on the results of many experiments made on dry and sound wood, grown in either Massachusetts, New Hampshire, or Maine. The specimens were selected as a just average of the respective kinds; and, as the experiments were carefully made, the tables may be considered as reliable.

TIMBER-STRAINS.

TIMBER may be subjected to three kinds of strain: —

1*st*, When the force tends to pull the piece in the direction of its length: this is called *tensile strain.*

2*d*, When the force tends to bend it in the direction of its depth, or across the fibres: this is commonly known as *cross-strain.*

3*d*, When it tends to compress it in the direction of its length, or what is called *compressive strain.*

TENSILE STRAIN.

The following table exhibits the tensile strength of an inch-square rod of each of the kinds of wood in common use; or, in other words, the power each will resist when so applied as to tend to tear it asunder in the direction of its length:—

Kind of Wood.	Weight in Pounds.
Black Spruce	10,260
White Pine	8,300
Carolina Pine	12,000
White Oak	13,200
Hemlock	9,100
Chestnut	10,500

PROBLEM I.

TO DETERMINE THE TENSILE STRENGTH OF A RECTANGULAR TIMBER.

RULE. — *Multiply the thickness of the piece in inches by its depth* * *in inches, and the product by the weight set against the kind of wood in the table. The product so obtained will be the force in pounds the piece will resist.*

EXAMPLE. — What force will be required to pull asunder a tie-beam of spruce, 7 inches thick and 10 inches deep?

Thickness,	7	10,260	Breaking-power.
Depth,	10	70	
	70	*Ans.* 718,200 lbs.	

* The distance across the top of the beam, when it is in a horizontal position, is commonly called its *thickness;* and that of the side, from the top to the under part, its *depth.*

PROBLEM II.

TO DETERMINE THE DIMENSIONS OF A PIECE OF TIMBER THAT WILL RESIST A GIVEN STRAIN, ONE SIDE ONLY BEING GIVEN.

RULE. — *Multiply the sum set against the kind of wood in the table by the given side in inches, and divide the force to be resisted by this product. The quotient will be the dimension, in inches, of the side required.*

EXAMPLE. — What must be the depth of a beam of white pine, 4 inches thick, to resist a strain of 232,400 pounds?

8,300	Breaking-weight.	33,200) 232,400 (7 inches.
4	Thickness.	232,400
33,200		*Ans.* 4 by 7 inches.

The following table exhibits the tensile strength of various kinds of wood, as given by the authors named: —

Kind of Wood.	Strength of a Square Inch in lbs.	Experimentalist.
English Oak	19,800	Bevan.
" "	17,300	Muschenbrock.
Beech	22,000	Bevan.
"	17,300	Muschenbrock.
Ash	16,700	Bevan.
"	12,000	Muschenbrock.
Elm	14,400	Bevan.
"	13,489	Muschenbrock.

Locust	16,000	Bevan.
"	20,582	Muschenbrock.
Walnut	7,800	Bevan.
"	8,130	Muschenbrock.
Poplar	7,200	Bevan.
"	6,641	Muschenbrock.
Pitch-Pine	7,818	Muschenbrock.
Larch	8,900	Bevan.
Teak	8,200	Bevan.
Mahogany	21,800	Bevan.
Lancewood	23,400	Bevan.

The following corollaries, in relation to the strength of timber, have been established by experiment: —

1*st*, A piece of timber should not be subjected to a permanent strain of more than a fourth of the power that would break it.

2*d*, A piece of perfect timber, while in a level position and properly supported, is supposed to be of equal tensile strength throughout; and, whether the piece be long or short, it is liable to part in one place nearly as quick as in another.

3*d*, A piece of perfect timber, in a vertical position, is in tensile strength proportionate to its length; a short piece being stronger, since a long one must, in addition to the power applied to the lower end, sustain its own weight; and hence, when it breaks, will part near the top.

4th, In calculating the strength of any piece of timber, only so much of the wood should be measured as is continued throughout the entire stick. For instance, a tie-beam measuring eight by ten inches, having an inch-and-a-half rod passing through it, should be considered as measuring but six inches and a half thick; and if the ends of struts, or any thing of the kind, be cut down, into and across the top of the beam, two inches, it would then measure but eight inches deep.

5th, A rectangular beam supported at both ends, with its diagonal placed vertically, will thereby be reduced, in *cross-strength*, one-tenth.

6th, The tough and hard woods, as oak and chestnut, are about an eighth, and the soft ones, as spruce, pine, and hemlock, from a sixteenth to a twentieth, as strong, when the power is applied at right angles to the fibres, as when applied to their length. This power is that which a pin exerts on the wood of a post through which it has been driven, when the tenon, which is pinned in, tends to drag it out, and thereby split the wood.

CROSS-STRAIN.

WHEN a piece of timber is supported only at the ends, and a weight or power is applied at the centre, it will, if the force is sufficient, bend or sag. If the power of resistance be great, the wood is said to be *stiff;* but, if it bends easily, it is said to be *flexible.* Should it bend much, without fracture, it is called *tough.*

If a beam, two feet long and an inch square, will support, at its centre, five hundred pounds, one of the same length, two inches wide and an inch deep, will support a thousand pounds. Hence we have as a rule, that *beams of the same depth are to each other as their thickness.* Should the beam described be turned upon its side, so as to make it an inch thick and two inches deep, it will support two thousand pounds. We therefore have as a second rule, that *beams of equal thickness are to each other as the square of their depth.*

If a beam, an inch square and two feet long, will support, at its centre, five hundred pounds, one four feet long will support but two hundred and fifty pounds. A third rule, therefore, is, that *beams are to each other inversely as their length.**

If a beam, sixteen feet long, supported at the ends, will support, at its centre, a weight of eight hundred pounds, it will support equally well twice that amount if eight hundred pounds be placed at points, each four feet from either side of the centre, — half-way between the centre and the points of support. Again: it will equally well support twice *that* amount (or 3,200 pounds), if sixteen hundred pounds be placed at points, each half-way from those last named and the points of support (two feet). A beam, therefore, that will support a thousand pounds at its centre, will support two thousand pounds if the weight be distributed equally over its entire length.

A beam, having but one end fixed in a wall, will sustain only a fourth as much weight, when applied to the end, as will one of the same dimen-

* Experiments made by Buffon tend to prove that the strength of a beam does not decrease in exact geometrical progression to its length, but that it will actually bear something more than half the amount which would break one of half its length.

sions with both ends in like manner supported, and the weight placed at the middle. When the weight is equally distributed over the entire length of a beam which has only one end supported, it will sustain twice the amount that would break it if applied to the middle.

Should three beams be fixed at one end in a wall, and the other end left unsupported, — one of them inclined upwards, one at the same angle downwards, and the third level or at right angles with the wall, — that inclined upwards would sustain the least weight; that inclined downwards, the most; and the horizontal one, a mean between the two. In calculating the strength of an inclined beam, the distance from the end of the beam, at right angles with the wall, should be taken as the actual length of the beam; which length, as a basis, will give the strength of the beam, if, instead of being inclined, it were placed in a horizontal position.

From the foregoing *data*, it will be seen, that, by the aid of tables and rules, it is easy to determine the strength of inclined as well as horizontal timbers.

The following table exhibits the cross-strength of each of the several kinds of wood; the pieces being dry, an inch square, and twelve inches long between the points of support: —

Wood.	Breaking-weight in lbs.
Black Spruce	590
White Pine	548
Carolina Pine	684
White Oak	738
Hemlock	426
Chestnut	595

PROBLEM III.

TO DETERMINE THE CROSS-STRENGTH OF A STICK OF TIMBER.

RULE. — *Multiply the thickness of the stick in inches by the square of its depth in inches, and divide the product by the length of the piece in feet. With the quotient multiply the sum in the table that is set against the kind of wood; and the product will be the breaking-weight in pounds.*

EXAMPLE. — What weight will a spruce-beam, 18 feet long, 6 inches thick, and 8 inches deep, sustain?

	Length.	Breaking-weight.
8 Depth.	18) 384 (21.3	590
8	36	21.3
—	—	—
64 Square.	24	177.0
6 Thickness.	18	590
—	—	1180
384	60	—
	54	12,567.0 lbs.

PROBLEM IV.

TO DETERMINE THE DEPTH OF A STICK OF TIMBER THAT WILL SUSTAIN A GIVEN WEIGHT, THE THICKNESS AND LENGTH BEING GIVEN.

RULE. — *Divide the weight to be sustained by the sum set against the kind of wood in the table. Multiply the quotient by the length of the stick in feet, and divide the product by the thickness of the stick in inches. The square-root of the quotient will be the depth of the stick in inches.*

EXAMPLE. — What depth will be required to a stick of chestnut, 19 feet long and 3 inches thick, that it may sustain 27,251 pounds?

Breaking-weight.		
595) 27251 (45.8	45.8	290.066 (5.38
2380	19 Length.	25
3451	4122	103) 400
2975	458	309
4760	Thickness 3) 870.2	1068) 9166
4760		8544
	290.066	

Ans. $5\frac{38}{100}$ inches nearly.

PROBLEM V.

TO DETERMINE THE THICKNESS OF A STICK OF TIMBER THAT WILL SUSTAIN A GIVEN WEIGHT, THE LENGTH AND DEPTH BEING GIVEN.

RULE. — *Divide the weight to be sustained by the sum set against the kind of wood in the table. Multiply the quotient by the length of the stick in feet, and divide the product by the square of the depth in inches. The quotient will be the thickness of the beam in inches.*

EXAMPLE. — What should be the thickness of a hemlock-beam, 21 feet long and 12 inches deep, that it may sustain a weight of 19,170 pounds?

Breaking-weight.

```
426) 19170 (45       45               12 Depth.
     1704            21 Length.       12
     ----            --               --
      2130           45              144 Square.
      2130           90
                     --
              144) 945 (6.56
                   864
                   ---
                    810
                    720
                    ---
                     900
                     864
```

Ans. $6\frac{56}{100}$ inches nearly.

The following table exhibits the breaking-weight of various kinds of wood as given by the authors therein named: —

Experiments on the Strength of Woods.

KIND OF WOOD.	Length in Feet.	Brdth. in Inches.	Depth in Inches.	Deflection in Inches at the time of fracture.	Weight in Pounds that broke the piece.	Authorities.
English Oak, young tree	2	1	1	1.87	482	Tredgold.
Oak, old ship-timber . . .	2.5	1	1	1.5	264	,,
,, from old tree	2	1	1	1.38	218	,,
,, medium quality . .	2.5	1	1		284	Ebbels.
Green Oak	2.5	1	1		219	,,
Oak, from Riga	2	1	1	1.25	357	Tredgold.
Green Oak	11.75	8.5	8.5	3.2	25812	Buffon.
Beech, medium quality .	2.5	1	1		271	Ebbels.
Alder	2.5	1	1		212	,,
Plane-tree	2.5	1	1		243	,,
Sycamore	2.5	1	1		214	,,
Green Chestnut	2.5	1	1		180	,,
Ash, from young tree . .	2.5	1	1	2.5	324	Tredgold.
Ash	2.5	1	1	2.38	314	,,
Common Elm	2.5	1	1		216	Ebbels.
Green Witch-Elm	2.5	1	1		192	,,
,, Acacia	2.5	1	1		249	,,
Sp. Mahogany, seasoned .	2.5	1	1		170	Tredgold.
Hond. ,, ,, .	2.5	1	1		255	,,
Green Walnut	2.5	1	1		195	Ebbels.
Lombardy Poplar	2.5	1	1		131	,,
Abele Poplar	2.5	1	1	1.5	228	Tredgold.
Teak	7	2	2	4.0	820	Barlow.
Willow	2.5	1	1	3.0	146	Tredgold.
Birch	2.5	1	1		207	Ebbels.
Cedar of Libanus, dry . .	2.5	1	1	2.75	165	Tredgold.
Riga Fir	2.5	1	1	1.3	212	,,
Memel Fir	2.5	1	1	1.15	218	,,
Norway Fir, fr. Long Sd.	2	1	1	1.125	396	,,
Mar-Forest Fir	7	2	2	5.5	360	Barlow.
Scotch Fir, Engl. growth	2.5	1	1	1.75	233	Tredgold.
,, ,, ...	2.5	1	1		157	Ebbels.
Christiania white Deal . .	2	1	1	0.937	343	Tredgold.
American white Spruce .	2	1	1	1.312	285	,,
Spruce-fir, British growth	2.5	1	1		186	Ebbels.
American Pine, Weymouth	2	1	1	1.125	329	Tredgold.
Larch, choice specimen .	2.5	1	1	3.0	253	,,
,, medium quality .	2.5	1	1		223	,,
,, very young wood .	2.5	1	1	1.75	129	,,
Riga Fir	4	3	3		4530	Fincham.
Red Pine	4	3	3		3780	,,
Yellow Pine	4	3	3		2756	,,
Cowrie	4	3	3		4110	,,
Poona	4	3	3		3990	,,

It has been decided by experiment, that a fifth of the breaking-weight will cause deflection, increasing with time, and ultimately producing a permanent set. By an examination of the table, it will be discovered that wood of old trees is much weaker than that of those of mean age; also that timber is stronger as it is heavier, though the increase in all examples is not exactly proportionate to its solidity.

COMPRESSION.

Compression is the power exerted on a post when loaded with a superincumbent weight, as that which is exerted on the collar-beam, or struts and rafters of a truss.

It has been discovered, that a timber, if placed as a post, whether long or short, would in either case, if entirely inflexible, support a weight equally well. But, inasmuch as there is some flexibility in *all* timber, a piece will, if higher than about seven times its diameter, bend and break before it can be crushed by compression; and it is stated, that a piece, if a hundred times as high as it is in diameter, will be incapable of supporting the smallest weight.*

The nature of the subject under consideration makes it next to impossible to determine rules which will be of much service. As the compres-

* Gwilt's "Encyclopædia of Architecture," p. 442, art. 1600.

sive strength of timber is so variable in different specimens, and in none so geometrically proportionate to its length as to give reliable *data*, rules for ascertaining the exact size for all purposes and situations would only confuse, if not deceive, the mechanic.

The power of resistance to compression is so great, that no serious danger need be apprehended from the use of such dimensions of timber for collar-beams, truss-rafters, struts, &c. (these being, when in use, in a state of compression), as will generally agree with the tie-beams and purlins; and the only rule that may be considered of value is, that the compressed pieces of any work should bear such a proportion to those subjected to a tensile or cross strain as will make the whole truss, whatever its design, comparatively uniform in appearance throughout.

The following table, prepared by Mr. Tredgold, was designed to aid in determining the strength of timber when compressed in the direction of its length. The calculations were made for foreign timber. It is presumed, however, they are quite as reliable for timber grown in America as for that grown in England, since in neither is their truth susceptible of mathematical demonstration.

Kind of Wood.	Proportional Strength.
English Oak	.0015
Beech	.00195
Alder	.0023
Green Chestnut	.00267
Ash	.00168
Elm	.00184
Locust	.00152
Riga Fir	.00152
Memel Fir	.00133
Norway Spruce	.00142
White Pine	.00157
Larch	.0019

PROBLEM VI.

TO DETERMINE THE DIAMETER OF A ROUND COLUMN THAT WILL SUPPORT A GIVEN WEIGHT.

RULE.—*Multiply the weight in pounds by* 1.7 *times the amount set against the kind of wood in the table; then multiply the square-root of the product by the length or height in feet; and the square-root of the last product will be the diameter of the post in inches.*

If the column be shorter than ten times its diameter, the dimensions ascertained by this rule will be too small; in which case, the true diameter may be determined by Problem VIII.

PROBLEM VII.

TO DETERMINE THE SIZE OF A RECTANGULAR POST THAT WILL SUPPORT A GIVEN WEIGHT.

RULE. — *Multiply the weight in pounds by the square of the length of the post in feet, and this product by the number set against the kind of wood in the table. Divide the product by the breadth in inches, and the cube-root of the quotient will be the thickness in inches.*

In case the post is less than ten diameters high, the dimensions will be determined by Problem VIII., as before directed.

RESISTANCE TO CRUSHING.

According to Rennie's experiments, the power of wood to resist crushing (a cube an inch square being used, and the power applied to the end of the grain) is as follows: —

Kind of Wood.	Resistance.
Elm	1284
American Pine	1606
White Deal	1928
English Oak	3860

PROBLEM VIII.

TO DETERMINE THE LOAD ANY POST OF LESS THAN TEN TIMES ITS DIAMETER IN HEIGHT WILL SUPPORT WITHOUT CRUSHING.

RULE.—*Multiply the area of the post in inches by the weight that will crush a square-inch of the kind of wood. A fourth of the product is the greatest permanent load the post will bear with safety.*

Only two other strains to which wood may be subjected need be noticed.

One is that exerted by the foot of a truss, rafter, or any thing of the kind, on the wood between it and the end of the tie-beam on which it stands; the tendency being to slide, or push off the wood. The quality which resists this is called the *lateral adhesion.* Experiments have proved that the soft woods, as spruce, pine, &c., will resist a force of from five to seven hundred pounds, and the hard woods, as oak and chestnut, from six to nine hundred pounds, to the square-inch. As no piece of good carpentry would be dependent on the simple adhesion of the wood alone for support, but, where the thrust is one of more than ordinary moment, bolts or straps should be employed, rules and further suggestions are uncalled for.

The other strain to which reference has been made is where the power tends to tear asunder the fibres of the wood in the direction of their length. (See corollary 6, page 48.) Experiments made on oak and chestnut show this resistance to be from nineteen hundred and fifty to twenty-six hundred pounds to the square-inch, and white pine and spruce from six hundred and fifty to twelve hundred pounds.

GEOMETRY AND SQUARE-ROOT.

GEOMETRY.

"GEOMETRY is the foundation of architecture, and the root of mathematics." Such being the case, a knowledge of its leading principles is essential to a successful practice of the art of carpentry. While only a part of the science is necessarily called into requisition, that part is all-important.

It is presumed that every apprentice will make himself familiar with the science by the study of some good treatise on the subject. A few rules, however, for making calculations will be given in this work. They are introduced, as in other cases of like nature, more for the purpose of refreshing the memory than for imparting original information.

The diagrams on Plate I. exhibit such general principles as are most frequently used by the carpenter; and it is believed they will convey all the information he may require.

PLATE I.

FIG. 1. — *To draw a line perpendicular to another at a given point.*

From the points A and C, equally distant from the given point B, with the radius AC describe arcs intersecting each other at D. From this point to B draw the line DB, which will be the line required.

FIG. 2. — *To draw a line perpendicular to another at its extremity.*

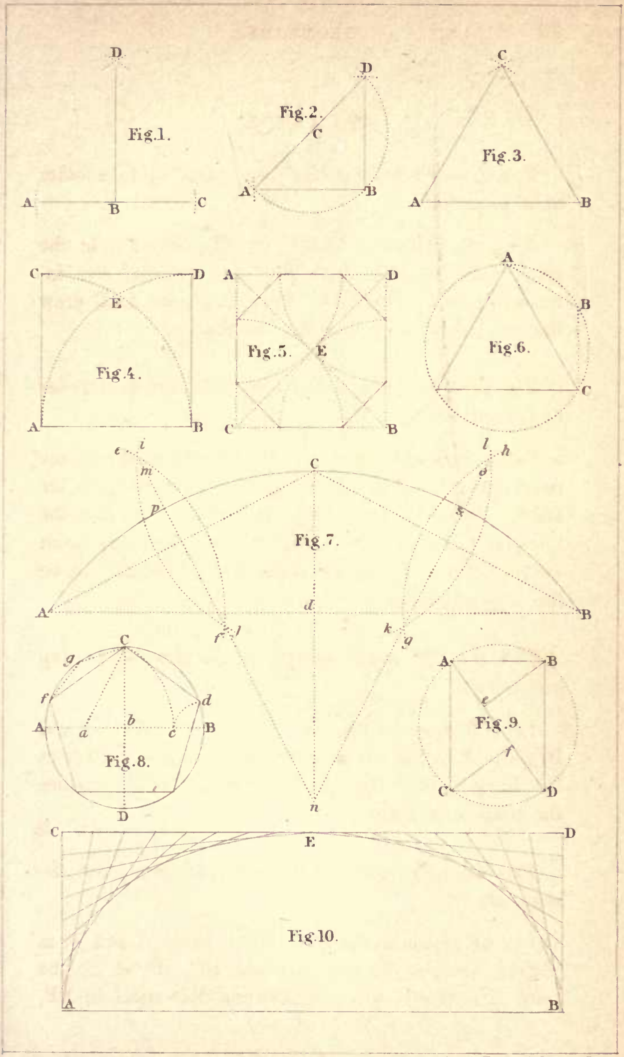
Let B represent the extremity of the line. From any point above the line AB, as a centre, describe the arc DBA. Draw AD from the point where the arc cuts the line AB. Through the centre C, and from the point where AD cuts the arc, draw the line DB, which will be the line required.

FIG. 3. — *To draw an equilateral triangle to any given base.*

Let AB represent the base. From the points A and B, with the radius AB describe arcs cutting each other at C. From C, draw the lines CA and CB, which produce the triangle required.

FIG. 4. — *To construct a square of any given dimensions.*

Let AB represent the given side. From A and B, as centres, describe the arcs AD and BC. From E, the point of intersection, set off EC and ED equal to EF,



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which are one-half the line EA; then draw from the points the figure CABD.

FIG. 5. — *To describe a regular octagon, or figure of eight equal sides, of a given dimension.*

Let AD represent the diameter of the octagon. From this, draw the figure ADBC; then draw the diagonals AB and CD. With the radius AE, on the points ADBC, describe arcs cutting the square. From the points of intersection, draw diagonals, and the octagon is formed.

FIG. 6. — *To draw a regular hexagon or triangle within a given circle.*

Apply the radius of the circle six times around the circumference, as at AB; and the line is a side of the hexagon. Draw a line from the points AC, and the line is the side of an equilateral triangle.

FIG. 7 *exhibits a method for finding the centre of a circle when an arc is given; also for describing a segment of a given height.*

Let AB represent the base, and *d*C the height. Produce the lines AC and CB. On the points A and B, with a radius of more than half the line AC describe the arcs *ef* and *gh*. On the point C, with the same radius, describe the arcs *ij* and *kl*. Through the points of intersection, draw the lines *mn* and *no*, cutting each other at the point *n*; which will be the centre required.

FIG. 8. — *To inscribe in a circle a regular pentagon, or figure of five equal sides.*

Draw two lines, AB and CD, perpendicular to each other. Divide the radius A*b* into equal parts, as at *a*.

On a as a centre, with the radius aC describe the arc Cc; then, on B as a centre, with the radius Bc describe the arc cd, and from the point of intersection d to C will be a side of the pentagon. A decagon, or figure of ten sides, is described by drawing the lines fg and gC, and then proceeding thus with each of the five sides till the figure required is completed.

FIG. 9. — *This figure exhibits a method of determining the dimensions and form of a rectangular stick of timber cut from a round stick, which shall be capable of supporting the greatest weight when lying in a horizontal position.*

The circle represents the outline of the log or stick, and ABDC the stick to be cut therefrom. To determine which, divide the line AD (the diameter of the log) into three equal parts. On the points e and f erect perpendiculars; which produced, cut the circumference at the points BC; which, together with the points AD, give the corners of the required stick.

FIG. 10. — *To describe an elliptic arch by intersecting lines, the base and height being given.*

Let AB represent the base, and AC the height. Divide AC and BD into any number of equal parts; then divide CD into two equal parts, as at E. Divide CE and DE each into the same number of parts as AC and BD. Then, from the points described, draw lines as shown in the figure; and the points where these intersect will be the track of the curve. Trace a line through them, and we have the figure AEB.

DEFINITIONS.

The *diameter of a circle* is a right line drawn through its centre, and terminated at each end by the circumference, as AB, fig. 8.

The *radius of a circle* is a right line drawn from the centre to the circumference, being half the diameter; as C*b*, fig. 8.

An *arc of a circle* is any portion of the circumfeference; as DB, fig. 2.

A *chord* is a right line joining the extremities of an arc; as AB, fig. 7.

A *segment* is any part of a circle bounded by an arc; as ABC, fig. 6.

A *semicircle* is half a circle; as ACB, fig. 8.

A *sector* is any part of a circle bounded by an arc and the radii; as *pns*, fig. 7.

A *quadrant* is a quarter of a circle; as A*b*D, fig. 8.

PROBLEM I.

TO FIND THE AREA OF A PARALLELOGRAM, WHETHER IT BE A SQUARE, A RECTANGLE, A RHOMBUS, OR A RHOMBOID.

RULE. — *Multiply the length by the perpendicular height, and the product will be the area.*

PROBLEM II.

TO FIND THE AREA OF A TRIANGLE.

RULE. — *Multiply the base by the perpendicular height, and half the product will be the area.*

PROBLEM III.

TO FIND THE AREA OF A TRIANGLE WHOSE THREE SIDES ARE GIVEN.

RULE. — *From the half-sum of the three sides subtract each side severally. Multiply the half-sum and the three remainders together, and the square-root of the product will be the area required.*

PROBLEM IV.

ANY TWO SIDES OF A RIGHT-ANGLED TRIANGLE BEING GIVEN, TO FIND A THIRD SIDE.

CASE I. — When two sides are given, to find the hypothenuse.

RULE. — *Add the squares of the two legs together, and the square-root of the sum will be the hypothenuse.*

CASE II. — The hypothenuse and one of the legs being given, to find the other leg.

RULE. — *From the square of the hypothenuse take the square of the given leg, and the square-root of the remainder will be equal to the other leg.*

PROBLEM V.

TO FIND THE AREA OF ANY REGULAR POLYGON.

RULE. — *Multiply half the perimeter of the figure by the perpendicular falling from its centre upon one of the sides, and the product will be the area of the polygon.*

PROBLEM VI.

TO FIND THE AREA OF A REGULAR POLYGON, WHEN THE SIDE ONLY IS GIVEN.

