Broadway Text-books of Technology . . .

Edited by G. UDNY YULE, formerly Assistant Superintendent of the Department of Technology, City and Guilds of London Institute, and Assistant Professor of Applied Mathematics at University College, London.

FIRST YEAR

CARPENTRY AND JOINERY

FIRST YEAR CARPENTRY AND JOINERY

BY

J. ERNEST MARSHALL, M.R.S.I.

FULLY ILLUSTRATED

FIFTH IMPRESSION

LONDON
GEORGE ROUTLEDGE & SONS, LTD.
BROADWAY HOUSE, 68-74 CARTER LANE, E.C.

Printed in Great Britain by T. and A. CONSTABLE LTD.
at the University Press, Edinburgh

PREFACE

THIS little work is intended for students taking a First Year Course in Carpentry and Joinery.

The principles of orthographic projection in plane and solid geometry have not been separately treated from a general standpoint, but only where they apply to each particular case. It is necessary, however, that the student should have already taken such work in a Preliminary Course, and it should be continued concurrently with this subject.

In so small a volume, some sections are unavoidably incomplete. For example, in connection with roofs the steel square has been introduced, but one side only is dealt with, the other being left for more advanced work.

The mechanics of the subject are supplemented by experimental examples, and it is suggested that the student should fit up his own apparatus for this purpose.

Instead of dealing with each subject as though it were so much matter to be locked up in separate compartments, the author has endeavoured to treat the work on a more comprehensive basis. Considerable experience in teaching has shown that the student is much more interested if the immediate application of merely theoretical points be made clear as they arise in practical examples. The principles involved in the construction and use of tools have been emphasised, but general descriptions of those tools already familiar to students of this subject, have been either omitted or only slightly touched upon.

It is desirable that the student should, at the outset, be led to understand the production of the work from a business standpoint as well as regards its construction. Where it is practicable, therefore, such questions as quantities of materials, labour, and cost, might be developed.

I am indebted to T. P. Hilditch, Esq., D.Sc., for kindly reading the proofs, and to the Editors for many valuable suggestions made during the production of the work.

J. ERNEST MARSHALL.

WARRINGTON.

CONTENTS

CHAPTER I

TIMBER—SEASONING, SHRINKAGE, AND PRESERVATION

CHAPTER II

TOOLS

CHAPTER III

FENCING

CHAPTER IV

BEAMS—THE REACTIONS OR PRESSURES ON THE SUPPORTS

CHAPTER V

WOODEN BEAMS: STRENGTH AND CONSTRUCTION

CHAPTER VI

JOINTS FOR LENGTHENING LARGE TIMBERS

CHAPTER VII

RAISING BEAMS BY MEANS OF PULLEY BLOCKS

CHAPTER VIII

FLOORS

CHAPTER IX

PARTITIONS

CHAPTER X

ROOFS

CHAPTER XI

CENTRES

CHAPTER XII

THE SCREW

CHAPTER XIII

CISTERN AND JOINTS

CHAPTER XIV

DOORS—DOOR FRAMES AND JAMB LININGS

CHAPTER XV

WINDOWS

CHAPTER XVI

A SIMPLE STAIR

FIRST YEAR
CARPENTRY AND JOINERY

CHAPTER I

TIMBER—SEASONING, SHRINKAGE, AND PRESERVATION

STRUCTURE OF TIMBER.—An examination of the transverse section of a log of timber reveals its general structure. Primarily it is built up of a number of concentric layers of woody fibre arranged one upon another about a central pith, Fig. 1. These layers are, when considered in the direction of