RULE. — *Multiply the square of the given side of the polygon by that number which stands opposite to its name in the following table, and the product will be the area:* —

No. of Sides.	Names.	Multiplier.
3	Trigon	0.43301
4	Tetragon	1.00000
5	Pentagon	1.72047
6	Hexagon	2.59807
7	Heptagon	3.63391
8	Octagon	4.82842
9	Nonagon	6.18182
10	Decagon	7.69420
11	Undecagon	9.36564
12	Duodecagon	11.19615

As the foregoing table extends to five places of decimals, it is exact enough for all practical purposes.

PROBLEM VII.

THE DIAMETER OF A CIRCLE BEING GIVEN, TO FIND THE CIRCUMFERENCE.

RULE. — *Multiply the diameter by* 22, *and divide the product by* 7: *the quotient will be the circumference. Or multiply the diameter by* 3, *and add a seventh part of the diameter to the product: the sum will be the circumference as obtained before. Either of these methods is sufficiently correct for common purposes.*

PROBLEM VIII.

THE CIRCUMFERENCE OF A CIRCLE BEING GIVEN, TO FIND THE DIAMETER.

RULE. — *Multiply the circumference by* 7, *and divide the product by* 22: *the quotient will be the diameter.*

PROBLEM IX.

THE CHORD AND HEIGHT OF A SEGMENT BEING GIVEN, TO FIND THE RADIUS OF THE CIRCLE.

RULE. — *To the square of the half-chord add the square of the height, and divide the sum by twice the height of the segment: the quotient will be the radius of the circle when it is less than a semicircle.*

PROBLEM X.

TO FIND THE AREA OF A CIRCLE, THE DIAMETER BEING GIVEN.

RULE. — *Multiply half the circumference by half the diameter, and the product will be the area.*

PROBLEM XI.

TO FIND THE AREA OF A SECTOR OF A CIRCLE.

RULE. — *Multiply the radius, or half the diameter, by half the length of the arc of the sector; and the product will be the area.*

PROBLEM XII.

TO FIND THE AREA OF THE SEGMENT OF A CIRCLE, THE CHORD AND HEIGHT OF THE ARC BEING GIVEN.

RULE. — *To two-thirds of the product of the base, multiplied by the height, add the cube of the height divided by twice the length of the segment; and the sum will be nearly the area.*

PROBLEM XIII.

TO FIND THE AREA OF AN ELLIPSIS, THE TRANSVERSE AND CONJUGATE, OR LONG AND SHORT, DIAMETERS BEING GIVEN.

RULE. — *Multiply the transverse axis by the conjugate, and the product multiplied by* .7854 *will be the area.*

PROBLEM XIV.

TO FIND THE AREA OF A PRISM.

RULE. — *Multiply the area of the base, or end, by the perpendicular height; and the product will be the solidity.*

PROBLEM XV.

TO FIND THE SOLIDITY OF A PYRAMID.

RULE. — *Multiply the area of the base, or end, by the perpendicular height; and a third of the product will be the solidity.*

PROBLEM XVI.

TO FIND THE SOLIDITY OF THE FRUSTUM OF A SQUARE PYRAMID.

RULE. — *To the rectangle of the sides of the two ends add the sum of their squares. That sum being multiplied by the height, a third of the product will be the solidity.*

PROBLEM XVII.

TO FIND THE SOLIDITY OF A SPHERE, OR GLOBE.

RULE. — *Multiply the cube of the diameter by* .5236, *and the product will be the solidity.*

PROBLEM XVIII.

TO FIND THE SOLIDITY OF THE SEGMENT OF A GLOBE.

RULE. — *To three times the square of half the diameter of the base of the segment add the square of the height of the same. Multiply that sum by the height named, and the product multiplied by* .5236 *will give the solidity.*

PROBLEM XIX.

TO FIND THE CONVEX SUPERFICE OF A RIGHT CYLINDER, THE CIRCUMFERENCE AND LENGTH BEING GIVEN.

RULE. — *Multiply the circumference by the length, and the product will be the area.*

PROBLEM XX.

TO FIND THE CONVEX SUPERFICE OF A RIGHT CONE, THE CIRCUMFERENCE AND SLANT SIDE BEING GIVEN.

RULE. — *Multiply the circumference by the slant side, and half the product will be the area.*

PROBLEM XXI.

TO FIND THE CONVEX SUPERFICE OF THE FRUSTUM OF A CONE, THE CIRCUMFERENCES OF BOTH ENDS AND THE SLANT SIDE BEING GIVEN.

RULE. — *Multiply the sum of the circumferences by the slant side, and half the product will be the area.*

PROBLEM XXII.

TO FIND THE SUPERFICE OF A SPHERE, OR GLOBE, THE CIRCUMFERENCE BEING GIVEN.

RULE. — *Multiply the square of the circumference by* .3183, *and the product will be the superfice.*

PROBLEM XXIII.

TO FIND THE CONVEX SUPERFICE OF THE SEGMENT OF A GLOBE, THE DIAMETER OF THE BASE OF THE SEGMENT AND ITS HEIGHT BEING GIVEN.

RULE. — *To the square of the diameter of the base add the square of twice the height, and the sum multiplied by* .7854 *will give the superfice.*

PROBLEM XXIV.

TO FIND THE CONVEX SUPERFICE OF AN ANNULUS, OR RING, WHOSE THICKNESS AND INNER DIAMETER ARE GIVEN.

RULE. — *To the thickness of the ring add the inner diameter. Multiply the sum by the thickness, and the product multiplied by* 9.869 *will be the superfice.*

SQUARE-ROOT.

As the extraction of the square-root of numbers is required to calculate the strength of timber, the rule will be given below, more to refresh the memory than to give original information as to its principles; it being presumed that every intelligent workman has made himself familiar with the rules of common arithmetic through works especially designed for the purpose.

RULE. — 1*st*, *Separate the given number into periods of two figures each, by placing a point over the first figure at the right hand, and then over every other figure towards the left.*

2*d*, *Ascertain the greatest square-number contained in the left-hand period, and place the root of it at the right hand of the given number, after the manner of a quotient in division. Subtract the square of this root from the period named, and to the remainder bring down the next period for a new dividend.*

3*d*, *Double the quotient already found, and place it at the left of the dividend for a divisor. Find how* *many times this divisor is contained in the new dividend (omitting the right-hand figure), and place the figure in the root as the second figure of the same, and likewise on the right hand of the divisor. Multiply the divisor by the last quotient-figure, subtract the product from the dividend, and to the remainder bring down the next period for a new dividend.*

4*th, Double the quotient already found for a partial divisor, and from these find the next figure in the root as before directed: so continue the operation until all the periods have been employed. Should a remainder exist, add two ciphers as a new period, and so continue pointing off the root after the rules of decimal fractions.*

EXAMPLE. — What is the square-root of 59,325 ?

```
        . . .
        59325 (243.5
        4
        ---
   44)  193
        176
        ----
  483)   1725
         1449
         -----
 4865)   27600
         24325
```

Required the square-root of 326,041 : —

```
         . . .
         326041 (571
         25
         ----
  107)   760
         749
         -----
 1141)   1141
         1141
```

EQUILIBRIUM

OF

STRAINS ON TIMBER.

EQUILIBRIUM OF STRAINS ON TIMBER.

A KNOWLEDGE of the relation that one part of a frame sustains to each of the others is of great importance to the carpenter; for, if ignorant of the force that each piece will be required to exert or resist, he cannot determine beforehand whether the assemblage will possess sufficient strength to answer the purpose designed. The timbers of a frame are usually acted upon by direct, and also by complex, forces.

POSITION.

The strains to which the timbers of a structure are subjected will always be governed by their position; and their particular inclination will increase or diminish these strains in accordance with the laws of mechanical forces.

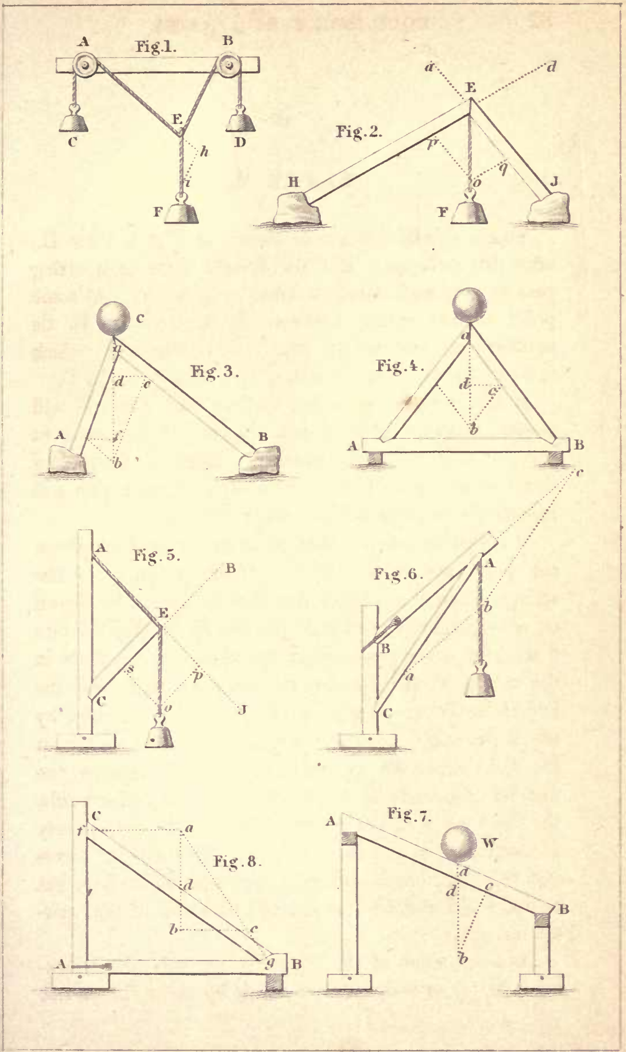
PLATE II.

To the side of a beam, as shown at Fig. 1, Plate II., affix two pulleys, A and B. To the ends of a string passing over each, attach weights, as C and D. At some point of the string between the pulleys, as E, tie another; to the end of which affix weight F, which must be lighter than the sum of the weights C and D.

If the work be then left to itself, the point E will assume a certain position, and the whole will remain at rest; and, if the arrangement be disturbed by pulling down or lifting up either of the weights, each part will recover its original position when left free.

It is thereby proved, that, when in that position alone, the parts are *in equilibrio.* If the position of the strings, when the weights are thus balanced, be drawn on paper, and any portion of the line E*i* be divided into a scale of parts representing the number of pounds in the weight F, the line AE be continued to *h*, and the line *ih* be drawn parallel to EB, then *ih*, measured by the scale, would show the number of pounds weight at D; and the line E*h*, measured in the same manner, the number of pounds in the weight C: or, in other words, the three sides of the triangle E*hi* will be respectively proportionate to the three weights. Therefore, to ascertain to which weight either side corresponds, we have but to find which weight draws in the direction of that particular side.

As a deduction of the foregoing, we have the following rule: *If a body be kept at rest by three forces, two*



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of which are represented in magnitude and direction by two sides of a triangle, the third side will represent the magnitude and direction of the other force.

NOTE. — Before proceeding to the immediate consideration of the strains to which timbers in a frame may be subjected, the student should make himself familiar with the mechanical principles demonstrated by Fig. 1, Plate II., as the principles therein contained are the base on which rests the science of carpentry.

We will now suppose that the point E, in Fig. 1, — instead of being sustained by the weights C and D, which act in the direction E*a* and E*b*, as shown at Fig. 2, — is supported by timbers HE and JE. The weight F being suspended from the point E, the timber HE will sustain a force equal to that which is exerted in the direction of E*b*; and JE, a force equal to that exerted in the direction of E*a*.

To determine these forces, we proceed as follows: Let any portion of the line EF, as E*o*, represent the weight F. Draw *op* parallel to HE; and *op*, measured by the scale, will represent the weight sustained by HE, and *oq* that sustained by JE.

From the above *data* we deduce the following: —

1*st*, A force or power applied to the end of a timber always acts in the direction of its length.

2*d*, If a post be somewhat inclined, as AC, Fig. 3, and another timber put against it, as BC, the post will be relieved of a part of the strain; for each piece will support a weight proportional to its own inclination.

3*d*, Should a weight be applied to the apex of two pieces of like inclination, as at Fig. 4, it will exert an equal strain on each.

4th, A weight, applied as shown in Figs. 3 and 4, tends to spread the timbers apart at the lower ends. In Fig. 3, we have supposed them to rest against an immovable abutment. It is obvious, that, the strain being a direct thrust, a *tie* connecting A and B will be an equivalent to the abutments. Fig. 4 represents this, AB being the *tie-beam*.

5th, If an inclined timber, as AB, Fig. 8, be cut at the ends so as to rest level on the walls, it will have no tendency to slide; and therefore, so long as it remains in this position, will not exert the slightest thrust on the walls.

TO DETERMINE THE STRAINS EXERTED ON TIMBER.

Being in possession of the foregoing facts and deductions, the carpenter is enabled to determine the exact strain to which the parts of any piece of framing will be subjected.

Suppose it be required to determine the strain exerted on each of the pieces shown at Fig. 3. From the point where the pieces meet, draw the vertical line *ab* of any convenient length; from *b*, draw *cb* parallel to AC. Assuming the weight C to be five hundred pounds, we proceed as follows: —

Let the line *ab* represent the weight. Divide it into ten equal parts, and one of these again into ten others. Each one of the divisions last named — being a hundredth part of the line *ab*, which represents the whole weight of five hundred pounds — will represent five pounds. Measure the line *cb* by this scale; and as many parts as it contains, multiplied by five, will be the number of pounds the piece AC must support. Proceed in the same way with *ca*, and the result will be the weight supported by BC.*

The horizontal strain exerted on the tie-beam may be determined as follows: From the point *c*, Fig. 4, draw a line parallel to the tie-beam. The line *cd*, measured by the scale as before described, will represent the pressure, or strain, exerted thereon by each piece. If the pieces be unequally inclined, as in Fig. 3, proceed as before described; and the parallel lines will represent the horizontal strain, as in Fig. 4. *af* will represent the vertical strain on A; and *ad*, the strain on B.

If a weight be applied to any part of an inclined beam, as W, Fig. 8, the direct transverse strain may be determined on the same principles. From a point beneath the centre of the weight, draw the line *ab* of any convenient length. From the end of the line at *b*, draw *cb* at right angles with the beam. Having divided the line *ab* into a scale of parts representing the number of pounds weight at W, we have, by measuring the line *cb* with this scale, the number of pounds weight exerted as transverse or *cross* strain on the beam AB.

It may also be observed, that *ac* will give the force with which the ball would move down the beam; or, in other words, if the ball be fixed, it would show the force exerted in the direction of the beam. *dc* will represent the strain exerted on the wall, should the beam rest against it. Those strains to which the several timbers of

* It should be borne in mind, that the particular inclination of the pieces determines the aggregate pressure; and, although the sum of the two may amount to more than the weight applied, it does not necessarily follow that the calculation is wrong.

a crane are subjected are identical with those exerted on the various timbers of most examples of framing.

While the crane is an exceedingly simple machine, it fully illustrates every point under consideration; and has, in consequence, become with most authors a favorite model for illustration.

Fig. 5 illustrates the nature and amount of strain a weight will exert on both a *tie* and a *strut* at the same time. Instead of the beams HE and JE of Fig. 2, as substitutes for the ropes AE and BE of Fig. 1, we may substitute, in place of rope EB, the strut CE, Fig. 5, and permit a rope AE to remain. The weight is supported in this example precisely as it was in each of the others, and the method of procedure to ascertain the respective strains is the same. E*o*, as a scale representing the weight, is the scale for measuring *po*, which is the strain on the strut CE; and *os*, the strain on the tie, or rope.

Fig. 6 represents the same principle, and, in like manner, illustrates the means of determining the strain on inclined timbers. A*b* represents the scale of weight. The line A*c*, measured by the scale, will give the strain on AB; and *bc*, that on CA. Should the projecting timbers be inclined downwards, the method of calculation would be the same.

If a beam be inclined against a wall, as at Fig. 7, and the inclination be less than forty-five degrees, there will be a tendency to slide; but there is an angle to which the end of the beam may be cut, so that this tendency will be entirely overcome.

This discovery is of great value to the carpenter, since the ends of truss-rafters, struts, &c., formed in accordance with the rule, will exert no lateral strain on the wood against which it abuts.

From the centre of the beam at *d*, draw the line *ab* parallel to AC. From *a*, draw *af* to the centre of the beam at *f*; then, from *a*, draw *ag* to the centre of the inclined beam at the lower end. *ag* will represent the direction in which the beam presses upon the abutment at B or *g*; and the parts should therefore be cut at right angles to the line named.

If we divide the line *ab* into a scale representing the weight on the centre of the beam, and draw *bc* perpendicular thereto, *bc* will represent the pressure against the abutment, or the tensile strain exerted on the beam AB.

The foregoing comprehends all the important principles relative to the strains exerted on the timbers of a frame. In calculating these, however, it is to be remembered, that the simpler a piece of framing is, so is the resolution of the forces exerted upon it; and *vice versâ*. Although, in most instances, strains are more or less complicated, interfering with, and at times counteracting, each other, still the exact strain upon each part is susceptible of calculation; and any one who has sufficient curiosity and perseverance may, by following the rules, determine the nature and quantity of the strain exerted on any specimen of framing, however complicated.

SCARFING, FLOORS, AND

TRUSSED BEAMS.

SCARFING.

It frequently occurs in the practice of carpentry, that single lengths of timber are too short for the distance required; in which case, the carpenter unites two or more pieces by a process technically termed SCARFING. The principal end to be attained is, that, when put together, the scarfed stick shall be equal in strength to a single piece of the same dimensions. To attain this, it is necessary so nicely to adjust the indentations, that the entire surface of each part shall come in contact with the corresponding part in the other piece; so that all may have a direct and uniform bearing, and none be made to resist a force that should be resisted by another.

Methods of scarfing are various; and, of many, we may truly say, that their design savors more of the imagination of the *artist* than the sober experience of the *mechanic*.

As it is not the purpose of this work to illustrate the whole range of experiments in these things, such methods only will be given as have proved themselves most useful, presuming these will meet every reasonable demand; remarking merely, that, when more complicated forms of indentation are made, it is always at the expense of utility.

Beams are seldom exposed to more than two kinds of strain which act upon the scarfing. One is, when the power is so applied as to exert a strain in the direction of the beam's length, as that produced by truss-rafters on a tie-beam: the other is, when the force or power tends to sag or break the beam in the direction of its *depth.*

In consideration of which, attention should be paid, in the selection of a method of scarfing, to the particular kind of strain to which the beam is most liable to be subjected.

The parts of a piece of scarfing are held together by bolts passing through the stick, as shown in the plate; and oak-keys are frequently put into the scarf to prevent the parts sliding past each other, as seen at *a*, Figs. 1, 2, 3. Care should be taken that neither bolts nor keys be so large as to require the removal of such an amount of wood as will materially weaken the timber.

These keys should be made of perfectly sound dry white oak. They should be in two parts, each slightly tapering on one side, so that, when driven in, they may tighten the joint.

The iron straps or bars used on a scarf (as shown on some of the examples) should be of the best wrought iron, from a fourth to a half inch in thickness, and from two to three inches wide, according to the size of the beam scarfed; and should be four in number to each scarf. The length of the scarfing for any beam should be about six times the depth of the stick, and the bolts which confine the work together should be from a half to three-fourths of an inch in diameter; making five-eighths of an inch as the best average size for bolts to beams of any dimension above eight or nine inches square.

PLATE III.

Plate III. exhibits five specimens, or examples, of scarfing. Figs. 1, 3, and 5 are best adapted to resist a strain in the direction of the *length* of the beam; and Figs. 1, 2, and 4, to resist one in the direction of its *depth.* In Figs. 4 and 5, the pieces are too short to admit of either of the other methods. The planks of example at Fig. 5 should be of good dry white oak; and, if the work is well done, this scarf is equal in strength to either of the more complicated methods. This practice is called by carpenters "*fishing* a beam."

It is well to observe here, that the examples cited as being particularly adapted to resist a longitudinal strain are also capable of sufficiently resisting a vertical one.

Fig 1.

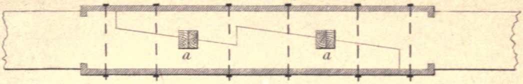


Fig. 2.

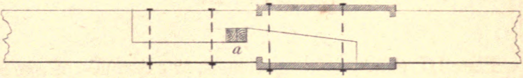


Fig. 3.

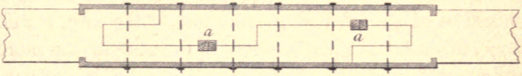


Fig. 4.

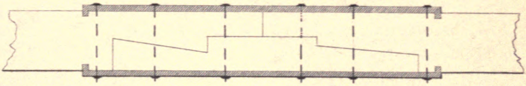
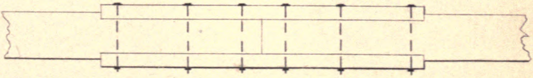


Fig. 5.



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FLOORS.

THE construction of floors is a branch of carpentry which does not demand much scientific consideration. If the timber be of proper size, sufficient in quantity, and the work well done, all is accomplished that can be desired. To effect this, however, the carpenter should avail himself of such rules as experience has proved to be valuable. The timbers of a floor should be selected of proper size to support any weight that will probably be placed upon them. A warehouse-floor, for instance, may at times be subjected to great strains, and should therefore be heavily timbered. It is often the practice, in constructing floors of the kind, to use long floor-joists extending from eighteen to twenty-four feet; in which case, the timbers vary in dimensions from three by thirteen inches to five by fourteen inches, and they are usually placed from fifteen to twenty inches apart from centres. A church or hall floor, when covered with people in a standing position, packed close, is loaded a hundred and twenty-five pounds to each square foot. Timbers three by twelve inches, if the bearings are not more than ten feet apart, placed sixteen inches from centres, will sustain the weight; and these dimensions are generally used in buildings of the kind.

The floors of dwelling-houses may be lighter. If the joists are materially longer, the size should not be much decreased. The lengths being from nine to fifteen feet, two by twelve will answer the purpose: two by ten inch joists, and even two by eight inch, are frequently used in cheap buildings. The principal objection to light timber arises, not from its liability to break, but from its vibration, which is apt to crack the plaster of the ceiling below.

Fig.1.

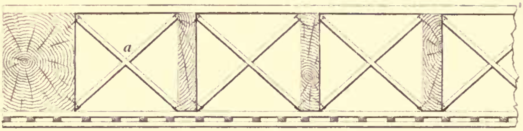


Fig.2.

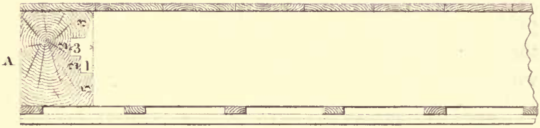


Fig.3.

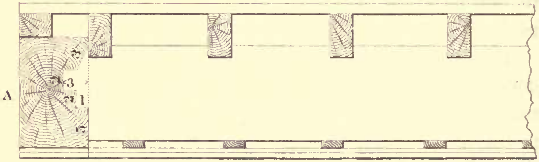


Fig.4.

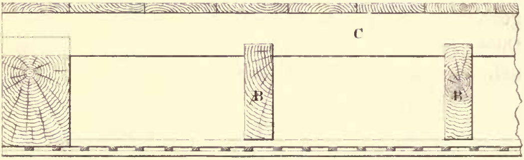


PLATE IV.

The method of framing shown at Fig. 1 of this plate, is, all things considered, quite as good as any in use. More complicated methods are not often attended with proportionate advantage. Fig. 2 exhibits the side of the joists of the same floor, the girder, &c., all of which will be readily understood without further explanation.

Fig. 3 exhibits a section of what is called a *bridged floor*. It is, in principle, like the other, with the addition of the smaller joists which bridge over the principal ones. Floors of this kind are seldom built in this country, but are much used in Europe.

Fig. 4 exhibits a side-view, or section, of the floor last described; BB showing the ends of the *principal*, and C the side of the *bridging*, *joists*. The part of the diagrams at A illustrates the method of framing the joists into the girder; the figures thereon denoting the dimensions of each part, being calculated for a stick twelve inches deep.

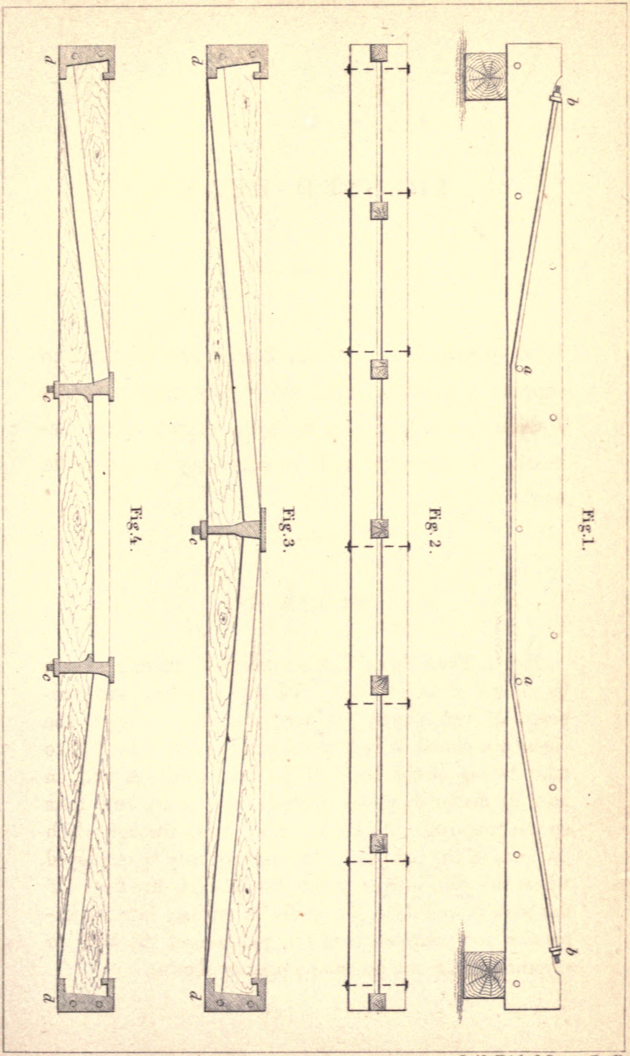
Every floor should be well bridged. This may be done in either of two ways: first, by cutting in between the sides of the joists, and at right angles to them, pieces of the same thickness and width as the joists themselves; secondly, by cutting in pieces of board one inch thick and three inches wide, crossing each other diagonally, as seen at *a*, Fig. 1, Plate IV. The ends of these pieces are scarfed, or cut bevelling, and firmly nailed to the sides of the joists.