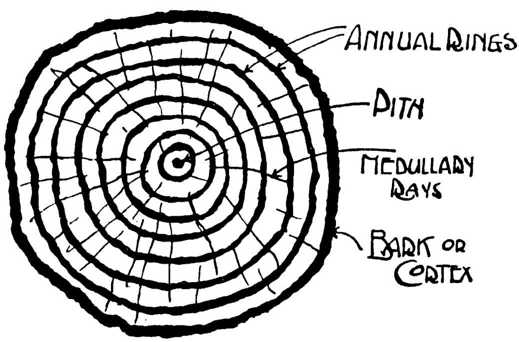


FIG. 1

the length or height of the tree, conical in shape. Usually one layer is formed annually, and the layers are, therefore, called annual rings. Each annual ring consists of two distinct layers; one is formed in the spring-time and the other during autumn. As a rule the autumn layer is more dense than the spring layer, and where this feature is most marked, as in pitch pine, the annual rings are strongly accentuated. One or two circumstances may here be mentioned to account for the difference in density. In the early spring the moisture from the ground is absorbed by the roots to form sap, and this rises in the stem of the tree just beneath the bark. The spring layer is formed by the *cambium* layer changing the sap into woody fibre in the form of cellular tubes bundled together. At the same time the bark becomes soft and spongy, making room for the new wood. The buds are opened and the leaves unfold to their full extent and then commence their work or function of taking in carbonic acid gas from the atmosphere, retaining the carbon and releasing the oxygen. In the autumn the sap descends with increased nourishment, and a new layer is deposited. The cell walls of the autumn layer are thicker and more compact than those of the spring layer, as shown in Fig. 2. This accounts for the difference between spring wood and autumn wood in density and hardness.

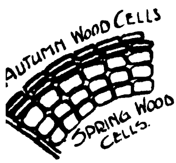


FIG. 2

Radiating from the cambium inwards are the medullary rays. These are plates of cellular tissue; their function apparently is to convey sap to the inner parts of the tree. In some woods, as oak and beech, the medullary rays are strongly marked and run practically unbroken from the pith to the bark. Boards cut with their sides along these rays are beautifully figured, and in oak this is called "silver grain."

As the tree matures, the inner portion of the stem becomes harder and more compact, forming what is known as heartwood or duramen. The portion near the bark known as sapwood or alburnum is, as yet, not true wood; but as the tree increases in age, the sapwood gradually changes into heartwood.

HOW TIMBER IS AFFECTED BY SEASONING.—The seasoning of timber is very important. It is advisable to fell trees during the winter, when there is less sap in the tree than at any other time. Sometimes they are felled in mid-summer following the period of the ascending of the sap, and when the stem or trunk is most free from sap. Whenever the tree may be felled there is invariably a quantity of sap and moisture to be removed by seasoning. Timber which is used before being properly seasoned will shrink, warp, and shake very considerably, and will, indeed, be liable to premature decay. There are various methods of seasoning, but these will not be fully dealt with here.

Briefly, the processes may be classified as (*a*) natural, and (*b*) artificial.

In the natural processes the log may be cut up into boards, say, 2 or 3 ins. thick, and placed in covered sheds which are open at both ends. The boards should be separated by ½ in. strips between them to allow of a free current of air on all sides (*see* Fig. 3).

Balk timber is usually placed in a stream of running water with the butt end facing the flow. The balk is held down

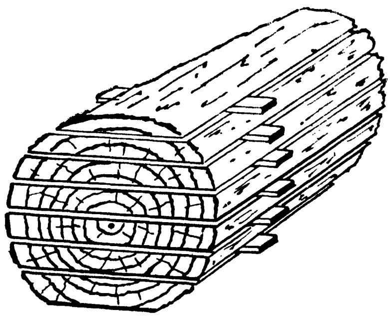


FIG. 3

below water-level, and the sap is driven out, its place being taken by the water which is afterwards easily and quickly dried out under cover by the natural process.

The artificial methods of seasoning include desiccating—*i.e.*, hot air chambers; also steaming, boiling, and smoking.

By these processes the length of time required for seasoning is very much reduced. If, however, the seasoning is hastened by high temperatures, as is the case in steam drying, the strength of the wood is impaired.

HOW SHRINKAGE AFFECTS TIMBER.—During the process of seasoning the evaporation of moisture causes the fibres to shrink or contract. Shrinkage may even occur to some extent after the timber is fixed in position, but this is sometimes due to the evaporation of moisture which may have been absorbed in transit. The direction in which shrinkage takes place should be specially noted.

Fig. 4 is a view of a log showing the effect of shrinkage. Considering a quartering from the log (Fig. 5), the shrinkage is clearly in the direction of the arrows, or along the annual rings with a contraction of the distance from D to C. The amount of shrinkage is greater therefore towards the outer edge of the log: similarly a board or plank cut from the log

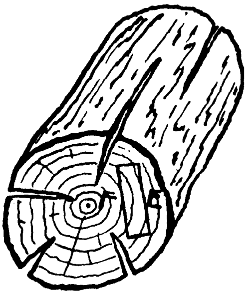


FIG. 4

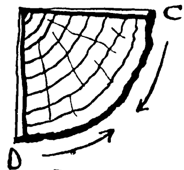


FIG. 5

as E F, Fig. 4, will contract to a greater extent at the side E, and will tend to warp as shown, Fig. 6. Such boards, if used as floor boards, should be placed with the heart side next the joists.

FIG. 6

FIG. 7

Floor boards are best sawn from the log radially, having their edges parallel to the annual rings as in Fig. 7. Timber does not shrink in the direction of the width of a board so cut, that is, in a direction at right angles to the annual rings.

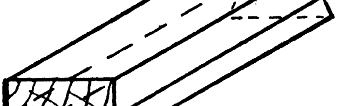


FIG. 8

Fig. 8 is a view of a wood block used in wood block floors. The annual rings are at right angles to the face of the block.

This is the best method of cutting the blocks, which are said to be "rift sawn."

PRESERVATION OF TIMBER.—The strength of timber can only be maintained by sufficiently protecting it from decay. There are many cases in structural work where there is no coating applied, or special treatment resorted to for the preservation of timber, excepting that of thorough seasoning beforehand. If, however, there is a good current of dry air about the surfaces of the wood, there should be little or no possibility of decay being set up from causes other than the attack of worms or insects.

Timber should, as far as possible, be protected from moisture, from the humid atmospheres of closed areas, and from the attacks of worms and insects.

Some of the methods of preservation will now be mentioned.

Creosote Oil—oil of tar—is a bye-product obtained in the distillation of coal-tar. Creosoting is one of the most successful methods used in the preservation of timber. The timber—which must be well seasoned—is placed in air-tight wrought iron cylinders. The air is withdrawn from the cylinders, and consequently from the pores of the timber, and the creosote oil, at a temperature of about 120° Fahr., is injected under a pressure which varies with the density of the wood, say from 60 lbs. to 160 lbs. per square inch.

In soft woods from 6 to 10 lbs. per cubic foot is injected, but in hard woods not more than 2 or 3 lbs. can be forced in.

Timber can be treated as described for about 8d. or 9d. per cubic foot.

The mere application of creosote oil is inferior to the above process as a timber preservative.

Gas-tar.—Where timber to be fixed in the ground, as posts, is not creosoted under pressure its preservation may be effected by coating with gas-tar, to which sand may be added—being sprinkled over the surface whilst still wet.

Charring.—Another method is to char over a fire the end to be fixed in the ground, quenching it afterwards with water. The carbonising of the post renders it proof against the attack of worms, and less liable to decay in wet situations. In this, and in all other cases, the timber should be thoroughly seasoned, and all traces of moisture removed before treatment.

Boucherie's Process.—In this process a solution of copper sulphate, in the proportion of 1 lb. of sulphate to 12½ gallons of water, is used. The solution is placed in a reservoir some 40 or 50 ft. above the timber to be treated. A tube is fitted to a nozzle, which is fixed to the end of the timber. The pressure due to the head of liquid is sufficient to cause the timber to become thoroughly impregnated.

Kyanising is a process named after its inventor (Kyan), where mercuric chloride is used. The salt is said to form in the timber insoluble compounds, giving it a permanent character. Its poisonous nature and expense, however, prevent its general use.

A number of other substances have been used with varying degrees of success, such as steeping in zinc chloride (Burnett's process); also by a double treatment of injecting first sulphate of iron and then sulphate of zinc (Payne's system).

Painting is another well-known method of preservation. A paint consists of some pigment mixed with oil and dries by oxidation of the oil. Turpentine is used in mixing paint as a diluent, but afterwards evaporates.

White lead is the chief pigment used, and makes the most lasting and durable paint. Raw linseed oil is generally used for inside work or for light-coloured paints, and boiled linseed oil is used for external work and for paints of darker colour.