TRUSSED BEAMS.

It frequently happens that beams are required to support a great weight, while they extend across a wide space, and can have no support from beneath. In such cases, it is necessary to truss the work.

PLATE V.

Fig. 1, Plate V., exhibits a method of trussing a beam by the use of an iron rod. All trussed beams are composed of two pieces. In the example at Fig. 1, the pieces are placed an inch apart, and the rod so bent as to take the sag of the beam at the points *aa*. A bolt, an inch in diameter, passes through the beam, and rests on the truss-rod. At *bb* are iron plates, through which the ends of the rod pass. This method may be employed where the span is from twenty-five to thirty-five feet. If the work is well done, the girder is strong; but the expansion and contraction of the rod subject the work to variation as the rod becomes longer or shorter.



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Figs. 3 and 4 are examples where oak-pieces and cast-iron keys are used instead of a rod. The oak-parts should be two by four inches, and let into the wood a quarter of an inch on each side, leaving the beams an inch and a half apart. The keys should be made with a screw and nut at *c* to tighten the work. The abutments at *dd* should also be of cast iron, and let into the wood, like the oak.

Fig. 2 represents a beam built with oak-keys, two inches square, let half an inch into the pieces, and the whole bolted together. This method produces a very strong beam, and is of great value. It is often the practice in carpentry to bolt two pieces of spruce together, with an oak-board an inch thick between them. The bolts should be of wrought iron, and five-eighths of an inch in diameter. Should unusual strength be required, the beam may be built with three or even four pieces, with the truss-work between them, and the whole bolted together as in an ordinary beam.

ROOFS, PARTITIONS, AND DOMES.

ROOFS.

"THERE is no article," says the learned Ware, "in the whole compass of the architect's employment, that is more important, or more worthy of distinct consideration, than the roof; and there is this satisfaction for the mind of the man of genius in that profession, that there is no part in which is greater room for improvement."

The suggestions above quoted, although made in the year 1756, remained quite unheeded till near the close of the last century, when Mr. Peter Nicholson made public the germ of an invention, which has, in process of time, brought about as great a revolution in the art of carpentry as the introduction of the arch did in that of masonry. The leading feature of the invention is the substitution of iron rods for wooden king and queen posts. The design by Mr. Nicholson was published in 1797; but, as late as 1828, Mr. Tredgold says, in his excellent Treatise on Carpentry, "It has been proposed to let the ends of the principal rafters abut against each other, and to suspend the king-posts by straps of iron; but a piece of good carpentry should depend as little on straps as possible." From the tenor of his remarks, it is reasonable to suppose that few, if any, successful experiments had been made; for he afterwards refers the reader to a design in his work, where the rafters abut against each other, and the beam is suspended by planks bolted to their sides. "This method," he adds, "is perhaps the best in use." A valuable standard work, entitled "Treatise on Architecture, Building, &c.," was published in Edinburgh in 1844. On page 154 of the work, attention is called to the suggestion of Mr. Nicholson, made forty-seven years before. The writer (Dr. Thomas Young) says, "There is a very ingenious project offered to the public by Mr. Nicholson ('Carpenter's Assistant,' p. 68). He proposes iron rods for king-posts, queen-posts, and all other situations where beams perform the office of ties. . . . We abound in iron; but we must send abroad for building-timber. This is, therefore, a valuable project. At the same time, however, let us not overrate its value." From the foregoing, it appears, that, up to a late day, but little advance had been made; the old methods of construction being looked upon with more favor than the new.

At what time, or by whom, the idea was first practically carried out in this country, is uncertain. The burden of evidence, however, indicates, that, although first published by Mr. Asher Benjamin, he was indebted for the suggestion to Mr. Charles G. Hall, now of Roxbury, Mass. Mr. Hall, an Englishman by birth, and an able architect and engineer, arrived in America in 1823. He soon became associated in business with an eminent architect of that day, Mr. Alexander Parris. Under the direction of these gentlemen, many large and important buildings were erected, in the roofs of most, if not all, of which, the principle under consideration was employed. Being thus freely used, it soon commended itself to the judgment of other architects, who in turn adopted it; and the work of Mr. Benjamin was no sooner published than a reform commenced, which has steadily advanced, until its great value and economy are universally acknowledged.

On the plates of this work pertaining to roofs are designs calculated for various spans, and of such rise, or pitch, as will accommodate them to any style of building; each having been so designed that timber may be used of such dimensions as will properly support a covering of heavy slates.

Of the *inclination*, or pitch, of the several roofs, but little need be said, since designs for buildings are so varied, that an attempt to illustrate them all would only encumber the work. A few suggestions will be made, which, together with those amendments naturally presenting themselves in particular cases, will give all the information required.

The pitch of any roof, covered with shingles or slates, should never be less than one-fourth the width of the entire span; for, if it be less, rain and snow will, in severe storms, be driven through the crevices. If the *design* of the building demands less inclination, a covering of tin, copper, lead, or something of like nature, should be used; in which case, any rise above a twenty-fourth of the whole span will be all that is required. The extent of the span will, however, to a certain degree, govern the inclination and form of the roof, in order to give strength to the truss. If the span is great, and a low roof is desired, it is best to truncate it, as shown on Plate IX., Fig. 1. Where slating is used, the boards should be matched, and planed to a uniform thickness; for if the joints are left open, as may be allowed in shingling, the passage of air through the openings carries with it rain or dry snow, when, in ordinary storms, it would exhibit no sign of defect.

TIMBERS OF A ROOF.

A trussed roof employs the following timbers,—*tie-beams*, *principal rafters*, *collar-beams*, *struts*, *purlines*, and *common rafters*.

TIE-BEAMS are the large and long timbers which lie in a horizontal position, and extend across the building at the base of the roof. They are usually subjected to two kinds of strain. One is that which is exerted by the principal rafters: the other is the *cross-strain*, and may be produced by the weight of the ceiling below, or a load upon the beams themselves. In mortising tie-beams, as little wood should be removed as the nature of the case will allow. Tenons may be small, their use being simply to retain each piece in its proper place. If the figuring laid down in this work is followed, the tie-beams of each design will be of sufficient size to resist the strains exerted by the inclined parts, and the rods will resist the cross-strain.

The weakest part of a tie-beam, and hence the one demanding most attention, is at its ends about the foot of the rafters. To strengthen this part, it is the usual practice to bolt pieces of strong white oak or Carolina pine to the under side of the beam. The pieces should be as thick as half the depth of the beam, and of sufficient length to extend from the end thereof to three feet beyond the heel of the rafters. (See S, Fig. 2, Plate VI.)

Objections to the use of strengthening-pieces have been made, because they present a joint or seam where dampness may gather, and produce decay in the wood; also because they are in effect a *camber* to the beam, exerting a thrust on the walls of the building. To a certain extent, these objections are valid; but neither is of sufficient moment to outweigh the benefit produced. The objection first named may be entirely obviated by thoroughly painting the pieces when the work is put together. The practice of cambering a tie-beam, by tightening the rods till the beam is curved upwards, cannot be considered advisable; for, if sufficient camber is produced to give the beam additional strength by its partaking of the nature of an arch, this is more than counteracted by injury to the walls of the building. A large ceiling, if entirely level, presents an optical delusion, leading the beholder to believe that the surface has a sag, or downward curve. In furring such ceilings, a rise of an inch in twenty feet will obviate the difficulty. While the carpenter is cautious in cambering beams for either of the purposes named, or any of like nature, he should remember that there will be a settlement from the shrinkage of the timbers, till each part has found a solid bearing. Hence the rods should be kept tightened; and, when the work is completed, the centre of the beam should be slightly curved upwards, that the tendency named may be counteracted.

Principal Rafters are the large inclined timbers which support the purlins: they should be of the same thickness as the tie-beam, and about four-fifths as deep. To a beam seven by ten inches, the rafter would be seven by eight inches. In some examples of framing, as that shown on Plate XI., Fig. 1, one rafter is placed above another; in which case, both should be of the same size, having pieces of oak-board, an inch and five-eighths thick and four inches wide, let into each rafter five-eighths of an inch, leaving the rafters three-eighths of an inch apart for the passage of air between them: the pieces should be perfectly dry, and tightly driven into the grooves. The timbers should be bolted together with bolts five-eighths of an inch in diameter.

Collar-beams are the horizontal timbers which lie between the heads of principal rafters. They are also known as *straining-beams.* As their use is to prevent the rafters approaching each other, their dimensions may be the *same* as the timbers named. In designs where these beams are liable to sag, they should be supported with struts, as seen at A, Plate VIII. The case not unfrequently occurs where collar-beams are serviceable as tie-beams, and thereby strengthen the principal tie-beam: an example of this kind may be seen at B and C, Plate XI. In cases of this kind, separate rods will be required. The top-truss, being needed *as a truss*, will require rods of its own to make it complete in itself; the main-beam being suspended by other rods.

Struts are the inclined pieces which support the principal rafters. The ends of struts should always be framed with a shoulder an inch and a half wide, and sloping from this to the end of the piece. It may be remarked here, that the ends of all *braces* (whatever their position) should be formed with a shoulder of like nature, proportional to the size of the piece. Struts, being always in a state of compression, need not be pinned to the beam or piece they support, a short tenon being all that is required to keep the parts in their proper place. The width of struts should be the *thickness* of the principal rafter; and they should be about half as thick as the rafter is deep. The carpenter should make it an invariable rule to place the curved or cambered side of a timber upwards, whenever such cambered side exists.

Purlins are the horizontal timbers extending from truss to truss to support the common rafters. They should always be framed or bridged over the principal rafters, by notching into the back of them and breast of the purlins, each half an inch, making an inch when the work has been put together. Their size is determined by their length of bearing and distance apart. When the trusses are within ten feet from centres, and the purlins less than eight feet apart on the principal rafters, they may be to them in thickness and depth, respectively, as five to eight. They should not be cut into lengths which will reach only over single spaces, but continued whole; and, when they are put on, they should be made to break joints, by the use of short lengths at the end of every other one. It is to be remembered, that the joints should always be made over the principal rafter. In cases where the roof is large, and exposed to the direct action of heavy storms, the purlins should be braced, like the posts and girts of a side-wall.

Common Rafters are the outside timbers of a roof, and are used simply to support the boarding. Being uniformly loaded, only light pieces are required; but they should always be jointed over the purlins, and never placed more than eighteen or twenty inches apart from centres. If the bearing is not more than eight feet, they may be two by six inches; but, where it is more, their depth should be proportionally increased. They should be notched into a half-inch, to keep them from sliding off the purlin; but the purlin itself should remain entire.

IRON WORK.

The bolts used at the foot of principal rafters should not be less than five-eighths of an inch in diameter, nor more than an inch. For most purposes, three-fourths of an inch is best; and, when one of an inch in diameter is not sufficiently strong, it is better to increase the number than the size, and they should always be set at right angles with the rafters. The rods which support the beams must be of sufficient size to prevent vibration, but may vary in diameter according to the nature of the work, from five-eighths of an inch to two inches in diameter.

Great care should be exercised in the selection, using none but the very best material.

It is a common practice, in some instances, to use cast-iron boxings at the ends of principal rafters, and such other parts of a truss as will be subjected to great pressure, causing the fibres of the wood to indent each other. It is rare, however, that boxings are absolutely necessary.

Where a piece of framing is liable to be exposed to dampness before the work is put together, the iron should be heated to a blue heat, and well oiled over with the best quality of raw linseed oil. If this is properly done, the pores of the iron will be filled, and the metal effectually protected against corrosion.

Straps should be used sparingly, if at all; as the shrinkage of the wood leaves them loose, and the work is liable to settle. In most examples of old carpentry, these were freely used; but modern methods of framing with rods and bolts have obviated the necessity for them, so that they are now but rarely employed.

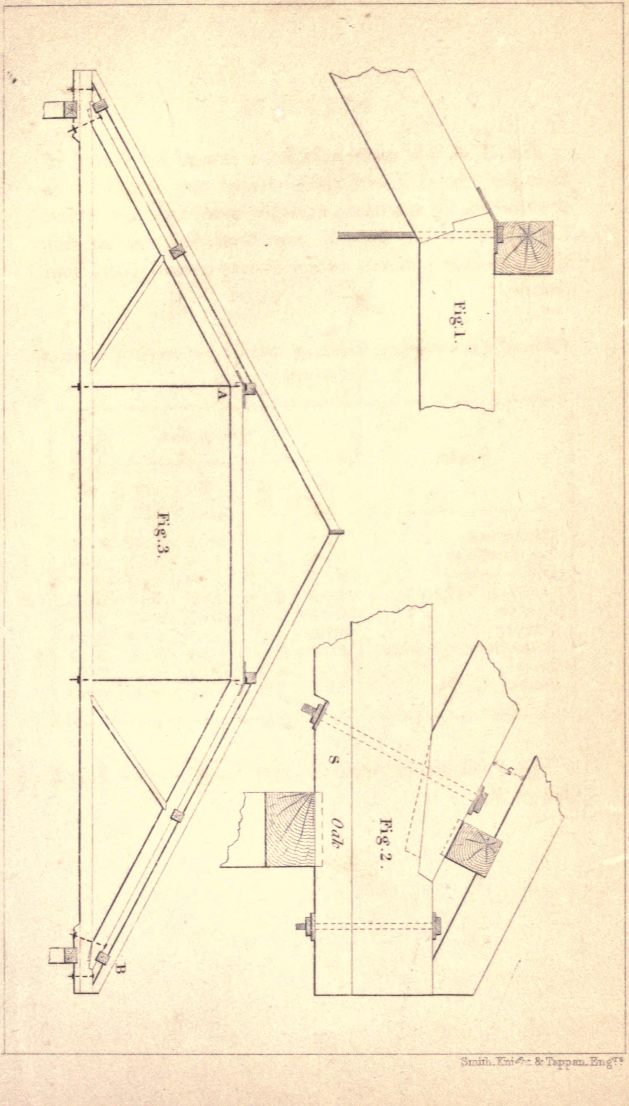
PLATE VI.

Fig. 3 of this plate exhibits a design for a roof of from forty to sixty feet span. Being very simple in its construction, it is more frequently used than any other. The trusses should be not more than eight or ten feet apart, and the common rafters twenty inches apart, from centres.

Table of dimensions, in inches, of timbers for roofs of various spans.

Names.	Span in Feet.				
	40	45	50	55	60
Tie-beams	6 × 8	7 × 8	8 × 9	8 × 10	9 × 11
Truss-rafters . . .	6 × 7	7 × 7	8 × 8	8 × 9	9 × 9
Collar-beams . . .	6 × 7	7 × 7	8 × 8	8 × 9	9 × 9
Common Rafters . .	2 × 6	2 × 6	2 × 6	2 × 7	2 × 7
Purlins	5 × 7	6 × 7	6 × 8	6 × 8	6 × 9
Struts	3 × 6	4 × 7	4 × 8	5 × 8	5 × 9
Strengthening-pieces	4 × 6	5 × 7	5 × 8	5 × 8	6 × 9
Rods	1 in.	$1\frac{1}{8}$ in.	$1\frac{1}{4}$ in.	$1\frac{1}{2}$ in.	$1\frac{3}{4}$ in.
Bolts	$\frac{3}{4}$ in.	$\frac{3}{4}$ in.	$\frac{7}{8}$ in.	1 in.	$1\frac{1}{8}$ in.

Fig. 1 exhibits in detail the framing at A, and Fig. 2 that at B.



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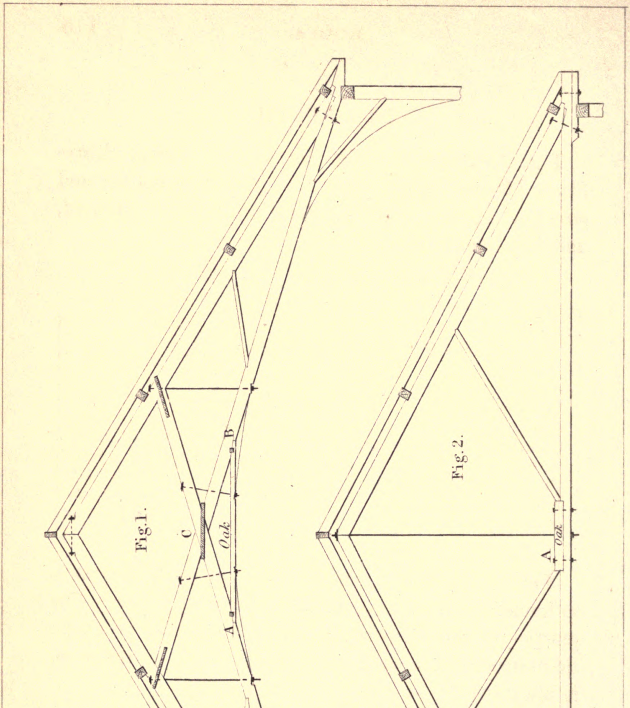

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PLATE VII.

Fig. 2 exhibits a design for a roof of from thirty-five to fifty feet span. This roof, from its simplicity and strength, is, like that on Plate VI., much approved, and in common use.

Table of timber-dimensions for various spans.

NAMES.	Span in Feet.			
	35	40	45	50
Tie-beams	6×7	6×8	7×9	8×9
Truss-rafters	6×6	6×7	7×8	8×8
Common Rafters	2×6	2×6	2×6	2×6
Struts	2×6	3×6	3×6	4×6
Purlins	4×7	5×7	6×7	6×8
Rod	$\frac{7}{8}$ in.	1 in.	$1\frac{1}{4}$ in.	$1\frac{1}{2}$ in.
Bolt	$\frac{5}{8}$ in.	$\frac{3}{4}$ in.	$\frac{7}{8}$ in.	1 in.

Fig. 1 exhibits an example of a roof, with tie-beams, so framed as to admit of finishing a curved ceiling. The practice of thus dispensing with a horizontal or single tie-beam should be used with great caution, as the work is always liable to settle.

Table of timber-dimensions for various spans.

NAMES.	Span in Feet.		
	40	45	50
Tie-beams	6×8	6×9	6×10
Truss-rafters	6×7	6×8	6×9
Common Rafters	2×6	2×6	2×6
Struts	2×6	3×6	4×6
Purlins	5×7	6×7	6×8
Oak-piece	4×6	5×6	6×6
Rods	1 in.	$1\frac{1}{8}$ in.	$1\frac{1}{4}$ in.
Bolts	$\frac{3}{4}$ in.	$\frac{7}{8}$ in.	1 in.

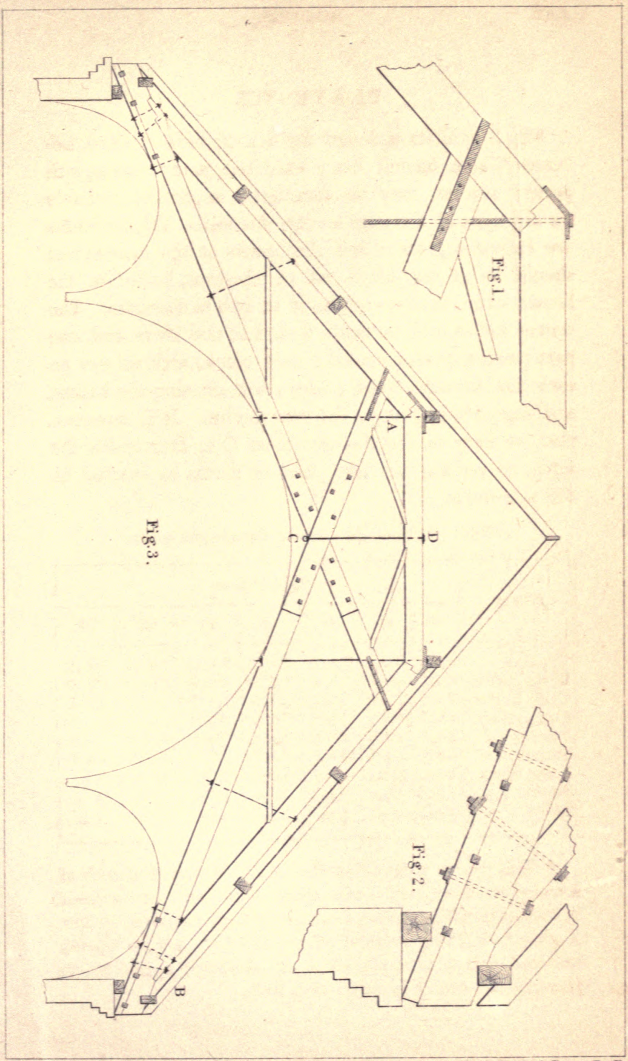
PLATE VIII.

Fig. 3 exhibits a design for a roof, with inclined tie-beams,* and, having been executed many times with perfect success, may be considered as entirely reliable for any span of less than seventy-five feet. The tie-beams are halved together; and the planks at the intersection should be of dry white oak or chestnut, bolted to the beams with bolts five-eighths of an inch in diameter. The centre rod should be made forked at the lower end, one part passing down outside of each plank, with an eye on each tine, through which passes a bolt, crossing the beams, and supporting them at the intersection. It is apparent, that, so long as the distance from C to D remains the same, no settling can take place, or thrust be exerted on the side-walls.

Table of timber-dimensions for various spans.

Names.	Span in Feet.						
	40	45	50	55	60	65	70
Tie-beam	6×8	6×9	7×10	7×11	8×10	8×11	9×12
Truss-rafter	6×7	6×8	7×9	7×10	8×9	8×10	9×10
Com. Rafter	2×6	2×6	2×6	2×7	2×7	2×8	2×8
Collar-beam	6×7	6×8	7×9	7×10	8×9	8×10	9×10
Purlins .	5×7	5×8	6×8	6×8	6×8	6×9	7×9
Struts . .	3×6	3×6	3×7	4×7	4×8	5×8	5×9
Long Rods	1 in.	$1\frac{1}{8}$ in.	$1\frac{1}{4}$ in.	$1\frac{1}{4}$ in.	$1\frac{1}{8}$ in.	$1\frac{3}{8}$ in.	$1\frac{1}{2}$ in.
Short "	$\frac{7}{8}$ in.	1 in.	1 in.	1 in.	$1\frac{1}{8}$ in.	$1\frac{1}{8}$ in.	$1\frac{1}{4}$ in.
Bolts . .	$\frac{3}{4}$ in.	$\frac{3}{4}$ in.	$\frac{7}{8}$ in.	$\frac{7}{8}$ in.	1 in.	$1\frac{1}{8}$ in.	$1\frac{1}{8}$ in.

* This roof was executed first at the Unitarian church of Somerville, Mass., in the year 1850, from drawings furnished by the author; the leading idea having been suggested by Rev. Augustus R. Pope, minister of the society. A very heavily stuccoed ceiling is appended to it, but, after a test of six years, is as perfect as when first built.



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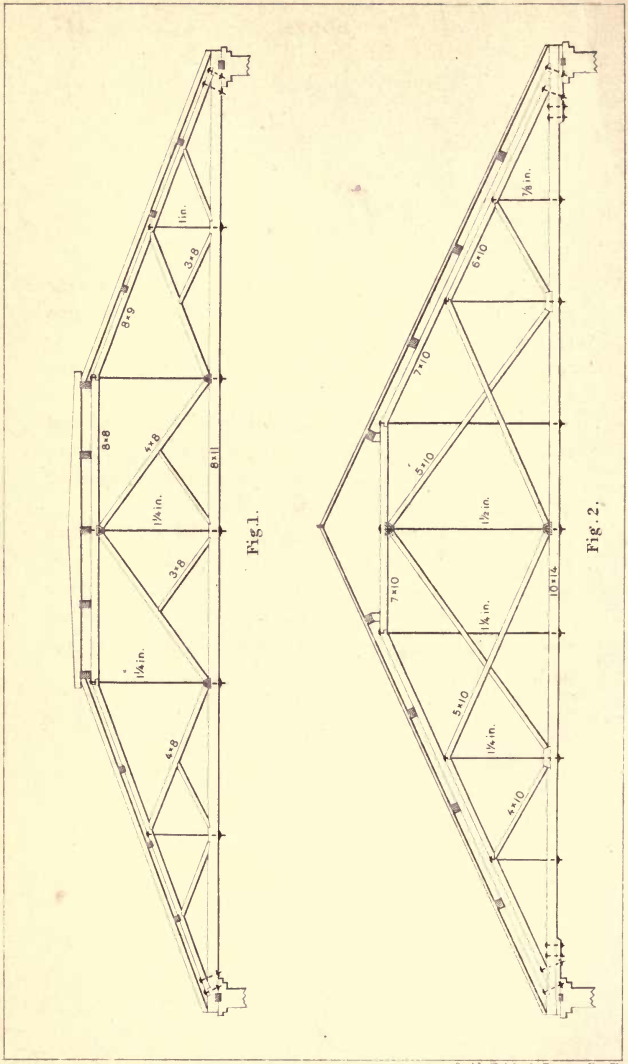

Fig. 1.

Fig. 2.

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PLATE IX.

Fig. 1, on Plate IX., is a design for a low roof of wide span. The figures show the dimensions of timber for one of from sixty-five to seventy-five feet. It may be extended to ninety feet by a proportional increase in the size of the rods and timbers.