New woodwork is usually knotted, primed, and stopped, and requires about four coats.

QUESTIONS ON CHAPTER I

(1) What is the object of seasoning timber? Name one or two methods, and explain how timber is affected by seasoning.

(2) What would you expect to find in a log from a tree which has been felled too soon? In what respect would it differ from a well-matured log?

(3) Show how shrinkage would affect a board whose sides are parallel to the annual rings. Suppose you had a number of such boards to join together, show how you would arrange them in relation to each other so as to minimise the effect of shrinkage as much as possible.

(4) What is meant by "rift" sawing, and what are the reasons for its adoption?

(5) Describe two well-known methods of preserving timber—one suitable for wooden fencing and the other for window frames.

(6) What is creosote oil, and how is timber treated with it? To what extent does it affect the weight of timber? Describe some other methods of preserving timber to be set in the ground.

(7) Describe and illustrate how boards are affected by shrinkage. How would you minimise the effect of this both in cutting the boards from the log, and in the work generally?

CHAPTER II

TOOLS

SOME of the most important tools in general use will be dealt with in the following pages.

The tools used for cutting will be classified as follows:—

1. Paring: the wedge being the fundamental form; including the axe, adze, chisel, gouge, plane, spokeshave.
2. Boring tools; including the centre bit, auger bit, twist bit, quill bit, and gimlet.
3. Tearing: saws.
4. Abrading including files, scrapers, and glasspaper.

The action of the wedge-shaped tools of the first group, such as the axe or chisel, is to divide and press the fibres apart and then to split the wood by overcoming the lateral cohesion of the fibres.

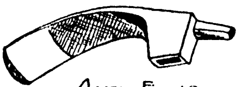
In some cases, although the cutting edge is essentially wedge-shaped, the action may not be altogether a wedging one. It will depend upon the angle at which the tool is applied to the surface of the wood. For instance, if the plane iron were to be fixed in a plane at right angles to the sole, its action would be a scraping one. In the case of the plane having the cutting-iron at an angle of 45°, there is both a wedging and a scraping action.

FIG. 9

PARING TOOLS—*Axe.*—The head shown in Fig. 9 is the Kent pattern, and the one in most general use. The handle is usually about 16 ins. long, which is a useful length for both heavy and light work. A head weighing $2\frac{3}{4}$ lbs. is a useful size.

Adze.—Fig. 10. These are fitted with long handles. They are useful where a large amount of timber has to be removed. The operator stands over the work keeping the handle in an upright position.

Chisel and Gouge.—A firmer chisel is shown in Fig. 11. This chisel is shorter and stiffer than a paring chisel, and more suitable for use where extra force must be applied in using the mallet.



ADZE FIG. 10

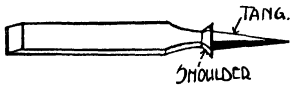


FIG. 11 FIRMER CHISEL

A chisel ground thin can be sharpened with a keener cutting edge than one ground thicker (*see* Figs. 12 and 13). A thinly-ground chisel although it does not retain its keenness so long, enters the wood easily and produces a smooth surface. A chisel ground thicker, as in Fig. 13, tends to crush and tear off the fibres and produces a rougher surface. The wedge-like shape of the edge of the chisel and gouge is twofold in its action—(i.) cutting, (ii.) splitting.

FIG. 12

FIG. 13

In cutting, the fibres are severed or divided and the wedge form lifts them or moves them away, allowing the edge to penetrate the wood further. A tool which is bevelled and sharpened on two sides tends to force the fibres apart before the cutting-edge can come into operation, consequently a rough surface is produced. In the chisel, however, the flat side can be kept in contact with the plane surface, as in Fig. 12, and as the splitting of the fibres is reduced a smoother face is obtained.

SCRIBING GOUGE FIG. 14

FIG. 15 FIRMER GOUGE

Fig. 14 is a scribing gouge which is ground on the concave side; and Fig. 15 represents a firmer gouge.

Mortise Chisel.—Fig. 16 shows a mortise chisel; the blade is made deep, enabling it to withstand heavy blows from the mallet, and the constant side-thrusts it receives when being released from the mortise hole.