Fig. 2 shows a roof of from eighty to a hundred and twenty feet span. The figures on the engraving are calculated for one of a hundred feet, and should be increased or diminished according to its width.

The tie-beam in this design should be made of two four-by-fourteen-inch planks, with short pieces of two-inch planks at intervals between them.

Some of the bearings in each of these examples are designed to be of cast iron, as will be discovered by consulting the drawing.

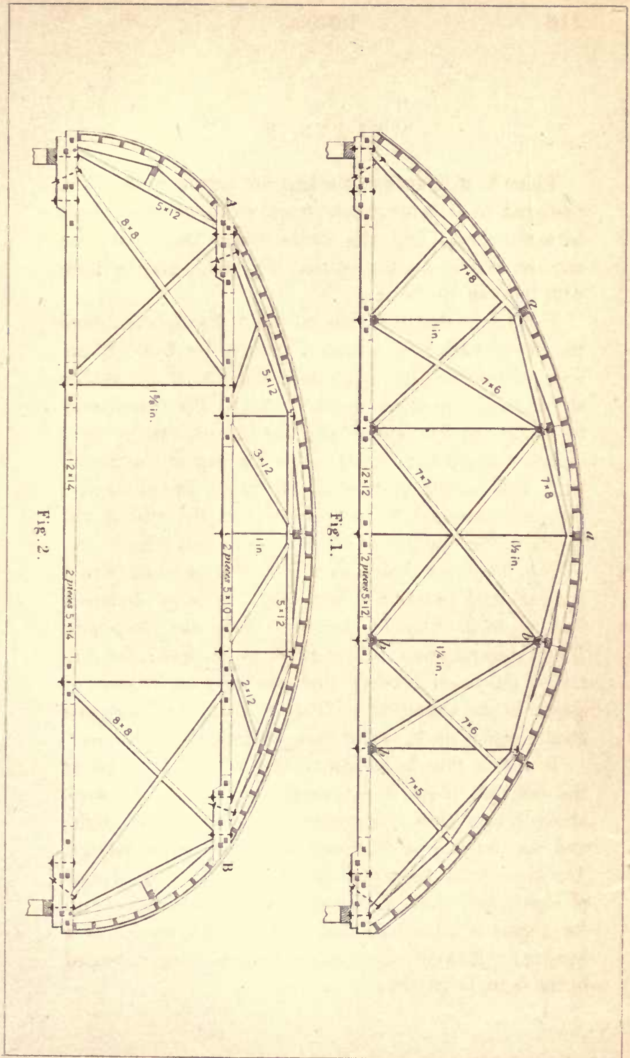
PLATE X.

Plate X. exhibits two designs for curved roofs. The tie-beams of each are in two pieces, with a two-inch plank between them; and the struts, where they cross, are notched into each other, so that their sides may be flush with those of the beams.

Fig. 1 represents a segmental roof. The figures denote the size of timber for a span of seventy-five feet. If the span be increased to ninety feet, the size of the timber should be increased about one-seventh. The trusses may be placed ten feet apart; and the rafters, two by eight inches, notched two inches below the top of the curved rib. The purlins at *aaa* should be six by six inches: they are designed to give firmness to the roof at the joints. The bearings at *bb*, &c., are of cast iron.

Fig. 2 shows a design for a roof of from seventy to a hundred and twenty-five feet span. It is so designed, that a room may be finished above the tie-beams. If the span be great, with a room as proposed, the centre of the beam between the rods must be trussed, as shown in the examples on Plate V.; and the floor-joists should bridge upon, rather than cut into, the tie-beams.

It will be seen, by an examination of the plate, that at the line AB there is a tie-beam, which, with the work above it, comprises a segmental roof, complete in itself; and its rise may be increased as circumstances require. The dimensions designated by the figures are for a roof of eighty feet span, and should be increased one-eighth for a span of a hundred feet, and one-fifth for one of a hundred and twenty-five feet, — the rods being increased in the same proportion.



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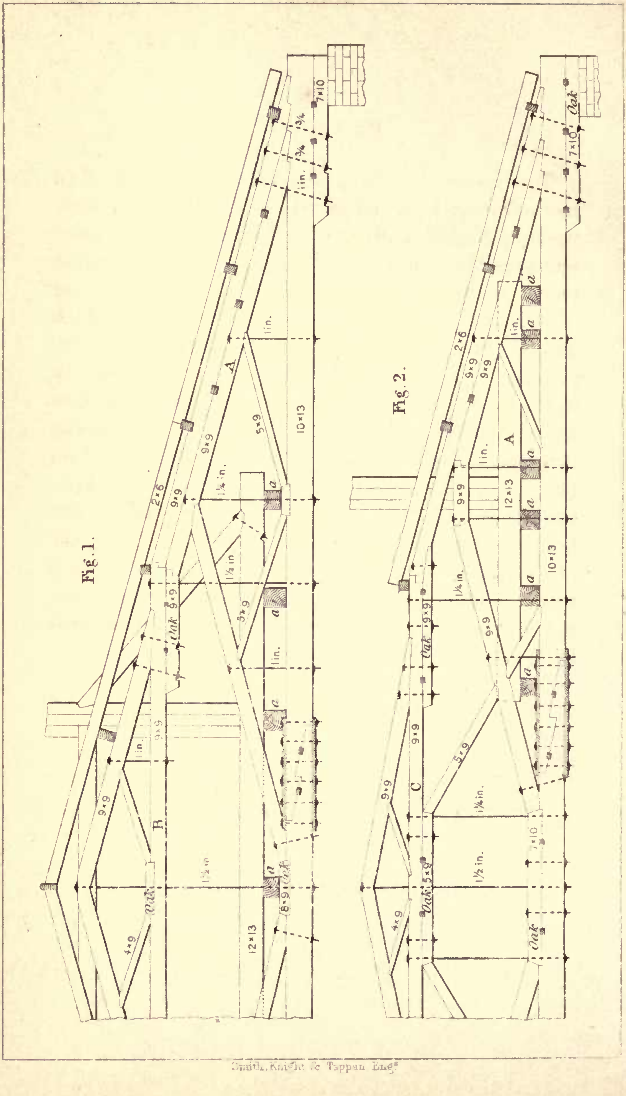

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PLATE XI.

The figures on this plate exhibit the design of a portion of the large trusses which support the dome of the State Capitol at Montpelier, Vt.* The span is sixty-seven feet four inches between the walls, and the trusses receive no support from below. The bearing-pieces are of white oak, the rest of the timber being spruce. Each truss is composed of two parts, or sections, like those represented by the designs. The beams are placed fourteen inches apart, with short transverse ones extending from one to the other, as at *aa*, &c., with another crossing them, as seen at A. Upon the beams last named stand the posts of the dome, which, when finished, will be forty-two feet in diameter. Its frame being octagonal, the two front and two rear posts are nearer together than the others, and consequently require a differently constructed truss. The student will readily discover, on examination, the manner in which the particular strains are resisted by the several parts of the work.

* These trusses, together with the framing of the roof and dome, employing eighty thousand feet of timber, were executed by Mr. Robert Gunnison, the master-carpenter, under the direction of Thomas E. Powers, Esq., the superintendent of construction, from drawings furnished by the author in 1857.

PLATE XII.

Fig. 1 of this plate shows the design of a roof over the Fitchburg Depot in this city. It was executed from drawings furnished by Mr. Charles G. Hall in the year 1848. The second floor of the building (some eighty feet wide, and a hundred and fifty feet long) is supported entirely by rods from the tie-beams. It has been loaded with people, at an average of a hundred and twenty-five pounds to the square foot, without any settlement whatever. The trusses are ten feet apart from centres.

Fig. 2 shows the roof of the Boston and Maine Railroad Depot, in Haymarket Square, Boston. It was executed from drawings made by Mr. Richard Bond, architect of the building. The trusses are twelve feet apart from centres. This roof remains as firm in every part as when first built; and, considering the quantity of timber used, it is a good roof.

The figures on each of these designs exhibit the dimensions of each part as taken from actual measurement.

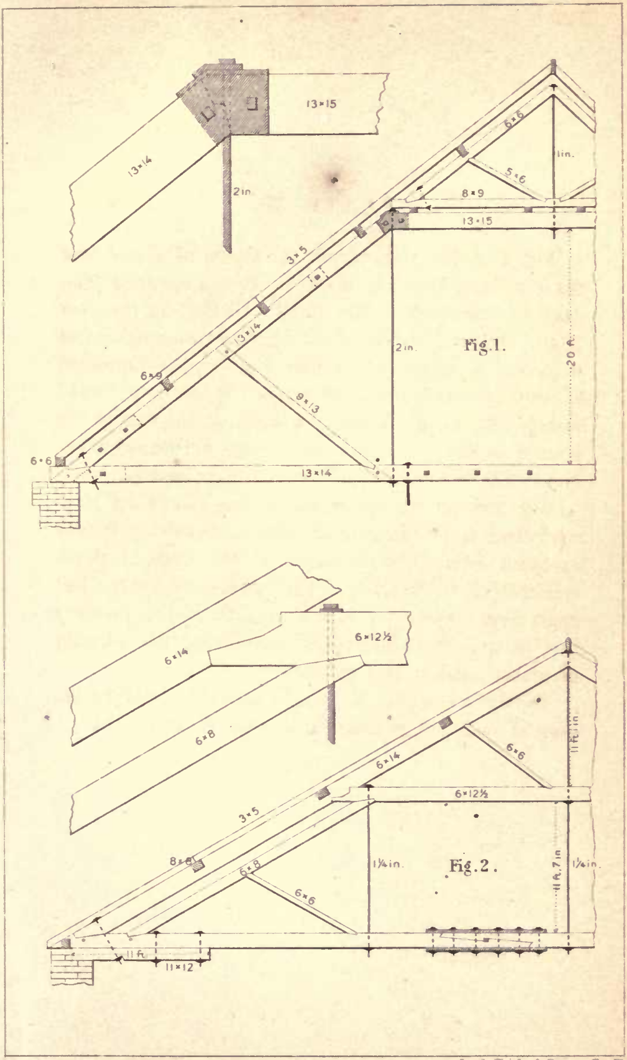

Fig. 1.

Fig. 2.

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Fig. 1.

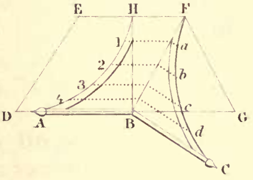

Fig. 2.

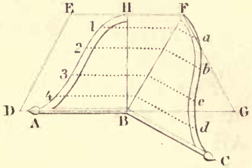

Fig. 3

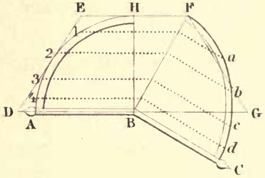

Fig. 4.

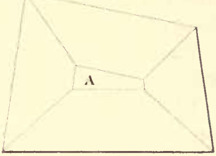

Fig. 5.

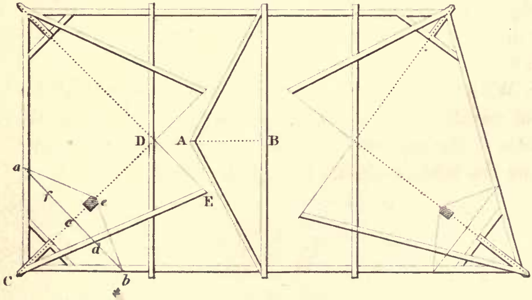

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PLATE XIII.

Figs. 1, 2, and 3 of this plate exhibit a method of drawing the angle-ribs of a roof, the outline of which is AH; and a portion of the plan, DEFG. Divide BH into any number of parts, as 1, 2, 3, 4, and draw lines through these points to the angle-line FB. From the points of intersection, on and at right angles with the line last named, draw *abcd* equal to 1, 2, 3, 4, measuring from BH to AH. Trace a line through the points, and the angle-rib is formed.

Fig. 5 illustrates the method of ascertaining the length and back of the angle-rafters of a hip-roof.

Let AB represent the pitch of the roof. From C, the corner of the plan, draw CD; and from D draw DE perpendicular to CD, equal to AB: from this point draw EC, which is the rafter required. To determine the back of the rafter, we proceed as follows: Draw *ab* perpendicular to CD. On the centre *c*, with a radius *cb* (the edge of the rafter) describe the semicircle *fed*; then from *e* draw *ea* and *eb*, which will be the angle of the rafter at *e*.

Where the plan of a roof is bounded by lines which are not parallel, it is the usual practice, in order that the sides of the roof may be of the same inclination, to truncate the work, as shown at A, Fig. 4.

PLATE XIV.

Fig. 1 of this plate exhibits a design for a roof of large span. The figures designate the dimensions of timber for a span of eighty feet. With a proportionate increase of the size of rods and timber, it may with safety be extended over a span of a hundred and twenty-five feet. The beam should be made in two sections, the centre portion between the rods trussed, and an oak-plank three inches thick bolted to the top of the beam, as seen at AB.

Fig. 1.

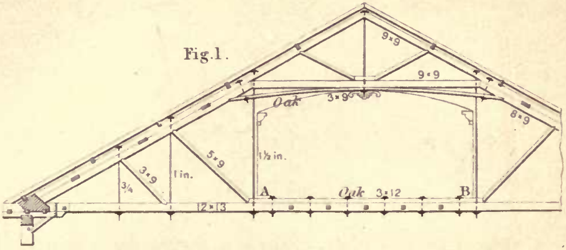


Fig. 2.

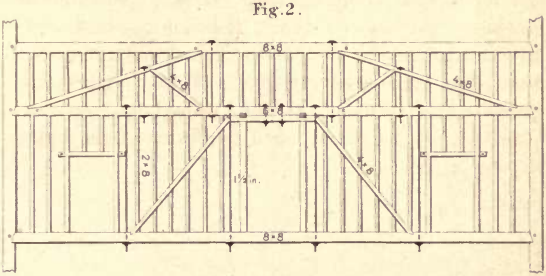
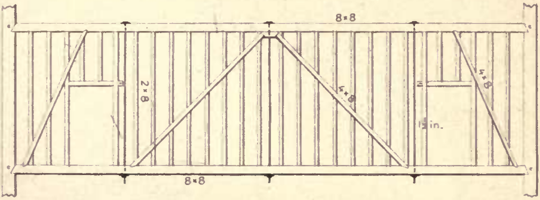


Fig. 3.



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PARTITIONS.

In cases where a large partition cannot have a proper support from below, — as, for example, where it stands over a hall or large room, — it should be trussed, so that its entire weight shall rest on the points of support.

Figs. 2 and 3, Plate XIV., exhibit two designs for partitions, which will readily be understood without further explanation.

DOMES.

To frame a dome is one of the simplest branches of the art of carpentry. It was, however, till a late day, thought to require great ingenuity and scientific skill.

A dome is, in all directions from the centre of its plan, an arch: hence it is possessed of great strength; and, if properly constructed, its lightness is its greatest recommendation. The dome of the State House at Boston is a fine specimen of framing. Its span is fifty-one feet, its height from the floor nearly the same; and, with the exception of the four posts which support the lantern, no timber is used larger than three inches thick, and twelve inches wide. Every other rib is at the base of these dimensions, the alternate ones being two by twelve inches. All are placed three feet apart on the circle, and taper to about eight inches wide at the top, where they are cut against a curb, being there, about twelve incnes apart from centres.

The scarfs are similar to Fig. 2, Plate XX., and are bolted together with bolts half an inch in diameter, with plank two inches thick, spiked on each side of the ribs over the scarfing.

The rough boarding is horizontal; and, after enduring the storms of more than half a century, the structure has proved itself well adapted to its intended purpose. Were the dome larger, the size of its timbers would not necessarily have been increased, since the principles of the arch pervade the whole. A more complicated framing would have detracted from its merit as a design, since all that can be desired is accomplished by the present one; and so simple are the principles involved, that it has not been thought necessary to illustrate them by an engraving.

Where a dome rests upon a high drum, like that of the Capitol at Montpelier, it may be necessary, if the structure stands in an exposed situation, to provide a skeleton-frame of posts, girts, braces, &c., in order to strengthen the work.

BRIDGES AND CENTERINGS.

BRIDGES.

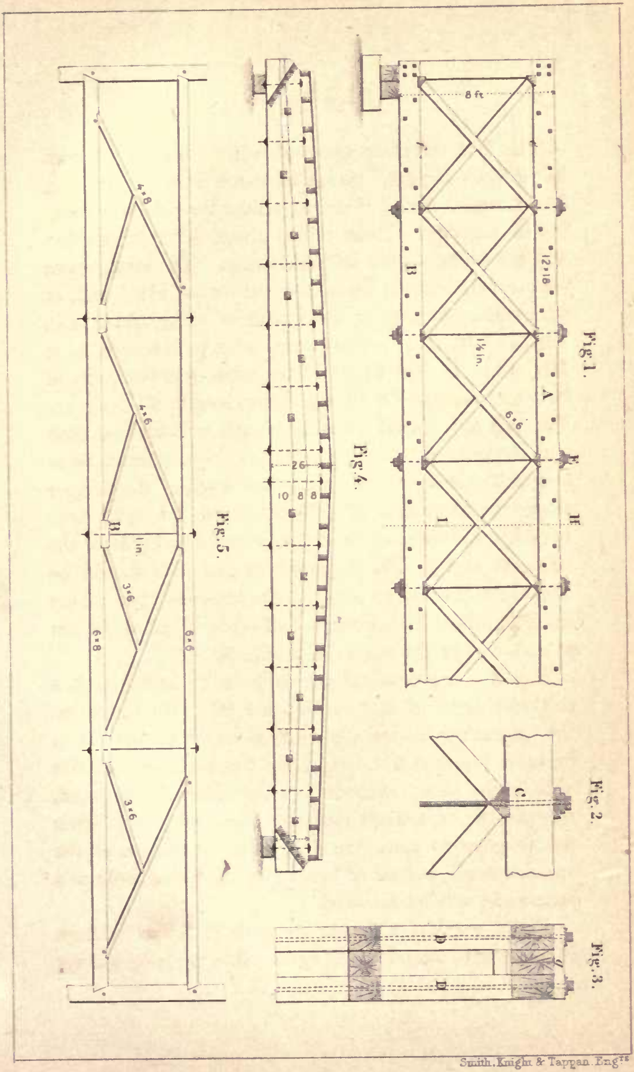
The designing of wooden bridges was for many years intrusted to the architect, but has, of late, been considered as more properly belonging to the engineer. As the mechanical part of bridge-building must be done by the carpenter, a few examples are given in illustration of his province. Most of them have been designed for this work; and those remarks which have been made in reference to other descriptions of framing will apply equally well to this.

PLATE XV.

Fig. 1 of this plate represents what is familiarly known as "*Howe's Bridge,*" taking its name from its inventor. The stringers A and B are of planks three inches thick, bolted together. These planks are of different lengths; and the joints should be well broken. The struts cross each other, without being notched or cut into; and, at their ends, they abut against a piece of white oak, as at C, Fig. 2. The rods are two in number to each section, as at DD, Fig. 3. The height of the sides, or trusses, should be about one-twelfth of the entire length of the span. The stringers should be wide enough to come out flush with the sides of the struts, and the oak-pieces must be as long as the stringers are wide. The depth of the stringer should be two-thirds of its width; and the struts one-twelfth the height of the truss, measuring between the stringers as *ef.* The diameters of the rods should be one-fourth that of the struts. An oak-piece, two inches thick and three inches and a half wide, is put at the nut at each end of the rod, as at *g*, Fig. 3.

Fig. 2 is the detail of the work at F; and Fig. 3, a sectional detail of that on the line HI. The figures on the engraving denote the dimensions of timber for a bridge a hundred feet long, eight feet high, and ten feet wide in the clear. Should a wider bridge be required, the number of sections must be increased. It is often the practice to place the floor-joists on the top of the upper stringer, instead of below; in which case, rails, or a balustrade, will be required.

Fig. 4 exhibits a design for a short bridge of from twenty-five to forty-five feet span. It is made by placing



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one timber above another, as shown in the drawing. The timbers being inclined, with oak-keys between them, and bolted together, a very strong truss is formed. The trusses should be about four feet apart, and the floor-joists three inches thick and twelve inches wide, placed twenty inches apart. These dimensions are for a bridge of thirty feet span.

Fig. 5 exhibits a design for a common gallery truss. The bearing-pieces should be of oak.

The dimensions are for a truss of sixty feet span. It may be made somewhat flatter, if desired, and still be sufficiently strong for practical purposes.

PLATE XVI.

The figures on this plate exhibit designs for bridges of from fifty to ninety feet span. Should it be desired, the floor-timbers of Fig. 2 may be placed upon the centre rail, and the work above them will answer for the rails of the bridge: if this be done, the centre rails will need additional support by bracing. The dimensions are for bridges of sixty feet span; all the bearing-pieces being of the best dry and sound white oak, bolted with five-eighth-inch iron bolts. It may be well to remark here, that the floors of all bridges require strong horizontal braces from the side-stringers, crossing each other at the centre in order to prevent vibration.

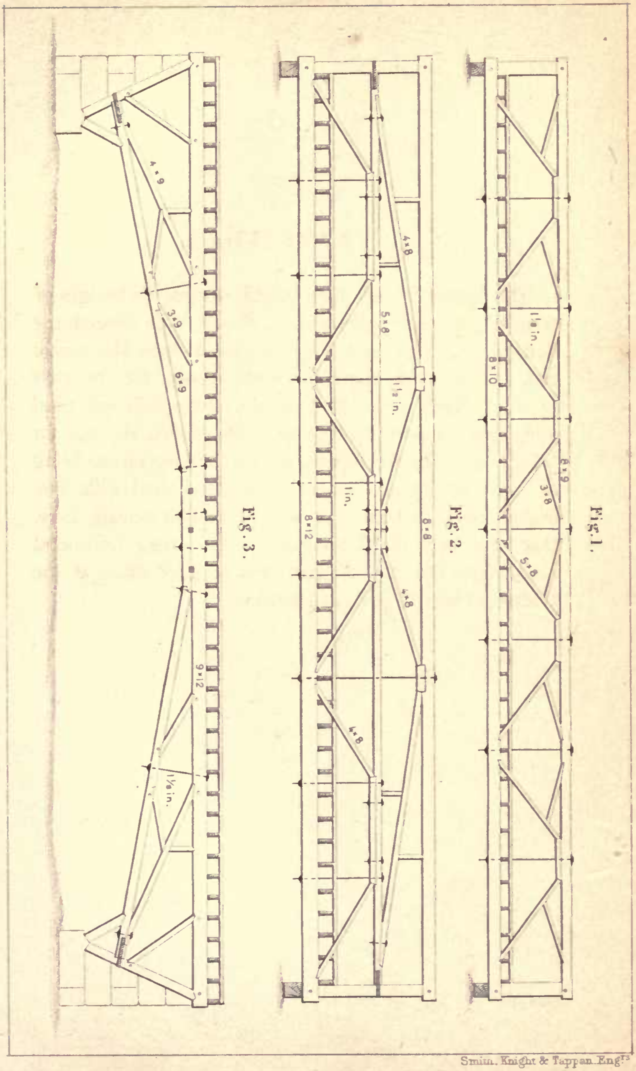

Fig. 3.

Fig. 2.

Fig. 1.

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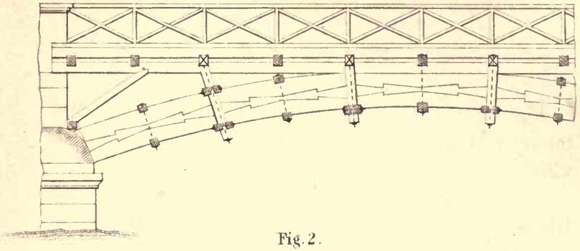
Fig.1.



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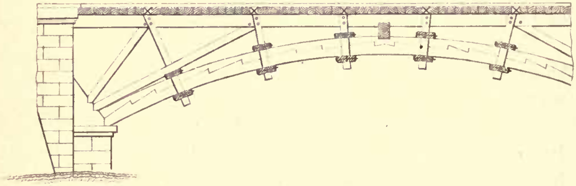

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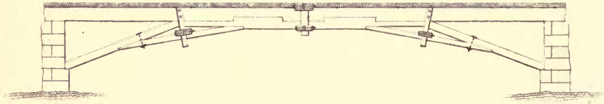

Fig.4.

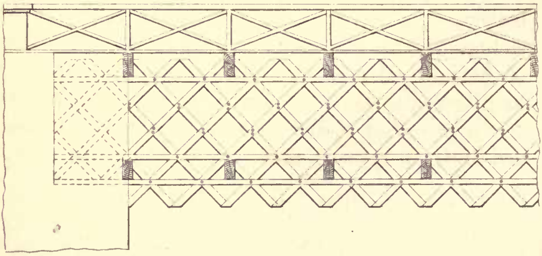

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PLATE XVII.

Fig. 1 represents a side-view of a timber-bridge over the river Meuse, in France. Its span is sixty feet, and its width twenty-eight feet. Each arch has four trusses.

Fig. 2 exhibits the design of a bridge over the river Rhone, in France. It is similar in principle to the example at Fig. 1, the trusses being secured by transverse timbers bolted together.

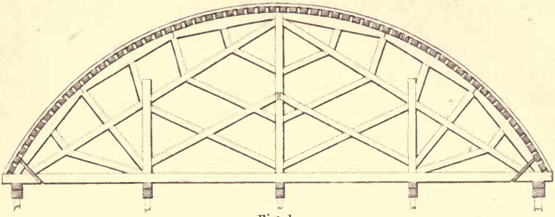
Fig. 3 represents a bridge over the river Loiret, near Orleans in France. Its span is sixty feet, and its width six feet six inches.

Fig. 4 shows part of a lattice-bridge invented by Mr. Ithiel Towne, of New Haven, Conn. Its span may be from seventy-five to a hundred and fifty feet. The lattice-framing is of planks three inches thick, and twelve inches wide, so arranged as to cross each other at right angles. They are confined together at the intersecting parts by oak tree-nails, an inch and a half in diameter, passing through each of the planks. The depth of the lattice-work should be about an eighth of the entire span. Plank-ribs are used at top and bottom on each side of the lattice-work; the sides being connected, top and bottom, at distances of twelve feet, by cross-timbers, and braced horizontally with diagonal braces. A bridge of this kind exists at Philadelphia, eleven hundred feet long, resting on ten stone piers. There is also another on the New-York and Harlem Railroad, seven hundred and thirty-six feet long, resting on but four piers.

BRIDGE-CENTERINGS.

A CENTERING is a frame of timber designed to support the stones of an arch while building. Where the bed of the river is not very deep, nor the tide strong, a centering may be made at small expense; but in other circumstances, and where the span is large, a more complex and expensive system of framing must be adopted.

In the construction of a centering, the principal object is so to arrange the timbers that a weight or pressure, when exerted upon any particular part, may be resisted, and the structure retain its original form throughout; and it should be so designed as to admit of removal without injury to the work resting upon it. In most examples, this is done by the insertion of a piece at the springing points, cut on its sides into a series of inclined planes: over these, oak wedges are driven, which, being easy of removal, admit the uniform releasing of every part of the work.



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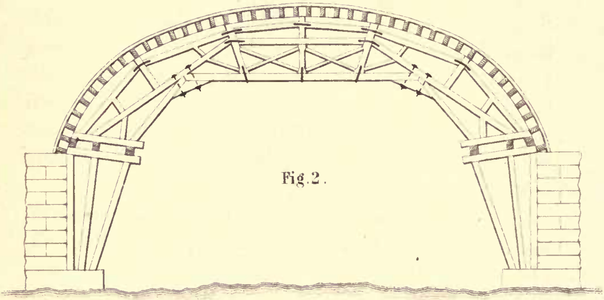

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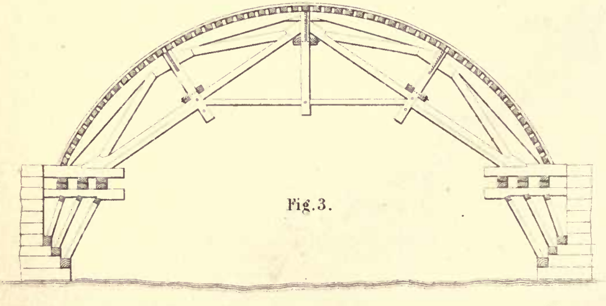


Fig. 3.

PLATE XVIII.

Fig. 1 of this plate exhibits a centre designed by Mr. Smeaton, architect of the celebrated Eddystone Lighthouse. It is familiarly known as the "*Cold-Stream Centre*," taking its name from the river over which the bridge was built. The span of the large or middle arch is sixty feet eight inches. The bridge is twenty-five feet wide outside; and, in its construction, five centres were used to each arch.

Fig. 2 exhibits a centre used in building the arches of a railroad-bridge over the river Ouse, near York, England. The bridge consists of three arches, each sixty-six feet span; the soffit of the arch (or width of bridge) being twenty-eight feet seven inches.

Fig. 3 is a design for a centre given by Mr. Tredgold, which may be used for any span short of seventy-five feet.

PLATE XIX.

Fig. 1 exhibits a part of one of the centres used in the construction of London Bridge. It was designed by Mr. Rennie in 1826. The width of the bridge, from "out to out," is fifty-six feet. The middle or centre one of its five arches is a hundred and fifty-two feet span, and has a rise of twenty-nine feet six inches. Each arch used eight centres, composed of fir; the springing-pieces being of elm, and the striking-wedges of oak.

Fig. 2 exhibits the design of a centre executed by Mr. Thomas Telford in building a stone bridge at Gloucester, England. The bridge consists of a single arch of a hundred and fifty feet span, with a rise of thirty-five feet. It is thirty-five feet wide; and six centres were used, connected by cross-bars and caps, and the whole steadied by diagonal braces. Between the timber which rested on the top of the piles, and the lower horizontal timber of each centre, were placed the wedges, which, being driven back, slackened it after the stone-work was completed. The piles were of Memel fir, shod with iron at each end, and the remainder of the work of Dantzic fir; the whole being fifteen inches square. Each centre was framed entire; and then, by the aid of barges and two cranes on the shore, was lifted into its place.

Fig. 3 exhibits a centering, simple in construction, but of great utility. It may be employed to advantage wherever the bed of the river can be used, and the tide is not too strong; and for any span from a hundred to two hundred feet.

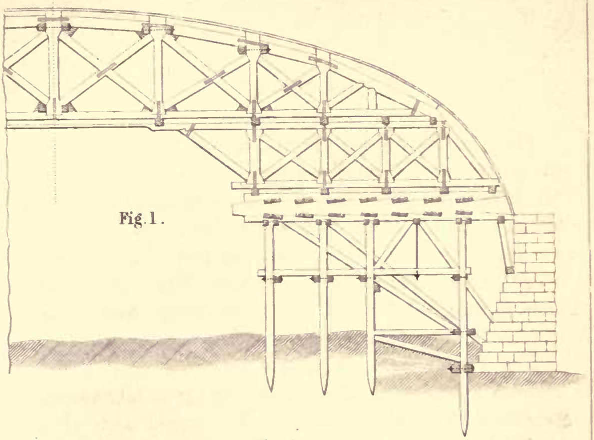


Fig. 1.

Fig. 2.

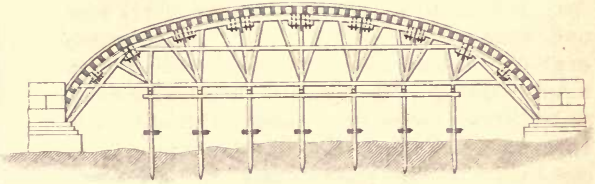
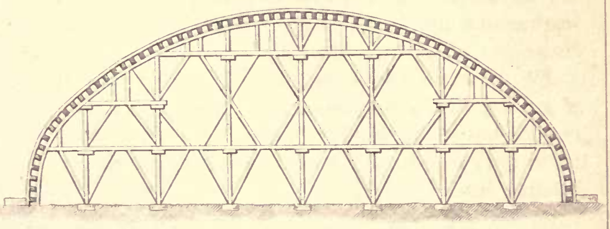


Fig. 3.



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JOINTS, IRON-WORK, AND

TIMBER-TABLES.

JOINTS IN FRAMING.

NOTHING is more essential to the permanency of a piece of carpentry than properly made joints. If the parts do not so fit together that each may have its full bearing, the structure will inevitably be weak. The examples on this plate are designed to represent in detail the best manner of forming joints of the various kinds most in use.

PLATE XX.

Fig. 1 represents the framing at the foot of the rafters of Fig. 1, Plate XIV. *abcd* is a cast-iron shoe, or boxing. AAA are oak-keys, two inches square. BB are wrought-iron straps, in place of which bolts may be used if desired.

Fig. 2 exhibits the method of splicing an upright timber; as, for instance, a tower-post. The length of such a splice should be three times the diameter of the stick, and bolted together with half or five-eighth inch bolts.

Fig. 3 illustrates a method of framing work at the foot of the rafters of a common roof. This method is much used. Each timber is to be notched into a half-inch to receive the purlin.

Fig. 4 shows the manner of framing a *centre-bearing* like that at A, Fig. 2, Plate VII.; or B, Fig. 5, Plate XV.

Fig. 5 exhibits the method of framing the foot of the rafters in a roof having inclined beams, as the example on Plate VIII.

Fig. 6 shows the detail of a piece of framing, as at AB, Fig. 1, Plate VII. At A is an oak-key two inches square.

Fig. 7 is the detail of framing at the intersection C of the plate before referred to; E being a wrought-iron strap, three-eighths of an inch thick and three inches wide, made in two parts, with shoulders, and a small bolt at *a* for securing the work.

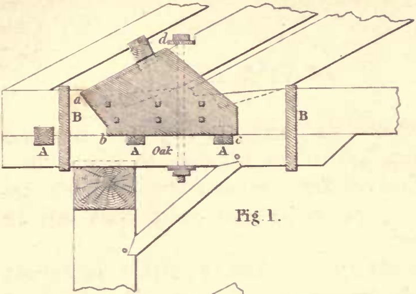
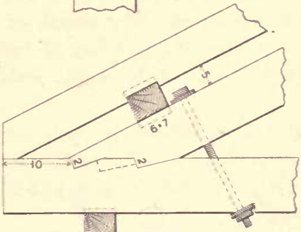


Fig. 1.

Fig. 2.



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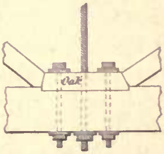
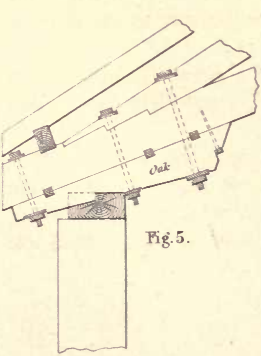


Fig. 4.



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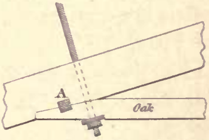

Fig 6

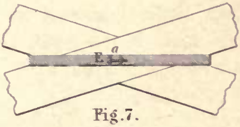

Fig. 7.

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IRON.

As cast and wrought iron are used in all heavy framing, a few pages of this work will be devoted to a consideration of its nature and properties.

Iron is a metal found in nearly all parts of the world. Its specific gravity is .7632; being, with the exception of tin, the lightest of all metals: and it differs from them all in the fact, that, while they are made brittle by the action of heat, its malleability is thereby greatly increased.

Iron shrinks so much in cooling, that a pattern for castings should be made an eighth of an inch larger per foot than the piece is required to be when cooled. It is heated so as to appear red in the dark at 752° Fahrenheit; and, in twilight, at 884°. It is made visibly red-hot by day at 1,077°, and is thoroughly melted at 2,754°.

Cast iron expands $\frac{1}{162000}$ of its length, in each direction, for every degree of heat; and its greatest expansion is $\frac{1}{1170}$ of its length in the shade, and $\frac{1}{1000}$ of its length when exposed to the sun. It will bear an extension of $\frac{1}{1200}$ of its length without permanent or serious alteration.

Wrought iron expands $\frac{1}{143000}$ of its length for each degree of heat. It will bear an extension of $\frac{1}{1400}$ of its length, and a pressure of 17,800 pounds to a square-inch, without injury. Its cohesive power is diminished $\frac{1}{3000}$ by every degree of heat.

The resisting power of *cast iron* has been greatly overestimated. The best experiments show that a force of 93,000 pounds to a square-inch will crush it, and that it will not bear more than 15,300 pounds without visible alteration.

The tensile strength of *wrought-iron* rods has been tested in a variety of ways. It has been decided that no particular amount can be named as the actual strain a rod will resist, as it has been repeatedly proved that no rod is to be depended upon as uniformly perfect throughout, a lesser strain often parting a rod of larger diameter. The cohesive power of *cast iron* is set down by most authors at 40,000, and of *wrought iron* at 60,000, pounds to a square-inch. A vertical rod, having a weight suspended at the lower end as in the case of rods supporting a tie-beam, not only supports the weight at the end, but must, in addition, sustain its own weight from the point at which it is suspended; so that a long rod will part near the upper sooner than the lower end. A perfect rod, therefore, decreases in strength as it is longer, and *vice versâ*. The iron-work in the examples of framing given in this work is so figured as properly to support the work, and, at the same time, prevent unnecessary vibration.

The following table shows the weight of a square-foot of cast or wrought iron plate, from a sixteenth of an inch to an inch in thickness, advancing by sixteenths:—

Dimens.	Wrought.	Cast.	Dimens.	Wrought.	Cast.
16ths.	lbs.	lbs.	16ths.	lbs.	lbs.
1	2.5	2.3	9	22.8	21.1
2	5.1	4.7	10	25.4	23.5
3	7.6	7.0	11	27.9	25.8
4	10.1	9.4	12	30.4	28.1
5	12.7	11.7	13	32.9	30.5
6	15.2	14.0	14	35.5	32.9
7	17.9	16.4	15	38.0	35.2
8	20.3	18.0	16	40.6	37.6

The following table shows the weight of a foot in length of wrought or cast iron, either round or square, from half an inch to three inches in diameter, advancing by eighths:—

Wrought.			Cast.		
Side of Square or Diameter.	Circular.	Square.	Side of Square or Diameter.	Circular.	Square.
Inches.	lbs.	lbs.	Inches.	lbs.	lbs.
½	.65	.83	½	.61	.78
⅝	1.02	1.3	⅝	.95	1.22
¾	1.47	1.87	¾	1.38	1.75
⅞	2.	2.55	⅞	1.87	2.39
1	2.61	3.33	1	2.45	3.12
1⅛	3.31	4.21	1⅛	3.1	3.95
1¼	4.09	5.2	1¼	3.83	4.88
1⅜	4.94	6.3	1⅜	4.64	5.9
1½	5.89	7.5	1½	5.52	7.03
1⅝	6.91	8.8	1⅝	6 48	8.25
1¾	8.01	10.2	1¾	7.51	9.57
1⅞	9.2	11.71	1⅞	8.62	10.98
2	10.47	13.33	2	9.81	12.5
2⅛	11.82	15.05	2⅛	11.08	14.11
2¼	13.25	16.87	2¼	12.42	15.81
2⅜	14.76	18.8	2⅜	13.84	17.62
2½	16.36	20.8	2½	15.33	19.53
2⅝	18.03	22.96	2⅝	16.91	21.53
2¾	19.79	25.2	2¾	18.56	23.63
2⅞	21.63	27.55	2⅞	20.28	25.83
3	23.56	30.	3	22.08	28.12

A cubic-foot of cast iron weighs 450.5 pounds; and one of wrought, 486.8. A cubic-inch of each weighs respectively .260 and .281.

The accompanying table shows the weight of bar-iron from a quarter of an inch to an inch in thickness, and from one to four inches in width, advancing by an eighth: —

Width of Bar.	Thick. ¼ in.	Thick. ⅜ in.	Thick. ½ in.	Thick. ⅝ in.	Thick. ¾ in.	Thick. ⅞ in.	Thick. 1 in.
1 in.	.84	1.25	1.66	2.08	2.5	2.91	3.31
1⅛	.93	1.4	1.87	2.34	2.81	3.28	3.75
1¼	1.04	1.56	2.08	2.6	3.12	3.64	4.16
1⅜	1.14	1.71	2.29	2.86	3.4	4.01	4.58
1½	1.25	1.87	2.5	3.12	3.75	4.37	5.
1⅝	1.35	2.03	2.71	3.38	4.11	4.73	5.42
1¾	1.45	2.18	2.91	3.64	4.37	5.1	5.83
1⅞	1.66	2.34	3.12	3.90	4.73	5.46	6.25
2	1.77	2.5	3.33	4.16	5.	5.83	6.66
2⅛	1.87	2.21	3.54	4.42	5.36	6.19	7.08
2¼	1.98	2.81	3.75	4.68	5.62	6.56	7.5
2⅜	2.08	2.97	3.96	4.94	5.98	6.92	7.91
2½	2.18	3.12	4.16	5.2	6.25	7.29	8.33
2⅝	2.29	3.28	4.37	5.46	6.61	7.65	8.75
2¾	2.4	3.43	4.58	5.72	6.87	8.02	9.16
2⅞	2.5	3.59	4.79	5.98	7.26	8.38	9.58
3	2.6	3.75	5.	6.25	7.5	8.75	10.
3⅛	2.7	3.91	5.21	6.51	7.86	9.11	10.42
3¼	2.81	4.06	5.41	6.77	8.12	9.47	10.83
3⅜	2.91	4.22	5.62	7.03	8.39	9.83	11.24
3½	3.01	4.37	5.83	7.29	8.75	10.2	11.66
3⅝	3.11	4.56	6.04	7.55	9.10	10.56	12.08
3¾	3.22	4.68	6.25	7.81	9.37	10.93	12.5
3⅞	3.30	4.84	6.46	8.07	9.64	11.30	12.92
4	3.34	5.	6.66	8.32	10.	11.66	13.33

The weights in the foregoing tables are those of English iron. American iron is a seventieth heavier; and therefore, in making calculations of its weight, one pound should be added to every seventy pounds as computed by the tables.

To ascertain the weight of any piece of *cast iron*, we have but to determine the contents in cubic inches, and multiply it by the decimal .260; or in feet, and multiply by 450.5. If it be of a shape or form that will readily admit of measurement in superficial feet as plates, we select the multiplier for the particular thickness as given in the table, and the product is the weight in pounds.

To determine the weight of a piece of *wrought iron*, we ascertain its contents in cubic inches, and multiply it by the decimal .281; or in feet, and multiply by 486.8; or, if it admits of measurement as a plate, multiply the amount of superficial feet by the figures set against the particular thickness in the table. To determine the weight of any piece of round, square, or flat iron, we select the amount given in the table, and multiply it by the number of feet in length of the piece whose weight we wish to obtain.

TABLES OF TIMBER-MEASURE.

THE accompanying tables exhibit the scantling, or dimensions, of building-timber reduced to board-measure. The figures in the left-hand column of each section represent the *length* of the piece in feet; those of the right-hand column, the *contained quantity* in feet and inches; and those over the head of each section, the thickness and depth of the piece in inches. The decimals denote twelfths of a foot. Thus, a stick, seven by nine inches square and nine feet long, contains forty-seven feet and three-twelfths of a foot.

If it is desired to know the quantity contained in sticks of greater length than those given in the tables, this may be ascertained by adding the amount of two or more requisite lengths together.

2×2		2×3		2×4		2×5		2×6	
1	0.4	1	0.6	1	0.8	1	0.10	1	1.
2	0.8	2	1.	2	1.4	2	1.8	2	2.
3	1.	3	1.6	3	2.	3	2.6	3	3.
4	1.4	4	2.	4	2.8	4	3.4	4	4.
5	1.8	5	2.6	5	3.4	5	4.2	5	5.
6	2.	6	3.	6	4.	6	5.	6	6.
7	2.4	7	3.6	7	4.8	7	5.10	7	7.
8	2.8	8	4.	8	5.4	8	6.8	8	8.
9	3.	9	4.6	9	6.	9	7.6	9	9.
10	3.4	10	5.	10	6.8	10	8.4	10	10.
11	3.8	11	5.6	11	7.4	11	9.2	11	11.
12	4.	12	6.	12	8.	12	10.	12	12.
13	4.4	13	6.6	13	8.8	13	10.10	13	13.
14	4.8	14	7.	14	9.4	14	11.8	14	14.
15	5.	15	7.6	15	10.	15	12.6	15	15.
16	5.4	16	8.	16	10.8	16	13.4	16	16.
17	5.8	17	8.6	17	11.4	17	14.2	17	17.
18	6.	18	9.	18	12.	18	15.	18	18.
19	6.4	19	9.6	19	12.8	19	15.10	19	19.
20	6.8	20	10.	20	13.4	20	16.8	20	20.

2×7		2×8		2×9		2×10		2×11	
1	1.2	1	1.4	1	1.6	1	1.8	1	1.10
2	2.4	2	2.8	2	3.	2	3.4	2	3.8
3	3.6	3	4.	3	4.6	3	5.	3	5.6
4	4.8	4	5.4	4	6.	4	6.8	4	7.4
5	5.10	5	6.8	5	7.6	5	8.4	5	9.2
6	7.	6	8.	6	9.	6	10.	6	11.
7	8.2	7	9.4	7	10.6	7	11.8	7	12.10
8	9.4	8	10.8	8	12.	8	13.4	8	14.8
9	10.6	9	12.	9	13.6	9	15.	9	16.6
10	11.8	10	13.4	10	15.	10	16.8	10	18.4
11	12.10	11	14.8	11	16.6	11	18.4	11	20.2
12	14.	12	16.	12	18.	12	20.	12	22.
13	15.2	13	17.4	13	19.6	13	21.8	13	23.10
14	16.4	14	18.8	14	21.	14	23.4	14	25.8
15	17.6	15	20.	15	22.6	15	25.	15	27.6
16	18.8	16	21.4	16	24.	16	26.8	16	29.4
17	19.10	17	22.8	17	25.6	17	28.4	17	31.2
18	21.	18	24.	18	27.	18	30.	18	33.
19	22.2	19	25.4	19	28.6	19	31.8	19	34.10
20	23.4	20	26.8	20	30.	20	33.4	20	36.8

2×12		2×13		2×14		3×3		3×4	
1	2.	1	2.2	1	2.4	1	0.9	1	1.
2	4.	2	4.4	2	4.8	2	1.6	2	2.
3	6.	3	6.6	3	7.	3	2.3	3	3.
4	8.	4	8.8	4	9.4	4	3.	4	4.
5	10.	5	10.10	5	11.8	5	3.9	5	5.
6	12.	6	13.	6	14.	6	4.6	6	6.
7	14.	7	15.2	7	16.4	7	5.3	7	7.
8	16.	8	17.4	8	18.8	8	6.	8	8.
9	18.	9	19.6	9	21.	9	6.9	9	9.
10	20.	10	21.8	10	23.4	10	7.6	10	10.
11	22.	11	23.10	11	25.8	11	8.3	11	11.
12	24.	12	26.	12	28.	12	9.	12	12.
13	26.	13	28.2	13	30.4	13	9.9	13	13.
14	28.	14	30.4	14	32.8	14	10.6	14	14.
15	30.	15	32.6	15	35.	15	11.3	15	15.
16	32.	16	34.8	16	37.4	16	12.	16	16.
17	34.	17	36.10	17	39.8	17	12.9	17	17.
18	36.	18	39.	18	42.	18	13.6	18	18.
19	38.	19	41.2	19	44.4	19	14.3	19	19.
20	40.	20	43.4	20	46.8	20	15.	20	20.

3×5		3×6		3×7		3×8		3×9	
1	1.3	1	1.6	1	1.9	1	2.	1	2.3
2	2.6	2	3.	2	3.6	2	4.	2	4.6
3	3.9	3	4.6	3	5.3	3	6.	3	6.9
4	5.	4	6.	4	7.	4	8.	4	9.
5	6.3	5	7.6	5	8.9	5	10.	5	11.3
6	7.6	6	9.	6	10.6	6	12.	6	13.6
7	8.9	7	10.6	7	12.3	7	14.	7	15.9
8	10.	8	12.	8	14.	8	16.	8	18.
9	11.3	9	13.6	9	15.9	9	18.	9	20.3
10	12.6	10	15.	10	17.6	10	20.	10	22.6
11	13.9	11	16.6	11	19.3	11	22.	11	24.9
12	15.	12	18.	12	21.	12	24.	12	27.
13	16.3	13	19.6	13	22.9	13	26.	13	29.3
14	17.6	14	21.	14	24.6	14	28.	14	31.6
15	18.9	15	22.6	15	26.3	15	30.	15	33.9
16	20.	16	24.	16	28.	16	32.	16	36.
17	21.3	17	25.6	17	29.9	17	34.	17	38.3
18	22.6	18	27.	18	31.6	18	36.	18	40.6
19	23.9	19	28.6	19	33.3	19	38.	19	42.9
20	25.	20	30.	20	35.	20	40.	20	45.

3×10		3×11		3×12		3×13		3×14	
1	2.6	1	2.9	1	3.	1	3.3	1	3.6
2	5.	2	5.6	2	6.	2	6.6	2	7.
3	7.6	3	8.3	3	9.	3	9.9	3	10.6
4	10.	4	11.	4	12.	4	13.	4	14.
5	12.6	5	13.9	5	15.	5	16.3	5	17.6
6	15.	6	16.6	6	18.	6	19.6	6	21.
7	17.6	7	19.3	7	21.	7	22.9	7	24.6
8	20.	8	22.	8	24.	8	26.	8	28.
9	22.6	9	24.9	9	27.	9	29.3	9	31.6
10	25.	10	27.6	10	30.	10	32.6	10	35.
11	27.6	11	30.3	11	33.	11	35.9	11	38.6
12	30.	12	33.	12	36.	12	39.	12	42.
13	32.6	13	35.9	13	39.	13	42.3	13	45.6
14	35.	14	38.6	14	42.	14	45.6	14	49.
15	37.6	15	41.3	15	45.	15	48.9	15	52.6
16	40.	16	44.	16	48.	16	52.	16	56.
17	42.6	17	46.9	17	51.	17	55.3	17	59.6
18	45.	18	49.6	18	54.	18	58.6	18	63.
19	47.6	19	52.3	19	57.	19	61.9	19	66.6
20	50.	20	55.	20	60.	20	65.	20	70.

4×4		4×5		4×6		4×7		4×8	
1	1.4	1	1.8	1	2.	1	2.4	1	2.8
2	2.8	2	3.4	2	4.	2	4.8	2	5.4
3	4.	3	5.	3	6.	3	7.	3	8.
4	5.4	4	6.8	4	8.	4	9.4	4	10.8
5	6.8	5	8.4	5	10.	5	11.8	5	13.4
6	8.	6	10.	6	12.	6	14.	6	16.
7	9.4	7	11.8	7	14.	7	16.4	7	18.8
8	10.8	8	13.4	8	16.	8	18.8	8	21.4
9	12.	9	15.	9	18.	9	21.	9	24.
10	13.4	10	16.8	10	20.	10	23.4	10	26.8
11	14.8	11	18.4	11	22.	11	25.8	11	29.4
12	16.	12	20.	12	24.	12	28.	12	32.
13	17.4	13	21.8	13	26.	13	30.4	13	34.8
14	18.8	14	23.4	14	28.	14	32.8	14	37.4
15	20.	15	25.	15	30.	15	35.	15	40.
16	21.4	16	26.8	16	32.	16	37.4	16	42.8
17	22.8	17	28.4	17	34.	17	39.8	17	45.4
18	24.	18	30.	18	36.	18	42.	18	48.
19	25.4	19	31.8	19	38.	19	44.4	19	50.8
20	26.8	20	33.4	20	40.	20	46.8	20	53.4

4×9		4×10		4×11		4×12		4×13	
1	3.	1	3.4	1	3.8	1	4.	1	4.4
2	6.	2	6.8	2	7.4	2	8.	2	8.8
3	9.	3	10.	3	11.	3	12.	3	13.
4	12.	4	13·4	4	14.8	4	16.	4	17.4
5	15.	5	16·8	5	18.4	5	20.	5	21.8
6	18.	6	20·	6	22.	6	24.	6	26.
7	21.	7	23·4	7	25.8	7	28.	7	30.4
8	24.	8	26·8	8	29.4	8	32.	8	34.8
9	27.	9	30·	9	33.	9	36.	9	39.
10	30.	10	33·4	10	36.8	10	40.	10	43.4
11	33.	11	36·8	11	40.4	11	44.	11	47.8
12	36.	12	40.	12	44.	12	48.	12	52.
13	39.	13	43.4	13	47.8	13	52.	13	56.4
14	42.	14	46.8	14	51.4	14	56.	14	60.8
15	45.	15	50.	15	55.	15	60.	15	65.
16	48.	16	53.4	16	58.8	16	64.	16	69.4
17	51.	17	56.8	17	62.4	17	68.	17	73.8
18	54.	18	60.	18	66.	18	72.	18	78.
19	57.	19	63.4	19	69.8	19	76.	19	82.4
20	60.	20	66.8	20	73.4	20	80.	20	86.8

4×14		5×5		5×6		5×7		5×8	
1	4.8	1	2.1	1	2.6	1	2.11	1	3.4
2	9.4	2	4.2	2	5.	2	5.10	2	6.8
3	14.	3	6.3	3	7.6	3	8.9	3	10.
4	18.8	4	8.4	4	10.	4	11.8	4	13.4
5	23.4	5	10.5	5	12.6	5	14.7	5	16.8
6	28.	6	12.6	6	15.	6	17.6	6	20.
7	32.8	7	14.7	7	17.6	7	20.5	7	23.4
8	37.4	8	16.8	8	20.	8	23.4	8	26.8
9	42.	9	18.9	9	22.6	9	26.3	9	30.
10	46.8	10	20.10	10	25.	10	29.2	10	33.4
11	51.4	11	22.11	11	27.6	11	32.1	11	36.8
12	56.	12	25.	12	30.	12	35.	12	40.
13	60.8	13	27.1	13	32.6	13	37.11	13	43.4
14	65.4	14	29.2	14	35.	14	40.10	14	46.8
15	70.	15	31.3	15	37.6	15	43.9	15	50.
16	74.8	16	33.4	16	40.	16	46.8	16	53.4
17	79.4	17	35.5	17	42.6	17	49.7	17	56.8
18	84.	18	37.6	18	45.	18	52.6	18	60.
19	88.8	19	39.7	19	47.6	19	55.5	19	63.4
20	93.4	20	41.8	20	50.	20	58.4	20	66.8

5×9		5×10		5×11		5×12		5×13	
1	3.9	1	4.2	1	4.7	1	5.	1	5.5
2	7.6	2	8.4	2	9.2	2	10.	2	10.10
3	11.3	3	12.6	3	13.9	3	15.	3	16.3
4	15.	4	16.8	4	18.4	4	20.	4	21.8
5	18.9	5	20.10	5	22.11	5	25.	5	27.1
6	22.6	6	25.	6	27.6	6	30.	6	32.6
7	26.3	7	29.2	7	32.1	7	35.	7	37.11
8	30.	8	33.4	8	36.8	8	40.	8	43.4
9	33.9	9	37.6	9	41.3	9	45.	9	48.9
10	37.6	10	41.8	10	45.10	10	50.	10	54.2
11	41.3	11	45.10	11	50.5	11	55.	11	59.7
12	45.	12	50.	12	55.	12	60.	12	65.
13	48.9	13	54.2	13	59.7	13	65.	13	70.5
14	52.6	14	58.4	14	64.2	14	70.	14	75.10
15	56.3	15	62.6	15	68.9	15	75.	15	81.3
16	60.	16	66.8	16	73.4	16	80.	16	86.8
17	63.9	17	70.10	17	77.11	17	85.	17	92.1
18	67.6	18	75.	18	82.6	18	90.	18	97.6
19	71.3	19	79.2	19	87.1	19	95.	19	102.11
20	75.	20	83.4	20	91.8	20	100.	20	108.4

5×14		6×6		6×7		6×8		6×9	
1	5.10	1	3.	1	3.6	1	4.	1	4.6
2	11.8	2	6.	2	7.	2	8.	2	9.
3	17.6	3	9.	3	10.6	3	12.	3	13.6
4	23.4	4	12.	4	14.	4	16.	4	18.
5	29.2	5	15.	5	17.6	5	20.	5	22.6
6	35.	6	18.	6	21.	6	24.	6	27.
7	40.10	7	21.	7	24.6	7	28.	7	31.6
8	46.8	8	24.	8	28.	8	32.	8	36.
9	52.6	9	27.	9	31.6	9	36.	9	40.6
10	58.4	10	30.	10	35.	10	40.	10	45.
11	64.2	11	33.	11	38.6	11	44.	11	49.6
12	70.	12	36.	12	42.	12	48.	12	54.
13	75.10	13	39.	13	45.6	13	52.	13	58.6
14	81.8	14	42.	14	49.	14	56.	14	63.
15	87.6	15	45.	15	52.6	15	60.	15	67.6
16	93.4	16	48.	16	56.	16	64.	16	72.
17	99.2	17	51.	17	59.6	17	68.	17	76.6
18	105.	18	54.	18	63.	18	72.	18	81.
19	110.10	19	57.	19	66.6	19	76.	19	85.6
20	116.8	20	60.	20	70.	20	80.	20	90.

6×10		6×11		6×12		6×13		6×14	
1	5.	1	5.6	1	6.	1	6.6	1	7.
2	10.	2	11.	2	12.	2	13.	2	14.
3	15.	3	16.6	3	18.	3	19.6	3	21.
4	20.	4	22.	4	24.	4	26.	4	28.
5	25.	5	27.6	5	30.	5	32.6	5	35.
6	30.	6	33.	6	36.	6	39.	6	42.
7	35.	7	38.6	7	42.	7	45.6	7	49.
8	40.	8	44.	8	48.	8	52.	8	56.
9	45.	9	49.6	9	54.	9	58.6	9	63.
10	50.	10	55.	10	60.	10	65.	10	70.
11	55.	11	60.6	11	66.	11	71.6	11	77.
12	60.	12	66.	12	72.	12	78.	12	84.
13	65.	13	71.6	13	78.	13	84.6	13	91.
14	70.	14	77.	14	84.	14	91.	14	98.
15	75.	15	82.6	15	90.	15	97.6	15	105.
16	80.	16	88.	16	96.	16	104.	16	112.
17	85.	17	93.6	17	102.	17	110.6	17	119.
18	90.	18	99.	18	108.	18	117.	18	126.
19	95.	19	104.6	19	114.	19	123.6	19	133.
20	100.	20	110.	20	120.	20	130.	20	140.

7×7		7×8		7×9		7×10		7×11	
1	4.1	1	4.8	1	5.3	1	5.10	1	6.5
2	8.2	2	9.4	2	10.6	2	11.8	2	12.10
3	12.3	3	14.	3	15.9	3	17.6	3	19.3
4	16.4	4	18.8	4	21.	4	23.4	4	25.8
5	20.5	5	23.4	5	26.3	5	29.2	5	32.1
6	24.6	6	28.	6	31.6	6	35.	6	38.6
7	28.7	7	32.8	7	36.9	7	40.10	7	44.11
8	32.8	8	37.4	8	42.	8	46.8	8	51.4
9	36.9	9	42.	9	47.3	9	52.6	9	57.9
10	40.10	10	46.8	10	52.6	10	58.4	10	64.2
11	44.11	11	51.4	11	57.9	11	64.2	11	70.7
12	49.	12	56.	12	63.	12	70.	12	77.
13	53.1	13	60.8	13	68.3	13	75.10	13	83.5
14	57.2	14	65.4	14	73.6	14	81.8	14	89.10
15	61.3	15	70.	15	78.9	15	87.6	15	96.3
16	65.4	16	74.8	16	84.	16	93.4	16	102.8
17	69.5	17	79.4	17	89.3	17	99.2	17	109.1
18	73.6	18	84.	18	94.6	18	105.	18	115.6
19	77.7	19	88.8	19	99.9	19	110.10	19	121.11
20	81.8	20	93.4	20	105.	20	116.8	20	128.4

7×12		7×13		7×14		8×8		8×9	
1	7.	1	7.7	1	8.2	1	5.4	1	6.
2	14.	2	15.2	2	16.4	2	10.8	2	12.
3	21.	3	22.9	3	24.6	3	16.	3	18.
4	28.	4	30.4	4	32.8	4	21.4	4	24.
5	35.	5	37.11	5	40.10	5	26.8	5	30.
6	42.	6	45.6	6	49.	6	32.	6	36.
7	49.	7	53.1	7	57.2	7	37.4	7	42.
8	56.	8	60.8	8	65.4	8	42.8	8	48.
9	63.	9	68.3	9	73.6	9	48.	9	54.
10	70.	10	75.10	10	81.8	10	53.4	10	60.
11	77.	11	83.5	11	89.10	11	58.8	11	66.
12	84.	12	91.	12	98.	12	64.	12	72.
13	91.	13	98.7	13	106.2	13	69.4	13	78.
14	98.	14	106.2	14	114.4	14	74.8	14	84.
15	105.	15	113.9	15	122.6	15	80.	15	90.
16	112.	16	121.4	16	130.8	16	85.4	16	96.
17	119.	17	128.11	17	138.10	17	90.8	17	102.
18	126.	18	136.6	18	147.	18	96.	18	108.
19	133.	19	144.1	19	155.2	19	101.4	19	114.
20	140.	20	151.8	20	163.4	20	106.8	20	120.

8×10		8×11		8×12		8×13		8×14	
1	6.8	1	7.4	1	8.	1	8.8	1	9.4
2	13.4	2	14.8	2	16.	2	17.4	2	18.8
3	20.	3	22.	3	24.	3	26.	3	28.
4	26.8	4	29.4	4	32.	4	34.8	4	37.4
5	33.4	5	36.8	5	40.	5	43.4	5	46.8
6	40.	6	44.	6	48.	6	52.	6	56.
7	46.8	7	51.4	7	56.	7	60.8	7	65.4
8	53.4	8	58.8	8	64.	8	69.4	8	74.8
9	60.	9	66.	9	72.	9	78.	9	84.
10	66.8	10	73.4	10	80.	10	86.8	10	93.4
11	73.4	11	80.8	11	88.	11	95.4	11	102.8
12	80.	12	88.	12	96.	12	104.	12	112.
13	86.8	13	95.4	13	104.	13	112.8	13	121.4
14	93.4	14	102.8	14	112.	14	121.4	14	130.8
15	100.	15	110.	15	120.	15	130.	15	140.
16	106.8	16	117.4	16	128.	16	138.8	16	149.4
17	113.4	17	124.8	17	136.	17	147.4	17	158.8
18	120.	18	132.	18	144.	18	156.	18	168.
19	126.8	19	139.4	19	152.	19	164.8	19	177.4
20	133.4	20	146.8	20	160.	20	173.4	20	186.8

9×9		9×10		9×11		9×12		9×13	
1	6.9	1	7.6	1	8.3	1	9.	1	9.9
2	13.6	2	15.	2	16.6	2	18.	2	19.6
3	20.3	3	22.6	3	24.9	3	27.	3	29.3
4	27.	4	30.	4	33.	4	36.	4	39.
5	33.9	5	37.6	5	41.3	5	45.	5	48.9
6	40.6	6	45.	6	49.6	6	54.	6	58.6
7	47.3	7	52.6	7	57.9	7	63.	7	68.3
8	54.	8	60.	8	66.	8	72.	8	78.
9	60.9	9	67.6	9	74.3	9	81.	9	87.9
10	67.6	10	75.	10	82.6	10	90.	10	97.6
11	74.3	11	82.6	11	90.9	11	99.	11	107.3
12	81.	12	90.	12	99.	12	108.	12	117.
13	87.9	13	97.6	13	107.3	13	117.	13	126.9
14	94.6	14	105.	14	115.6	14	126.	14	136.6
15	101.3	15	112.6	15	123.9	15	135.	15	146.3
16	108.	16	120.	16	132.	16	144.	16	156.
17	114.9	17	127.6	17	140.3	17	153.	17	165.9
18	121.6	18	135.	18	148.6	18	162.	18	175.6
19	128.3	19	142.6	19	156.9	19	171.	19	185.3
20	135.	20	150.	20	165.	20	180.	20	195.

9×14		10×10		10×11		10×12		10×13	
1	10.6	1	8.4	1	9.2	1	10.	1	10.10
2	21.	2	16.8	2	18.4	2	20.	2	21.8
3	31.6	3	25.	3	27.6	3	30.	3	32.6
4	42.	4	33.4	4	36.8	4	40.	4	43.4
5	52.6	5	41.8	5	45.10	5	50.	5	54.2
6	63.	6	50.	6	55.	6	60.	6	65.
7	73.6	7	58.4	7	64.2	7	70.	7	75.10
8	84.	8	66.8	8	73.4	8	80.	8	86.8
9	94.6	9	75.	9	82.6	9	90.	9	97.6
10	105.	10	83.4	10	91.8	10	100.	10	108.4
11	115.6	11	91.8	11	100.10	11	110.	11	119.2
12	126.	12	100.	12	110.	12	120.	12	130.
13	136.6	13	108.4	13	119.2	13	130.	13	140.10
14	147.	14	116.8	14	128.4	14	140.	14	151.8
15	157.6	15	125.	15	137.6	15	150.	15	162.6
16	168.	16	133.4	16	146.8	16	160.	16	173.4
17	178.6	17	141.8	17	155.10	17	170.	17	184.2
18	189.	18	150.	18	165.	18	180.	18	195.
19	199.6	19	158.4	19	174.2	19	190.	19	205.10
20	210.	20	166.8	20	183.4	20	200.	20	216.8

10×14		11×11		11×12		11×13		11×14	
1	11.8	1	10.1	1	11.	1	11.11	1	12.10
2	23.4	2	20.2	2	22.	2	23.10	2	25.8
3	35.	3	30.3	3	33.	3	35.9	3	38.6
4	46.8	4	40.4	4	44.	4	47.8	4	51.4
5	58.4	5	50.5	5	55.	5	59.7	5	64.2
6	70.	6	60.6	6	66.	6	71.6	6	77.
7	81.8	7	70.7	7	77.	7	83.5	7	89.10
8	93.4	8	80.8	8	88.	8	95.4	8	102.8
9	105.	9	90.9	9	99.	9	107.3	9	115.6
10	116.8	10	100.10	10	110.	10	119.2	10	128.4
11	128.4	11	110.11	11	121.	11	131.1	11	141.2
12	140.	12	121.	12	132.	12	143.	12	154.
13	151.8	13	131.1	13	143.	13	154.11	13	166.10
14	163.4	14	141.2	14	154.	14	166.10	14	179.8
15	175.	15	151.3	15	165.	15	178.9	15	192.6
16	186.8	16	161.4	16	176.	16	190.8	16	205.4
17	198.4	17	171.5	17	187.	17	202.7	17	218.2
18	210.	18	181.6	18	198.	18	214.6	18	231.
19	221.8	19	191.7	19	209.	19	226.5	19	243.10
20	233.4	20	201.8	20	220.	20	238.4	20	256.8

12×12		12×13		12×14		12×15		13×13	
1	12.	1	13.	1	14.	1	15.	1	14.1
2	24.	2	26.	2	28.	2	30.	2	28.2
3	36.	3	39.	3	42.	3	45.	3	42.3
4	48.	4	52.	4	56.	4	60.	4	56.4
5	60.	5	65.	5	70.	5	75.	5	70.5
6	72.	6	78.	6	84.	6	90.	6	84.6
7	84.	7	91.	7	98.	7	105.	7	98.7
8	96.	8	104.	8	112.	8	120.	8	112.8
9	108.	9	117.	9	126.	9	135.	9	126.9
10	120.	10	130.	10	140.	10	150.	10	140.10
11	132.	11	143.	11	154.	11	165.	11	154.11
12	144.	12	156.	12	168.	12	180.	12	169.
13	156.	13	169.	13	182.	13	195.	13	183.1
14	168.	14	182.	14	196.	14	210.	14	197.2
15	180.	15	195.	15	210.	15	225.	15	211.3
16	192.	16	208.	16	224.	16	240.	16	225.4
17	204.	17	221.	17	238.	17	255.	17	239.5
18	216.	18	234.	18	252.	18	270.	18	253.6
19	228.	19	247.	19	266.	19	285.	19	267.7
20	240.	20	260.	20	280.	20	300.	20	281.8

13×14		13×15		14×14		14×15		14×16	
1	15.2	1	16.3	1	16.4	1	17.6	1	18.8
2	30.4	2	32.6	2	32.8	2	35.	2	37.4
3	45.6	3	48.9	3	49.	3	52.6	3	56.
4	60.8	4	65.	4	65.4	4	70.	4	74.8
5	75.10	5	81.3	5	81.8	5	87.6	5	93.4
6	91.	6	97.6	6	98.	6	105.	6	112.
7	106.2	7	113.9	7	114.4	7	122.6	7	130.8
8	121.4	8	130.	8	130.8	8	140.	8	149.4
9	136.6	9	146.3	9	147.	9	157.6	9	168.
10	151.8	10	162.6	10	163.4	10	175.	10	186.8
11	166.10	11	178.9	11	179.8	11	192.6	11	205.4
12	182.	12	195.	12	196.	12	210.	12	224.
13	197.2	13	211.3	13	212.4	13	227.6	13	242.8
14	212.4	14	227.6	14	228.8	14	245.	14	261.4
15	227.6	15	243.9	15	245.	15	262.6	15	280.
16	242.8	16	260.	16	261.4	16	280.	16	298.8
17	257.10	17	276.3	17	277.8	17	297.6	17	317.4
18	273.	18	292.6	18	294.	18	315.	18	336.
19	288.2	19	308.9	19	310.4	19	332.6	19	354.8
20	303.4	20	325.	20	326.8	20	350.	20	373.4

GLOSSARY OF TERMS

IN COMMON USE AMONG CARPENTERS.

GLOSSARY.

A.

ADHESION. A physical term, denoting the force with which a body remains attached to another when brought in contact. *Cohesion* is the force that unites the particles of a homogeneous body. The insertion of a nail into wood is accomplished by separating the particles, and thereby destroying the cohesion; and its extraction, by overcoming the adhesion and friction. Adhesion, as related to woods, may be considered as follows: 3*d*. nails, 18 of which weigh 1 pound, $1\frac{1}{4}$ in. long, when driven $\frac{1}{2}$ in. into spruce, across the fibres of the wood, require a force of 73 pounds to extract them. A 6*d*. nail, driven 1 in. into dry oak, resists a strain of 507 pounds; and when into dry elm, 378 pounds. If the same nail be driven into elm endwise, or parallel with the grain, it may be drawn out by a strain of 257 pounds. The adhesion, therefore, when driven into the wood named, across the grain, or at right angles to the fibres, is greater than when driven parallel with them, as 4 to 3. In dry spruce, it is nearly as 2 to 1. A common screw, a fifth of an inch in diameter, has an adhesion about three times as great as a common 6*d*. nail. If the nail last named be driven 2 in. into dry oak, it will resist a direct strain of nearly half a ton.

ADZE. An edged tool used by carpenters to chip surfaces lying in a horizontal position, or in situations where they cannot easily be cut with an axe.

ANGLE. A term in geometry signifying a corner, or the point where two converging lines meet. Angles are of three kinds; viz., *right*, *obtuse*, and *acute*. A right angle is formed by a line joining another perpendicularly, or at an inclination of 90°, which is one quarter of a circle. In an obtuse angle, the inclination of the lines is greater or more open than 90°. In acute angles, their inclination is less than a right angle. A solid angle is the meeting of three or more plain angles at a point.

ANGLE-BRACE. A piece framed across the angle of a piece of framing. It is also termed an *angle-tie*, or *diagonal tie*, and is nearly synonymous with *brace*.

ANGLE-RAFTER. A piece in a hip-roof at the line where the two adjacent inclined sides unite. It is continued from the eaves to the ridge, and serves to support the jack-rafters.

APERTURE. An opening through a wall or partition. "Apertures," says Sir Henry Wotton, "are inlets for air and light: they should be as few in number, and as moderate in dimensions, as may possibly consist with other due respects; for, in a word, all openings are weakenings.

They should not approach too near the angles of the walls; for it were, indeed, a most essential solecism to weaken that part which must strengthen all the rest."

APRON. The horizontal piece in wooden stairs supporting the carriages at their landings.

ARC. A term in geometry signifying any portion of a circle, or curve.

ARRIS. The intersecting line where two surfaces of a body meet.

ARRIS-FILLET. A piece of wood, triangular in section, used to raise the slates or shingles which are against any portion of the work projecting from the roof; as a party-wall, sky-light, chimney, battlement, &c.

ARTIFICER. One skilled in any mechanical art; an inventor, or contriver.

ARTISAN. A mechanic trained to manual dexterity in any art or trade.

ASHLERING. The short studs of a building between the plate and girt of the attic-floor. Buildings are framed in this manner where the attic is designed for occupation; the short studs cutting off the acute angle which the rafters would make, were they permitted to come to the floor.

AUGER. A tool used by carpenters for boring holes.

AUXILIARY RAFTERS. Pieces of timber framed in the same vertical plane with *principal rafters*, placed under and parallel to them to give additional strength to the truss. (See Plate XI.)

AXE. An instrument for hewing timber or chopping wood. The axe is of two kinds; the *broad axe* for hewing (the handle of which is usually so bent as to adapt it for hewing either right or left), and the *narrow axe* for cutting, &c.

AXIS OF A DOME. A right line passing through its centre, and perpendicular to its base.

B.

BACK. The side opposite the face of any piece of work. When a timber is in a horizontal or inclined position, the upper side is called the *back;* and the under side, the *breast*. The top side or surface of rafters, and the curved ribs of ceilings or of hand-rails, are called *backs*.

BACKING A HIP-RAFTER, OR RIB. The act of forming the upper surface of either in such a manner as to make it range with the backs of the rafters, or ribs, on each side.

BALKS, or BAULKS. Small sticks of roughly hewn timber, being the trunks of small trees partially squared. The term usually denotes sticks less than 10 in. square at the but, and tapering a good deal as they approach the other end.

BAR-POSTS. Posts fixed in the ground at the sides of a field-gate. They are mortised to receive the movable, horizontal bars.

BASIL. The slope or angle of an edge tool, as that on a chisel or plane-iron. The angle is usually 12° for soft and 18° for hard wood.

BATTER. A term applied to a wall which is not plumb or perpendicular on its face, but which slopes from an observer standing in front.

BAULK-ROOFING. A term in use when timbers were generally hewn, instead of sawn as at present. It formerly designated a roof framed of baulk-timber, which, being hewn from small trees, could not be formed into square timbers, having an arris full and square.

BAY. The space intervening between two given portions of the wall or floors of a building.

BAY OF JOISTS. The joisting of a particular portion of a building, as between the posts of a side-wall or the girders of a floor.

BEAM. A large and long piece of squared timber, used in horizontal positions for supporting a superincumbent weight, or for counteracting two opposite forces, tending either to stretch or to compress it in the direction of its length. Employed as a lintel, or for the support of the ends of joists in a floor, it simply sustains a weight; if employed as a tie-beam to the truss of a roof, it resists the strain or thrust exerted by the truss-rafters; or, if as a collar-beam between the heads of truss-rafters, it resists the strain they exert, and is compressed.

BEAM-COMPASS. An instrument for describing circles of a larger diameter than may be practicable with ordinary compasses. It consists of a rod, or beam, on which are two sliding sockets, one provided with a sharp steel needle for fixing the centre of the circle to be described, and the other with a pencil for describing the circle itself. A very common method among carpenters for marking large circles, such as plans of domes, &c., is to determine the centre, and then affix to it the end of a slip or lath of wood, at the other extremity of which is the instrument for tracing the circle required.

BEAM-FILLING. The brick-work about the rafters at the eaves of a brick building.

BEARER. Any timber or wall that supports another timber, and retains it in its proper place.

BEARING. The distance or length which the ends of a timber or joist rest on another, or are inserted in a wall. A beam inserted 12 in. in a pier or wall is said to have a 12 in. bearing.

BEETLE. A large and heavy wooden mallet or hammer for driving stakes, piles, wedges, &c. It has one, two, or three handles, as may be required.

BELFRY. The part or section of a steeple in which the bell is suspended. The term was formerly used to denote more particularly the *framing* to which the bell was hung.

BELL-ROOF. A roof the vertical section of which is concave at the bottom, and convex at the top. It is often called an *ogee roof*.

BELVIDERE. A turret or lantern used for an observatory; also an arbor or artificial eminence in a garden.

BEVEL. An instrument of the nature of a try-square, one leg being movable on a centre, so that it may be set at any angle. The term also denotes an angle which is more or less than a right angle.

BINDING-JOISTS. In old methods of framing, binding-joists were large joists or timbers framed between the girders, in a transverse direction, for the support of the floor-joists above, and the ceiling-joists below. This method of framing is now but seldom used in this country.

BOARD. In America, a board is a piece of timber of any length or width, and from $\frac{1}{2}$ in. to 2 in. in thickness. Pieces of 2 or more in. up to 6 in. in thickness are called *planks*. In England, a board is a piece of timber more than 4 in. in width, and may be $2\frac{1}{2}$ in. thick; and all boards wider than 9 in. are called *planks*.

BOARDING-JOISTS. The same as floor-joists.

BOLT. A square or round iron pin, with a head or flange at one end, and a thread and nut at the other.

BOND. Any thing that connects and retains two or more bodies in a particular position.

BOND-TIMBERS. The timbers or pieces of wood which are built into the walls of a brick or stone building to secure the internal finishing.

BONING. The act of judging and forming a plain surface or straight line by the eye. The art is usually termed *sighting*. Carpenters and joiners use for this purpose two *straight edges*, by which they determine whether the surface is true or twisted

BORING. The act of perforating any substance. In joinery, this is done with a brad-awl, gimlet, or bit; and in carpentry, by an auger.

BOW. Any part of a building that projects from a straight wall. It may be either circular or polygonal in plan: the last-named are termed *canted bows*.

BRACE. A piece of timber fixed across the internal angle of the larger timbers of a frame; by which arrangement the whole of the work is stiffened, and the building prevented from swerving either way.

BREAK IN. An old expression in use among carpenters, signifying the act of cutting or breaking a hole into a brick or stone wall to admit the ends of joists, beams, &c.

BREAST-SUMMER. A piece of timber used for sustaining a superincumbent weight, and performing the office of a lintel over any large opening; as large windows, or doors in a store, or an open passage-way under the second story of a building.

BBIDGE. A term denoting that one timber lies across and immediately upon another, or is notched into it. Thus, in framed roofing, the common rafters bridge over the purlins, and the purlins over the principal rafters.

BRIDGING. Pieces placed between timbers to prevent their nearer approach. In floors, the joists are often stayed in this manner by pieces of the same kind of joist cut and nailed in between them at right angles, or by narrow pieces of board placed in a similar position, and diagonally crossing each other.

BRIDGING-FLOORS. Those in whose construction bridging-joists are used.

BRIDGING-JOISTS. Those sustained by a beam beneath them.

BUILDING. A fabric or edifice of any kind, constructed for occupancy; as a house, barn, church, &c.

BULKER. A term in use in some parts of England to denote a beam or rafter.

BUTMENT-CHEEKS. The two sides of a mortise in any piece of framing.

BUT-END. The end nearest the root of a tree.

BUTTRESS. A pier or external support, designed to resist any pressure from within which may affect the wall or thing so supported.

C.

CALIBER. The greatest diameter of any round body; as of a log or ball, or the bore of a gun.

CAMBER. An arch or curve on the top of an aperture or of a beam. A beam is said to be *cambered* when it is hewn or bent so as to form a slight curve.

CAMBER-BEAMS. Beams which are cambered.

CAMBERATED. Arched or vaulted.

CAMPANILE. A tower for bells. In Italy they are usually separate from the church, and are, in general, highly ornamented and costly edifices. The celebrated one at Cremona is 395 ft. high. That at Florence, built from a design by Giotto, is 267 ft. high, and 45 ft. square. The most remarkable campanile in the world is doubtless that at Pisa: it was built about the year 1174, and is commonly known as the "Leaning Tower." It is cylindric in plan; is 50 ft. in diameter, and 150 ft. to the platform, on which are the bells. From this platform a plumb-line falls, on the leaning side, nearly 13 ft. from its base. Its entire height is 180 feet.

CAMPSHOT. The sill or cap of a wharf or wall.

CANT. An external corner or angle of a building. Among carpenters, the term is also used to denote the act of turning a piece of timber.

CANTHERS. In ancient carpentry, the ends of the jack-rafters of a roof. They are considered by some to have given rise to the mutules of the Doric order.

CAPSTAN. A strong and massy column or cylinder of iron or wood, at the top of which is a circular cap, with horizontal mortises or holes around it at equal distances to receive bars or levers, for the purpose of turning it, and thus winding up a rope, the other end of which is attached to the weight to be raised, or to apply the power of the machine to any thing requiring removal.

CARCASS. The unfinished state of a building before it is partitioned off into rooms, the floors laid, &c.

CARPENTER. In America this word is often used indiscriminately to signify an artificer who begins and completes the entire wood-work of an edifice. The term properly denotes one who does the framing, raising, boarding, and partitioning off the rooms of a wooden building. The *finishing* of its several parts is done by the *joiner*. In ship-building the carpenter hews out the timbers, sets up the frame, and planks it; while the *ship-joiner* completes the work.

CARPENTER'S RULE. An instrument by the use of which carpenters take dimensions, &c. It is figured in inches, and parts of inches; and to some kinds is affixed a slide, the figures upon which enable the artificer to make calculations in multiplication and division, besides many others which constantly occur in his practice.

CARPENTER'S SQUARE. An instrument made of steel, one leg of which is 24 in. long and 2 in. wide, and the other 16 in. long and 1½ in. wide; the legs being figured in inches, and parts of inches. This instrument is used not only as a square and measuring-rule, but, with a plummet and line, to determine levels. The *joiner's* square has one leg of wood, and the other of steel without figures.

CARPENTRY. The work performed by carpenters, or the art of hewing, framing, and joining the timbers, and all the heavier parts of a building. Also a structure of framed timbers; as a roof, a floor, or an arch-centering.

CARRIAGE. The diagonally notched plank which is placed in an oblique position for the support of the treads and risers of a flight of stairs.

CASSION. A large and strong chest, made water-tight, and used in the construction of the piers of a bridge, where the rapidity and depth of the river present a difficulty in building the foundation. The floor of a cassion is so constructed that the sides may be detached from it when desired. The bed of the river is levelled at the site of the proposed pier; the cassion is launched, and floated to the location, and sunk. The pier is then built therein as high as the level of the water; the sides of the cassion are then removed, the pier resting on the foundation prepared for it. The tonnage of each of the cassions used in the construction of Westminster Bridge, over the Thames, was equal to that of a forty-gun ship.

CASTING. A term denoting the bending or twisting of a board or any piece of wood from its original state. It is synonymous with *warping*.

CATENARY CURVE. The curve formed by a chain or rope, of uniform density, hanging freely between two points of suspension. Galileo is supposed to have been its discoverer: and it is certain that he proposed it as the proper figure for an arch of equilibrium; supposing it, however, to be identical with the parabola. James Bernouilli, an eminent mathematician, born at Basil in 1654, investigated its nature; but its peculiar properties were afterwards demonstrated by John Bernouilli, his brother. Their opinion was adopted and advocated by Huygens and Leibnitz.

CEILING. The surface of a room opposite the floor.

CENTRE. A point which is equally distant from the extremities of a line, figure, or body: the middle point or place of any thing.

CENTERING. The temporary frame or woodwork whereon any arched work is constructed.

CHALK. A variety of carbonate of lime. Red chalk is an indurated or hardened ochre, and takes its name from its color. French chalk, used by tailors, is a soft magnesian mineral, of the nature of steatite, or soapstone.

CHAMFER. A furrow, slope, or bevel. A beam or joist is said to be chamfered when the arris is so cut as to convert its original right angle into an obtuse angle, at the lines where the slope intersects with the plane of the other sides.

CHEEKS. Two upright, similar, and corresponding parts of any timber-work; such as the studs at the sides of a door, window, &c.

CHIP. A piece of wood, or other substance, separated from a body by any cutting instrument. As a verb, it signifies to separate into small pieces or chips by gradually hewing or cutting.

CHISEL. A well-known instrument, made of iron, faced at the bevel, or cutting end, with steel. Those used for paring, being thin, are called *paring-chisels*: those used for framing are heavier and thicker, being called *firmer* or *framing chisels.*

CHIT. An instrument formerly used for cleaving laths.

CHORD. The right line which joins the two extremities of an arc. It is so called from its resemblance to a bow and string, the chord representing the string.

CIRCLE. A figure bounded by one continued curved line, called the *circumference*, all parts of which are equidistant from a point called the *centre*. It is the most capacious of all plain figures. The circumference of any circle, divided by 3.1416, will give the diameter; or the diameter, multiplied by the same number, will give the circumference. In common practice, where great exactness is not required, it is usual to consider the diameter to the circumference as 22 to 7.

To find the *area* of any circle, multiply half the diameter by half the circumference; or, for a more accurate calculation, multiply the square of the diameter by .7854, or the square of the circumference by .07958. Squaring the circle, as it is termed, is the attempt to ascertain the exact contents of a circle in square measure, — a problem as yet unsolved.

CLAMP. A piece of wood so fixed to another that the fibres or grain of one may cross those of the other, and thus prevent its warping or twisting.

CLEAR. The clear or unmolested distance between any two surfaces or points. The net distance between a floor and ceiling is said to be the height of the story in the clear.

CLERE-STORY. A continuation of the nave, choir, and transepts of a church, above the roof of the aisles.

CLEAVING. The act of separating, by force, one part of a piece of wood or other substance from another, in the direction of its fibres.

CLEFTS. Those cracks or fissures produced in wood when wrought too green; or when, in an unseasoned state, it is exposed to sudden heat. In *thin stuff*, as boards, &c., the clefts, being somewhat different from those in framing lumber, are usually termed *shakes.*

COCKING. A method of confining the tie-beams of a roof to the top of the wall-plates, or the joists of a floor to the girders and girts, by dove-tailing the parts together. Its design is to prevent the walls from spreading.

COLLAR-BEAM. A beam used to prevent the bending or sagging of the rafters in a common roof, or the nearer approach of the tops of the rafters in one that is trussed.

COMPASSES. A mathematical instrument for describing circles and measuring distances. *Common* compasses need no description. *Triangular* compasses have, in addition to the two legs of common ones, another, made with a joint, and movable in any direction. *Beam* compasses are designed for describing large circles. (See description.) *Proportional* compasses have two pairs of legs, connected by a shifting centre sliding in a groove, and thereby regulating the proportion which the opening or distance between the joints at one end bears to that at the other. They are used to enlarge or diminish drawings to any given scale.

COMPRESSIBILITY. The quality of being compressible, or the capacity of being reduced to smaller dimensions. A post sustaining a heavy superincumbent weight, or the collar-beam or strut of a truss-roof, when in use, are said to be in a state of *compression*.

CONCUS. This term is doubtless derived from the Latin *concutio*, to shake or shatter. In carpentry, it properly denotes wood so rotten or decayed in some of its parts as to be shaky. Of late years, it is generally used to signify rotten or decayed knots; and boards or sticks of timber having such knots are termed *concussed*.

CONE. A solid body having a circle for its base, and terminating at its top in a point, or vertex.

CONICAL ROOF. A roof whose exterior surface is formed like a cone.

CONSTRUCTION. The act of building, or of devising and forming. Among architects, the term more generally denotes the arranging and distributing of the parts of a building in such a manner as will insure durability to the structure, and economy in the use of its materials.

CONSTRUCTIVE CARPENTRY. Practical or operative carpentry.

CONTACT. A touching or juncture of two bodies. Things are said to be in contact when parts of them are so near together that there is no sensible intervening space. The places where they touch are called the *points of contact*.

CONTOUR. The outline bounding any figure.

CONTRACTION. The act of drawing together or shortening, by causing the parts of a body to approach each other. Thus, in an iron rod, heat, by insinuating itself between the particles of the metal, causes the rod to become longer; and it is then said to be expanded. Cold, which is simply the absence of heat, causes or permits the particles to come nearer each other; and the rod in this state is said to be contracted.

CONVERGENT LINES. Lines tending to one point, and which, if continued, would meet.

COUNTER-SINK. To sink a recess or cavity in any material, for the reception of a projection on the piece to be connected with it; as the head of a screw or bolt, or the plate of iron against which the nut or head of a bolt is fixed.

CRADLING. The timber-ribs to which are nailed the laths or furrings of a vaulted ceiling.

CRAMP. An iron instrument used by carpenters to draw or force mortises and tenons together. It is made of iron, with a movable shoulder at one end, and a screw at the other.

The term also denotes a piece of iron bent at the ends towards one side, and used to confine the larger timbers of a frame together.

CRANE. A machine for raising great weights. It consists of a stout upright shaft or post, termed a *puncheon*, from which projects a strong arm, or piece of timber, furnished at the extremity with a tackle and pulley.

CROSS-BEAM. A large beam extending from wall to wall of a building, or the girder holding the sides of an edifice together.

CROSS-GRAINED. A twisted or irregular disposition of the fibres of wood, as in that part of a tree where the branches shoot from the trunk.

CROSS-SPRINGERS. In a groined ceiling, the ribs springing from the diagonals of the piers or pillars on which an arch rests.

CROWN OF AN ARCH. Its highest point of elevation.

CUBIT. A lineal measure, of different length in different nations. In ancient architecture, it was equal to the length of the arm from the elbow to the extremity of the middle finger, or about 18 in. According to Dr. Arbuthnot, the Roman cubit was 17 4-10 in.; and the Scripture cubit, a little less than 22 in. The geometrical cubit of Vitruvius was 6 ordinary cubits, or 9 ft.

CURB-ROOF. A roof having two different slopes on each side. It is identical with the gambrel-roof.

CURB-PLATE. A circular plate or curb, formed by scarfing two or more curved pieces together at their ends, or by uniting together pieces of plank in layers, breaking the joints as in brickwork. Curb-plates are used at the eye of domes, &c.

CURLING-STUFF. Wood in which the fibres, instead of being straight, are winding, as where the branches of trees shoot from the trunk; the spiral character of the formation causing the wood to wind or curl.

CURSOR. The sliding part of beam-compasses, or that part of proportional compasses by which the points are set at a given ratio.

CURVE. A line that is neither straight nor composed of straight lines, but which bends continually without angles.

CURVILINEAR. Bounded by a curved line. Thus a roof is curvilinear when its plan is either circular or elliptical.

CUT-ROOF. One that is truncated, having a flat on the top.

D.

DAM. A mole, bank, or wall of earth, or a frame of wood, built to obstruct a current of water, and raise its level for driving machinery, &c.

DEAL. A term more commonly used in England than in America. It denotes the wood of the fir-tree, when made into planks or boards. They are imported into England from Christiana and Dantzic, taking the names of *Christiana deals* and *Dantzic deals*. The usual thickness of the former is 3 in., and their width 9 in. Those of $1\frac{1}{4}$ in. thickness are called *whole deals;* and those of half that thickness, *slit deals.*

DENSITY. A term in physics, denoting the closeness or compactness of the constituent parts of a body. In philosophy, the density of a body is the quantity of matter contained in a given bulk. Thus, if a body of equal bulk or size with another is of double the density, it contains double the quantity of matter. For example: A cubic foot of oak is more dense, and therefore contains more matter, than the same amount of pine; and a cubic foot of iron, being more dense, contains more matter than either. The weight required to crush a piece of wood is relatively as the density of the wood. A block of pine, being less dense than one of oak, is therefore more easily crushed.

DERRICK. A machine used by carpenters for raising any heavy body; as the larger timbers of a frame, or sections of the frame itself.

DESIGN. In architecture, a term denoting a plan or representation of any building. The term signifies either the general arrangement of floors, or the arrangement and disposition of the windows, doors, &c., of a building.

DETAILS. Drawings made on a larger scale than those which simply exhibit the design of a building. They are usually of the full size of the work to be executed, and are often termed *working-drawings.*

DIAGONAL. A right line so drawn through a figure as to join the two opposite angles. Euclid used the term *diameter* in the same sense. In modern practice, *diameter* applies more properly to circular, and *diagonal* to angular figures.

DIAGONAL SCALE. A measuring scale formed by horizontal lines, with diagonals drawn across them. It is designed for particularly accurate measurements.

DIAMETER. A right line passing through the centre of a figure, and dividing it into equal parts.

DIMENSION. The extent or size of a body; or length, breadth, and thickness or depth. A *point* has no dimensions; a *line* has one dimension, — namely, *length ;* a *superfice* (as the side of a squared stick of timber) has two dimensions, — *length* and *breadth ;* and a *solid* (as the whole stick) has three dimensions, — *length*, *breadth*, and *thickness*. The word is generally used in the plural, and denotes the whole extent of, or space occupied by, a body; as the dimensions of a room, house, or ship.

DISCHARGE. To unload or relieve; as the removal of weight from a beam, or other timber, when too heavily loaded.

DISPOSITION. The manner in which the several parts of a body are placed or arranged.

DOME. The spherical or other shaped convex roof over a circular or polygonal building. A *segmental* dome is one whose rise or elevation is less than one-half its diameter. A *stilted* or *surmounted* dome is higher than the radius of its plan or base. The oldest dome of which we are informed is that of the Pantheon at Rome, which was erected under Augustus, and is still quite perfect. In the following table will be found the dimensions of several of the principal domes of Europe. The heights are given from the ground.

	ft.d.	ft.h.
Pantheon at Rome	142	143
Sta. Maria del Fiore at Florence	139	310
St. Peter's at Rome	139	330
St. Sophia at Constantinople	115	201
Baths of Caracalla (ancient)	112	116
St. Paul's, London	112	215
Mosque of Achmet	92	210
Chapel of Medici	91	199
Baptistery at Florence	86	110
Church of Invalids at Paris	80	173

DORMANT TREE. A word of bad etymology, and nearly out of use. It is synonymous with the terms *lintel* and *summer.*

DOUBLE FLOOR. A floor constructed with binding and bridging joists.

DOVE-TAIL. A joint formed like a dove's tail: hence its name. It is made by so shaping the parts of the wood to be joined. that, when one is let into the other. it cannot be drawn out by a direct strain while its wedge-like form is retained.

DOWELS. Pins of wood or iron which unite two boards or timbers in such a manner as to disguise the fastenings.

DRAFT. A drawing representing the plans, elevations, and sections of a building, drawn to a scale, thus exhibiting all its parts in the same relative proportion to each other as they are intended to be in the building itself. The term "draught" signifies the same thing.

DRAGON-BEAM. A piece lying in a horizontal position, and framed diagonally from each of the angles of a hip-roof to a piece at right angles with it, and which is framed across the corner from one plate to the other. The timber into which the dragon-beam is framed is called the *angle-tie.*

DRAWBORE. To confine a tenon to a mortise by means of a pin through the parts, the hole in the tenon being nearer the shoulder than the holes in the cheeks of the mortise are to the abutment against which the shoulder is to come.

DRIFT. The horizontal power exerted by an arch when it tends to overset, or spread apart, the pier from which it springs. As a verb, it denotes the act of driving out a pin or wedge by a power exerted against the smaller end.

DRUXEY. Timber in a state of decay, having white, spongy veins, is said to be *druxey*.

DRY-ROT. A disease in timber which destroys the cohesion of its parts, and reduces its substance to a dry powder.

DWANGS (*Scotch*). The short pieces of board or joist used in bridging the joists of a floor.

E.

EAVES. The edge or lower border of a roof which so projects from the face of a wall as to throw off the water that falls on the roof.

EDGE. The space between the lines of intersection of two surfaces or sides of a solid; being that part or superfice of a rectangular body which contains the length and thickness; and is either straight or curved, according to the contour of the surfaces or sides. The edge of a *tool* is the part where the two surfaces meet when ground to an acute angle.

EDIFICE. A word nearly synonymous with building, structure, or fabric. The term *edifice* cannot, however, be applied with propriety to ordinary buildings, but rather denotes architectural structures of importance; as large mansion-houses, theatres, churches, &c.

EFFECT. That quality in an architectural composition which is calculated to attract the attention of the beholder, and excite in him the sensation intended by the designer.

ELASTIC CURVE. The curve or figure assumed by an elastic body, as a lath, or thin strip of wood or whalebone, when one end is fixed horizontally in a vertical wall, and the other loaded with a weight, by which the lath is curved or bended.

ELASTICITY. The inherent property or quality in a body by which it recovers its former figure or state after being relieved from any pressure, tension, or distortion. Elasticity is perfect only where a body recovers its exact original form and shape, and in the time which was required to produce the flexure or bending. The quality of *perfect* elasticity is rarely, if ever, found. A steel rod is said to be more elastic than one of iron; and a string of India-rubber is more so than one of hemp or cotton. *Brittle* is the opposite of *elastic*; and therefore a piece of wood is more elastic than a piece of glass.

ELEVATION. A drawing or geometrical representation of a side or end of any building. In an elevation, every part of the structure represented is supposed to be directly opposite to, and on a level with, the eye.

ELLIPSE. A figure produced by a plane passing obliquely through a cylinder; being what is commonly called an *oval*.

ENTER. The act of inserting the end of a tenon into a mortise, previous to its being driven in up to the shoulder.

EXTRADOS. The interior curve, or back, of the stones or voussoirs of an arch.

EYE OF A DOME. The opening at its top inside the curb.

F.

FABRIC. Any large or important building.

FACADE (*French*). A term denoting the principal or most important front of a building; as that which faces on a public street, lawn, or garden.

FATHOM. A measure of length comprising six feet. It is used chiefly among seamen for measuring ropes and chains, and for sounding the depth of water.

FELLING TIMBER. The act of cutting down trees.

FILLING-IN PIECES. The short studs which are cut in against the braces of a frame, or the short pieces of rafters cut in against the hips of a roof or groin. The term is synonymous with *jack-timber*.

FIRMER-CHISEL. A thick and heavy chisel for framing. (See CHISEL.)

FLANK. The part of a building that joins the front. The side of a building is called the *flank;* and a geometrical elevation of the same, a *flank elevation*.

FLEXIBILITY. The quality in a body which admits its bending, or flexure.

FLEXURE. A winding, or bending. The sag of a stick of timber is called its *flexure*.

FLOOR. The lower horizontal surface of a room. Carpenters generally include in the term the timbers and joists on which the floor-boards are laid, as well as the boards themselves. There are as many respective floors to a building as the building is stories in height. The first is usually called the *entrance story:* and the floor on which the principal drawing-rooms are, the *principal story*.

FLOOR-JOISTS. Those joists in modern carpentry supporting the boards of the floor of which they are a part.

FLUSH. A term which signifies that surfaces are on the same plane or line. The studs of a wooden building are said to be *flush* with the posts and girts.

FOOT. A measure of length, containing 12 English in., — supposed to have taken its name from the length of the human foot. The term is also used to denote surface, or solidity; as a *square foot*, and a *solid* or *cubic foot*. The length of the lineal foot varies in different countries. The accompanying table contains its dimensions, in English in., in the principal cities of Europe: —

London	12	in.
Amsterdam	11 2-10	,,
Antwerp	11 3-10	,,
Bologna	14 4-10	,,
Bremen	11 6-10	,,
Cologne	11 4-10	,,
Copenhagen	11 6-10	,,
Dantzic	11 3-10	,,
Frankfort on the M.	11 4-10	,,
Madrid	12	,,
Paris	12 1-12	,,

FORE or JACK PLANE. The plane used by carpenters to take off the rough surface of boards and timbers, preparatory to finishing them with the jointer and smoothing-plane.

FOX-TAIL WEDGING. A method of securing a tenon in a mortise. It is done by first splitting the end of the tenon, and then introducing a wedge, a portion of which is permitted to project from the cleft. The tenon is then put into the mortise, the back or bottom of which, opposite the end of the tenon, resisting the head of the wedge, it is forced into the split in the tenon, driving its parts asunder; and it is thus compressed and held fast by the cheeks of the mortise.

FRAME AND FRAMING. The rough timber-work of any building, including roofs, partitions, floors, &c.

FURRING. Thin pieces of wood nailed to beams or any timbers falling back of the surface or line they are intended to form, either in consequence of sagging, or from any original deficiency in size. The term may be appropriately applied to any pieces of wood employed in bringing crooked or uneven work to a regular surface.

FUST. A term used in some parts of England to denote the apex or ridge of a roof.

G.

GAUGE. An instrument for drawing lines on any surface of a piece of wood parallel to one of the arrises of that surface.

GABLE The vertical triangular piece of wall at the end of a building, bounded by a horizontal line level with the eaves, together with the two inclined lines of the roof.

GAIN. The term is probably derived from the Welsh word "*gan*," a mortise, and "*gann*," to contain: hence any piece of timber, having one or more mortises, may be said to be *gained*. In England, the term more properly applies to the bevelled shoulders of a floor-joist, for the purpose of giving additional resistance to the tenon below it. In America, the term is generally understood to mean a notch or mortise cut into the arris of a beam or timber to admit the end of another. In framing ordinary house and barn floors, the joists are *gained* into the sills and girders instead of being mortised.

GAMBREL-ROOF. (See CURB-ROOF.)

GIMLET. A well-known instrument used by carpenters and joiners for boring small holes.

GIRDER. The principal beams or timbers in a floor into which the joists are framed. Their chief use is to lessen the bearing or length of the joists.

GIRT. The term, when used to denote the size of timber, signifies the circumference, or distance around the outside of the stick, and applies to all timber, whether round or square. Among American carpenters, the term is used to designate those horizontal timbers in the outside walls of a wooden building which are framed in between the posts at the floors of the several stories; the timber beneath the post being the *sill*, and that immediately on its top the *plate*. Into the top and bottom edges of the girt the studs are framed; and into its side, or bridging it at the top, the ends of the joists of the floor

GRAIN. The direction of the lines or fibres of wood. Thus, when those lines are straight and parallel, the wood is said to be *straight-grained*; but, when they are twisted or crossed, it is said to be *cross-grained*.

GROIN. The curved line of intersection where two arches cross each other.

GROOVE. A sunken channel.

GROUND-PLAN. The horizontal section of that part of a building lying next above the surface of the ground. A story, of which the floor is below the surface of the ground, is called a *basement*.

H.

HALVING. A method of joining timbers by cutting away a portion of each, so that they may lock into each other.

HAMMER-BEAM. A short timber often used in ancient timber-roofs at the foot of the principal rafters. They extend a short distance out from the wall on the inside of the building, and are supported by a brace from the underside.

HANDSPIKE. A lever of wood for turning a windlass or capstan.

HEADWAY OF STAIRS. The clear distance or vertical height from the top of a given stair to the ceiling above.

HEW. To cut with an axe or hatchet so as to make an uneven and rough surface straight and true. The practice of hewing timber for frames is nearly out of use; most of that used at the present day being sawed at a mill. The modern carpenter is seldom familiar with this process: still, a competent knowledge thereof, although not often needed, is essential to a thorough understanding of his profession, and should by no means be neglected.

HIP-RAFTER. A piece of timber placed between the two adjacent inclined sides of a hip-roof to support the jack-rafters.

HIP-ROOF. A roof of which the end of the sides is not terminated by lines on the same plane as the ends of the building, but by hips formed by the other sides or ends inclining from the end-plates to the ridge.

I.

INCH. A lineal measure. In England and America, it is the sum of the lengths of three barley-corns, or the twelfth part of a foot.

INTER-JOIST. The space or interval between two joists.

INTER-TIES. Short pieces of joist or timber used in floors and partitions to bind the work together. The word is synonymous with *bridging*.

IN THE CLEAR. A phrase denoting the clear or unobstructed distance between any two given points. A room, the ceiling of which is ten feet above the floor, is said to be ten feet high *in the clear*.

J.

JACK-PLANE. A plane used to take off the rough surface of wood previous to its being finished by the jointers and smoothing-plane.

JACK-RAFTER. The shorter rafters, which, in a hip-roof, are cut in against the hip-rafters.

JACK-RIBS. The shorter ribs of a groin, which are cut in against the angle-rib of a groined ceiling.

JACK-STUDS. The shorter studs in the side of a building, which are cut in under or upon the braces, &c.

JACK-TIMBER. Any piece of timber in the frame of a building, if cut short of its usual length, receives the epithet *jack*

JAMB. The side of any opening in a wall.

JAMB-POSTS. The posts at the sides of a door to which the jamb-linings are affixed.

JERKIN-HEAD. A roof the end of which is constructed in a shape intermediate between a gable and a hip: the gable being continued, as usual, up to the line of the top of the collar-beam: and, from this level, the roof is hipped, or inclined backwards. This form is rarely adopted, except in some cottages, or in decorative architecture.

JOGGLE. A joint so formed, that, when its parts are joined, a force applied perpendicular to that which holds them together will not cause them to slide past each other. A strut of a truss-roof, or a brace, when tenoned or let into the wood against it at its end, in any part of a building, may be said to be *joggled*.

JOINER. A mechanic who finishes a building after it has been framed, raised, and boarded by the carpenter. The work performed by the joiner is called *joinery*.

JOINT. The place where two surfaces meet.

JOINTER. The name of the two larger planes used by joiners. They are of two lengths; thus taking, respectively, the names of *long* and *short* jointer.

JOISTS. Those smaller timbers of a building, framed into the girders and girts, to which the floor-boards are nailed, or into the plates and girts upon which is nailed the outside boarding. The term, in this country, generally denotes any piece of timber more than 2 and less than 6 in. square. It is synonymous with the old term *juffers*.

K.

KERF. The channel, or slit, made in wood by the teeth of a saw. The term is also used to denote the notches usually made in a stick of timber by the hewer, before he takes off the larger pieces between the kerfs.

KEY. A piece of wood (usually of oak) let into another to prevent warping. It also denotes the wedge-formed pieces sometimes put into a mortise at the side of a tenon to prevent its being drawn back out of the mortise. Also those square or round pieces usually put through a scarfing to prevent its parts sliding past each other.

KING-POST. In old methods of carpentry, the centre-posts in a trussed roof. This post is also known as *curb-post* and *prick-post.*

L.

LANDING. That part of a floor at the termination of a flight of stairs, either at the bottom or top.

LANTERN. An erection on the top of a roof or dome, having an aperture for the admission of light. Its plan may be either circular, elliptical, square, or polygonal.

LATH. Literally, a thin slip of wood. In America, the word is used almost exclusively to denote strips of wood 4 ft. long, $1\frac{3}{4}$ in. wide, and $\frac{3}{8}$ of an in. thick, used for covering the partition-studs and furring, preparatory to plastering. Laths of this kind are cut from the refuse pieces of timber called *slabs*, which are the segmental pieces first cut from a log previous to sawing it into boards, &c. They are put up in bundles of a hundred each. In England, the term *lath* generally denotes narrow strips of wood nailed to the rafters to support the slating or tiling of a roof; also those which support plastering.

LEDGMENT. The development of a body as stretched out or drawn on a plane, so that the arrangement of its parts, and the dimensions of its different sides, may be readily seen and ascertained. The drawing of a roof, as seen from a point over it, is said to be a view of the same in *ledgment.*

LEDGERS are, in scaffolding, the horizontal pieces parallel to the walls of the building. They are nailed to the outside of the poles, and opposite the end of the brackets upon which the floors of the scaffolding are laid.

LEVEL. A horizontal line, or plane parallel with the horizon. The term also denotes an instrument used by artisans to decide when lines or planes are of equal elevation at both ends.

LINE. In geometry, a term denoting a magnitude of but one dimension, which Euclid defines to be length without breadth or thickness. The term also denotes the twelfth part of a French in. A *right line* is the shortest straight line that can be drawn between two given points A *horizontal line* is one level or parallel with the horizon. A line which is *plumb* leans neither way, but is at right angles with, or perpendicular to, a level line.

LINTEL. A horizontal piece of timber or stone, over a door, window, or other opening, to support a superincumbent weight.

LUMBER. The term in this country is usually understood to mean logs or timbers after they are cut and sawed or split for use, and applies to all descriptions and dimensions; such as beams, boards, joists, planks, shingles, &c.

M.

M ROOF. A roof formed of two common roofs by placing their eaves against and parallel to each other, like the letter W inverted (M). The design of the M roof is that a larger space or span may be roofed over with light timber than could safely be done were the span covered with a single pitched roof. By the use of the M roof, a saving is also made in the gable-end ; the sum of the surface of the two gables of the M roof being less than in one large gable.

MALLET. A large wooden hammer used by carpenters for driving the chisel in mortising, &c.

MANSARD ROOF. Identical with the gambrel or curb roof. The Mansard roof was so named from its inventor, Francis Mansard, who was born at Paris in 1645. His true name was Hardouin Julius Mansart. He was an eminent architect, and was employed by Louis XIV. to build the Palace of Versailles and the Hospital of the Invalids. He died in 1708, at the age of sixty-three.

MENSURATION. The science which teaches the methods of calculating the magnitude of bodies, lines, and superfices.

MODEL. A miniature pattern of the whole or some part of a building, showing how the work is to be arranged and constructed.

MORTISE. A sinkage, or recess, in a piece of timber to receive the tenon, or end, of another stick.

N.

NAKED FLOORING. A term denoting the timbers of a floor, such as beams, girders, joists, &c., before the boards are laid upon them, or the furrings affixed beneath.

O.

OUT TO OUT. An expression denoting the magnitude of any body measured to the extreme outside.

OUT OF WIND. An expression used by artificers to signify that the surface of a thing is a true and perfect plane. A squared piece of timber, which by any means has become twisted, is said to be *winding*.

P.

PALE. A sharp-pointed stake of wood used for landmarks, &c.

PALISADE. A fence or fortification made of stakes, sharpened, and driven firmly into the ground.

PARALLEL. In geometry, a term applied to lines or surfaces which run in the same direction, being at every point equidistant from each other.

PARALLELOGRAM. Any four-sided rectilinear figure whose opposite sides are parallel. The term usually denotes a figure greater in length than in width.

PARTITION. A wall dividing one room from another. When a partition is of great length, and is unsupported from beneath, it should be trussed: it is then called a *trussed partition*.

PEDIMENT. The triangular part of a portico, or roof, which is terminated by the sloping lines of the roof. Pediments may be either triangular or segmental in contour. The term *gable* is nearly identical with pediment; but the latter term more properly applies to a gable when finished with an entablature, raking-mouldings, &c.

PENDENTIVE CRADLING. The timber-work which supports the laths and plaster of vaulted ceilings.

PERPENDICULAR. A line, or surface, falling on another at right angles. The term also denotes a line at right angles with the horizon; although, in the latter case, the proper term is *vertical*.

PILES. Large unhewn timbers driven into the earth, upon the heads of which are laid the foundation-stones of large buildings, the piers of bridges, &c. Piles are used where the soil is too loose and spongy to insure the foundation against settlement without them. They are usually of oak or spruce, and are from 7 to 15 in. in diameter. They are sharpened at one end, and, if need be, shod with iron, and hooped at the top. They are then driven into the ground, as far as possible, by a machine, which lets a heavy weight fall upon their heads from a height of about 30 ft. Piles, when driven so far below the surface of the ground that water always remains over them, are quite impervious to decay. Nearly the entire city of Amsterdam is built on piles. The foundation-stones of the new Custom House in Boston rest on more than three thousand. They are driven at distances of 2 ft. from centres.

PIN. A piece of wood, commonly of chestnut or oak, sharpened at one end, and used to confine timbers together. Pins made by hand, and therefore left somewhat rough, are preferable to those made by a machine, as the latter, being nearly smooth and round, easily turn or work, when the wood about them has shrunk in drying; whereas those made by hand are polygonal, and, when driven into holes, their angles cut into the wood, and they are thereby effectually prevented from turning. Small pins are called *pegs*. The pins used in ship-building are made by machinery, and are called *treenails*.

PITCH. In carpentry, the term denotes the angle formed by the inclined sides of a roof. In a building where the extreme height from the top of the rafters at the ridge is one-third of the width of the building at the eaves, from "out to out," the roof is said to be *one-third pitch*; if one-quarter the width, *one-quarter pitch*. If it be 10 ft. from the top of the rafters to a line level with the eaves, it is *10-ft. pitch*.

PLAN. The representation of the horizontal section of a building, showing the disposition of the rooms by the arrangement of the partitions, &c. The word *plan* is quite extensive in its signification, and, as commonly used, denotes the general idea; hence, the design of the several parts of a building, whether as regards finish, arrangement of rooms, or the composition as a whole, may with propriety be termed its *plan*; but, among architects, the term more properly denotes a drawing exhibiting the form, arrangement, and size of the rooms on the several floors. A representation of a front or side is called an *elevation*.

PLANK. A piece of timber of any length, having a width of more than 6 in., and from 2 to 6 in. thick. If less in thickness than 2 in., it is usually called a *board*. If the piece be less in width than 6 in., and not thin enough to be called a board, it is termed a *joist*. If thicker than 6 in., it is commonly called a *timber*.

PLATE. The horizontal piece of timber that lies immediately on the top of the posts of a frame, or on the top of the walls of a brick or stone building. *Gutter-plates* are pieces of timber framed out from the side-walls for the support of the gutter.

PLATFORM. An assemblage of timbers laid in a horizontal position, and covered with planks or boards, like a floor.

PLUMB. A line perpendicular to, or at right angles with, the horizon. A level line and a plumb-line form a right angle when they are brought in contact. Hence, if one of the blades of a carpenter's framing-square be placed on the edge, in a level position, the other blade, being at right angles with it, will be a plumb-line.

PLUMB-RULE. An instrument for determining plumb-lines.

POST. Any piece of timber used in a vertical position to support a superincumbent weight, or to support the horizontal timbers in the frame of a building.

PROTRACTOR. An instrument for laying down angles. They are usually made of brass or German silver.

PUNCHEON. Nearly synonymous with post. It also denotes the short studs in a partition over a door. The word *puncheon* properly designates an upright post or arbor in any machine which turns vertically; as a crane, for instance.

PURLINS. The horizontal pieces of timber which lie on the trusses of a roof, and support the common rafters.

Q.

QUEEN-POST. A suspension-post in a trussed roof where two posts are employed in the truss instead of one, as is the case with a truss framed with a king-post.

R.

RABBET. A recess, or channel, cut into the arris of a piece of wood. A channel cut into a plane surface is called a *groove*.

RADIUS. The semidiameter of a circle, or the length of a right line drawn from the centre to the circumference.

RAFTERS. The inclined timbers of a roof, which support the covering. Those forming part of a truss, and which support the purlins, are called *truss-rafters*. The smaller rafters to which the boards are nailed are called *common rafters*.

RAIL. A term in architecture of many meanings, but denoting more particularly any timbers or pieces of wood, in the rougher kinds of work, lying in a horizontal position, as in fences, &c.

RELISH. A term denoting the piece cut out between two tenons existing on the same piece of wood; also a piece cut from the edge of a tenon when it would be too wide if its whole width were left.

RESISTANCE. The power or quality in a body which enables it to avoid yielding to force or external pressure of any kind, and which lessens the effect of the opposing power; as the resistance of water to the motion of a ship, or that of wood to the operation of a cutting instrument. The following table exhibits the degree of resistance to pressure in the more common kinds of woods, taking common New-Jersey freestone as the unit: —

Freestone	1
Alder, Birch, or Willow	6
Beech, Cherry, Hazel	$6\frac{2}{3}$
Holly, Elder, Pear, and Apple	7
Walnut, Thorn	$7\frac{1}{2}$
Elm, Ash	$8\frac{1}{2}$
Box, Plum, Oak	11

The resistance of lead by the same unit is $6\frac{1}{2}$; brass, 50; iron, 107.

RIB. A curved piece of wood used for supporting the lathing and plastering of a vaulted ceiling, or the boarding of a dome.

RIDGE. The highest line of a roof at the angle made by the meeting of the top of the rafters. The piece of wood against which the top ends of the rafters bear is called the *ridge-piece*, or *ridge-pole*.

RIGHT LINE. The shortest line that can be drawn between two given points.

ROD. The term literally signifies any thing which is long and slender, and may be used to denote either a piece of wood or metal. It denotes also a measure of length, being $16\frac{1}{2}$ ft.

ROLLS or ROLLERS. Plain cylinders of wood used in moving large timbers or other heavy materials. They are usually from 3 to 10 in. in diameter, and from 1 to 6 ft. long. To move one end is called *cutting the roller*.

ROOF. The exterior horizontal covering of a building.

ROOFING. The general assemblage of timber and other materials which compose the roof of a building.

ROTUNDA. A building round on its exterior and interior, as the Pantheon at Rome. The term is often used, however, to denote any large circular room the ceiling of which is arched like a dome. The large room beneath the great centre dome of the Capitol, at Washington, is commonly called the *Rotunda*.

S.

SAG or SAGGING. The bending or yielding of a stick of timber between the points of support when the timber lies either in a horizontal or an inclined position.

SALLY. A projection of any kind. In carpentry, the term denotes the end of a piece of timber when cut to an acute angle, obliquely to the fibres of the wood. For example, the lower end, or foot, of common rafters, where they are connected with the plate; the end of a stair-carriage, &c. The outer point is called the *toe;* and the inner point, the *heel.*

SAW-PIT. The pit, or excavation, over which timber is sawed. Formerly the labor was done by two persons, one standing in the pit, and the other on the top of the log. The men who performed the work were called *sawyers.* This work is now done by machinery; and, fortunately for the carpenter, he is now seldom called upon to render so laborious a service as that of sawing logs by the severe and slow process of hand-labor.

SCAFFOLDING. An assemblage or structure of joists and boards, or planks, used in erecting or decorating the walls of a building. Scaffoldings are usually built by first erecting joists in a perpendicular position, at suitable distances apart, and nailing boards to the outside of them at distances of every 6 ft. in height, in a horizontal position, and parallel to the walls of the building. The joists are called *stage-poles;* and the horizontal boards, *ledgers.* At every pole, and at right angles with the ledgers, are other boards, continued in from them to the walls. The last-named pieces are called *brackets.* These are covered with a floor of boards, simply laid on the brackets without nailing. The word *staging* is often, though improperly, used among workmen for scaffolding. A kind of scaffolding is sometimes used in the erection of wooden buildings, which consists of what are termed wooden *jacks;* they being confined to the walls by means of a bolt, with a nut on the inside. The jacks support boards, forming a floor as in a scaffolding, with brackets and poles.

SCALE. An implement for measurement. Scales are usually made on wood or metal, and are of three kinds; viz., the *plain scale*, the *Gunter's scale*, and the *diagonal scale.* The plain scale contains simple divisions of any required dimension. The Gunter's scale is marked by various lines and numbers, by which, with the aid of a pair of dividers, many questions in arithmetic and practical geometry are readily solved: it is usually 2 ft. long and 2 in. wide. The diagonal scale is formed by dividing its width into a certain number of parts, and then drawing diagonal lines across them. By this implement, measurements may be made with great exactness. The word *scale* also refers to the magnitude of a drawing, map, or other object, as compared with its original.

SCANTLINGS. A term sometimes used to denote small timbers; as joists, &c.

SCARFING. The joining, or splicing, two pieces of wood, so that the whole may appear as but one piece.

SCRIBING. Fitting the edge of a piece of wood to the surface of another.

SECTION. A geometrical representation of a part of the interior of a building as cut by a vertical or horizontal plane. A section not only exhibits the lines where the separation is made, but also the *elevation* of those parts of the building exposed to view, if the nearer sectional part was actually removed. A *longitudinal section* is one on a line with the length of the building; a *transverse section* is one on a line with its width, or across it; and a *horizontal section* shows the floors, being usually called the *plan.* The term *section* also denotes a part, or portion, considered as separate from the rest.

SEGMENT. A part or piece cut from any thing, particularly the portion contained between the chord and arc of a circle.

SEVERY. A compartment or division of scaffolding.

SHAKE. A crack, or fissure, in wood, caused by its being dried too rapidly. A piece having many slits, or clefts, is said to be *shaky*.

SHORE. A prop, or brace, standing in an oblique position against a wall to retain it in its proper place. To "shore up a wall" is to put shores against it.

SHOULDER. The plane at the tenoned end of a stick of timber, which is transverse to its length, and at right angles with the tenon projecting from it.

SILL. The lowest principal piece of timber in the frame of a structure which lies in a horizontal position.

SITE. The situation or lot of land on which a structure stands.

SLEEPERS. Pieces of timber which lie horizontally on the ground, under the principal timbers of a ground-floor.

SLIDING-RULE. One having a figured slide, which, being moved against logarithmic lines, determines various arithmetical calculations.

SOCKET-CHISEL. Same as firmer-chisel.

SPAN. The distance, or spread, between the eaves of a roof, the abutments or piers of a bridge, &c.

SPAN-ROOF. A roof consisting of two simple inclined sides in contradistinction to shed-roof.

SPIRE. That part of a steeple which diminishes as it ascends. Any tapering body.

SPLAYED. A term denoting a side which makes an oblique angle with that adjoining. The jambs of a window are often splayed; thus, by making the aperture larger in the room, admitting more light.

SQUARE. A figure of four equal sides, and as many right angles. Also an instrument used by carpenters and joiners for laying out and squaring their work. (See CARPENTER'S SQUARE.) A thing is said to be square when its angles are right angles.

STAGE. A floor on which actors perform in a play-room. In ancient theatres, the stage was called the *proscenium*. This term in modern times denotes more particularly the front of the stage at the line where the curtain falls.

STANCHION. A prop, or support. The term is nearly synonymous with *post*.

STARLINGS. An English term denoting piles driven about the piers of a bridge, or the sides of a timber-wharf, to give them support.

STAY. Any thing performing the office of either a tie or a brace, which prevents the swaying of the work to which it is affixed.

STEEPLE. The lofty erection, ending in a point, which surmounts a church. It is composed of a tower and spire. The tower extends from the ground to the line where the steeple begins to diminish. From this point, the remainder is called the *spire*. Where the edifice has a porch or projection in front, the steeple is considered to begin at the top of the porch named.

STORY. That vertical division of a building occupying the space from the top of one floor to the under side of that immediately over it. A building is said to be as many stories high as there are alternate spaces of this description from the top of the sills to the top of the plates at the eaves. In America, the *principal* story is usually on the first floor: in England, it is on the second. In this country, we usually denominate the first story above the ground the *principal* or *entrance story*; that above this, the *chamber-story*; and those above them, the *third*, *fourth*, *fifth stories*, &c.

STORY-POST. A post between two adjoining stories of a building, for supporting a superincumbent weight.

STRAIN. The force exerted on any material which tends to destroy the cohesion of its parts.

STRAINING-PIECE. A piece placed between two opposite pieces of timber to prevent their nearer approach. It is always in a state of compression.

STRAP. An iron plate, bar, or

band for confining together two or more pieces of timber.

STRIATED. Marked with small furrows, or channels, as those in a piece of wood sawed by a large saw in the direction of its length. When, in sawing lumber, the saw is not firmly fixed in the frame, the sides of the timber are made rough or ridgy, and are then said to be *striated*.

STRIKING. This term denotes the act of lining out, or marking off the surface of any piece of timber. for making mortises, tenons, &c.; also removing the centering on which a vault or arch has been built.

STRUT. This term is nearly synonymous with *brace;* and, if it may be more properly used in any case, it is when it denotes a timber designed to keep extended those parts of the work against which its ends come. The term *brace* may be used as a substitute for *strut*, but not *strut* for *brace*. A strut, therefore, is always in a state of compression, while a brace may be either compressed or extended.

STUBSHOD. A term in common use among carpenters and joiners to denote the roughly split wood at the end of a piece of timber. not sawn through, but split or cleft apart, after the log was removed from the track over the saw-pit.

STUDS. Those short timbers, or joists, framed into the sides and ends of wooden buildings to complete the framing of the wall. Those at the sides of windows are generally made somewhat larger than the rest, and are called *window-studs:* those cut in, under, or over the braces are called *jack-studs*. Of late years, the term is used to denote also those timbers, or joists, called *partition-studs*, to which the lathes are nailed in partitions. In England, partition-studs are usually called *quarters*.

STUFF. This word is used by carpenters and joiners to denote indiscriminately lumber of any kind. Lumber, sawed to any particular size or dimension, is called *dimension-stuff*. It is to the carpenter and joiner what the general term *stock* is to other mechanics.

SUMMER. Any large beam designed to cover a wide opening. A small summer is called a *lintel*.

SUPERSTRUCTURE. That part of an edifice erected above the basement.

T.

TAIL-TRIMMER. A piece of timber, into which the ends of joists are framed, where chimney-flues, or any thing of like nature, prevent the insertion of the ends of the joists as may be done where the wall is solid.

TAPERING. A term denoting that the sides of a body gradually approach each other in the direction of their length; so that, if continued, they would meet at a point.

TEMPLET. A short piece of timber laid under the end of a beam or girder in the walls of a brick or stone building.

TENON. The end of any piece of wood so reduced as to fill and fit into a mortise. The tenon projects from the rest of the wood; and the place where it commences is so cut as to form a surface at right angles with it called the *shoulder*.

TENSION. The stretching or degree of extension to which a thing may be strained in the direction of its length.

THRUST. The force exerted by one body against another; as that of a segmental arch against its abutments, or the rafters of a common roof against the plates.

TIE. A timber, chain, or rope so fixed as to retain two bodies in a particular position when a tendency exists to diverge or spread apart.

TIE-BEAM. The beam at the foot of a pair of large rafters, serving to tie the walls of the building together by counteracting the thrust exerted by the rafters named.

TIMBER. This term is used so indefinitely, that it is a matter of some nicety to lay down any definition which will not clash with so-called "well-established usage." The true meaning of the word seems to be *wood fit for buildings*. And, as used at present, it denotes, 1st, The trunks and larger limbs of trees either standing or cut down; 2d, All *large* sticks, after they are sawed or hewn out, and squared for use.

TOE OF A RAFTER. The extreme point of a rafter, after it is so cut at the end that it may fit on the plate. The inner point is called the *heel* of the rafter.

TOEING. An expression denoting a nail, or other article, driven diagonally through one piece of wood to confine it to another. Nails are driven toeing into wood, when, from the peculiar form of the piece and the disposition of the parts to be confined together, it is difficult to use the nail at right angles.

TORSION. The strain on any material which tends to cause the same to twist or wind.

TRANSVERSE. A cross direction. The transverse strain on a piece of timber is when the force is so applied as to break it down when it lies in a horizontal position.

TRAMMEL. An instrument for describing an ellipse, or oval.

TRIM. To fit or prepare any piece of wood so as to make it suit another. To make a tenon smaller, that it may fit into a mortise, is to *trim it up*.

TRIMMER. A small beam into which is framed the ends of floor-joists at an opening in a floor. The joists into which the ends of trimmers are framed are called *trimming-joists*. Trimmers are used at the sides of well-rooms, of stairs, against chimneys, &c. The last are usually called *tail-trimmers*.

TRUNCATED. A term denoting that the top or apex of any thing is cut off. The part that remains is called the *frustum*. A hip-roof, the rafters of which do not continue up to a point, but end against a framed platform, is said to be *truncated*.

TRUSS. A peculiar combination and arrangement of timbers in framing, whereby they are made to mutually support each other.

TRUSSED PARTITION. A partition having a truss within it. Partitions are trussed when, from the arrangement of the rooms under it, a support cannot be given from below without interfering with the clear space of the room.

TRUSSED BEAM. One containing the principles of a truss.

TRY. To plane out a piece of wood true and square. The act of squaring wood by the plane, preparatory to putting the work together, is called *trying it out*.

TUSK. A bevelled shoulder made on the end of a piece of framing-timber above the tenon. The tusk is framed into the beam or girder, and is designed to give additional strength to the tenon.

U.

UPHERS. An old term denoting small poles or sticks of timber partially squared. They were used for scaffolding, common roofs, &c.

V.

VALLEY. The line at the internal meeting of the two inclined sides of a roof. The rafter under the valley is called the *valley-rafter*.

VAULT. An arched roof or ceiling over an apartment.

VAULTED. Arched like a vault or the interior of a dome.

VERTEX. The point of termination of any thing, the sides of which are inclined and continued till they meet; as a cone or a common roof.

W.

WALL. The sides or ends of any building or apartment.

WALL-PLATE. A piece of timber placed horizontally on the top of a wall. The term *plate* denotes the same thing.

WEDGE. One of the five mechanical powers. It has five surfaces; is thick at one end, and slopes to a thin edge at the other.

WELL-HOLE. The open hole, in a flight of stairs, at the end of the steps.

WICKET. A small door made through a larger door or gate.

WINDLASS. A machine for raising weights. It consists of a strong cylinder of wood or iron, which moves on an axis, and is turned by a crank, or by means of levers inserted in mortises cut into the outside of the cylinder near the ends. Around the cylinder is wound, by its revolutions, a rope or chain, the other end of which is attached to the weight to be raised. The windlass is used in a horizontal position. The capstan, an instrument of the same nature, is used upright. (See CAPSTAN.)

THE END.

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