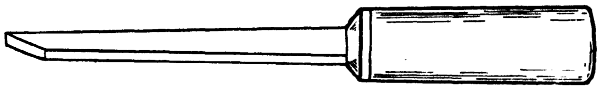


Fig. 16 Mortise Chisel

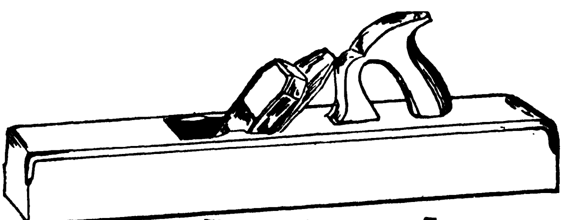
Planes.—Figs. 17 to 19 show a jack plane, trying plane, and smoothing plane.

The stock is generally made of beech wood, and in this is placed the cutting-iron which is held by means of a wedge. A plane with a long stock, such as the trying-plane, is particularly

Jack Plane Fig. 17

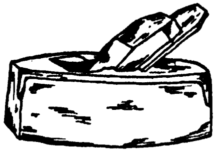
suited for the producing of level surfaces. On the other hand, a smoothing plane, having a short stock, will more easily follow the undulations of an uneven surface, and of course, is only used for the purpose of producing a smoother face.

The cutting-iron is usually fixed in the stock at an angle



Trying Plane Fig. 18

of 45° to the sole of the plane. At a smaller angle the shaving would come off with a series of comparatively long splits, and a correspondingly rougher surface would be produced. A much smoother surface is obtained when, after cutting the fibres, the shaving is lifted sharply away from the surface. To do this it would appear that a greater angle even than 45° is necessary; but it is found that an iron so fixed has too much of a scraping action for general use. By having the cutting-iron at 45° and securing to it a cap-iron shaped as shown in section Fig. 20, the shaving, as is seen, can be lifted away almost at right angles to the surface.



SMOOTHING PLANE FIG 19

For hardwood and especially for wood having an irregular grain, such as mahogany or oak more of a scraping action is admissible and the cutting-iron may with advantage be fixed at an increased angle, say 50°. For

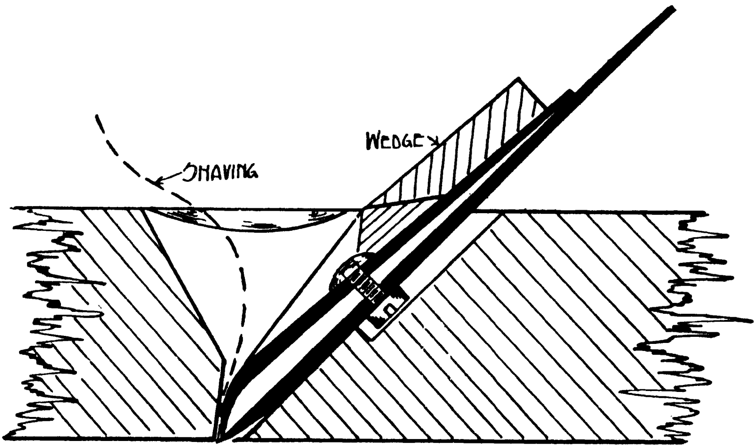


FIG.20 SECTION MOUTH OF PLANE

moulding and rebate-planes where only one iron is used, the iron is fixed at from 55° to 60°.

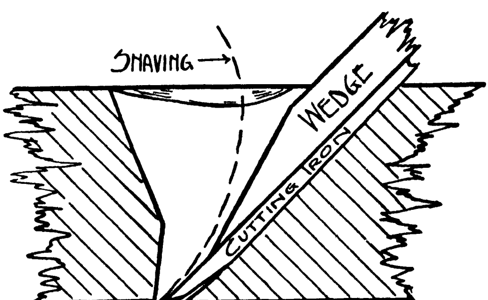


FIG.21 WITHOUT CAP-IRON

Fig. 21 shows a cutting-iron and the angle of the shaving leaving the wood where no cap-iron is used. The cap-iron further strengthens the edge of the cutting-iron and prevents vibration or "chattering." Figs. 22 and 23 are views of the cutting-iron and cap-iron.

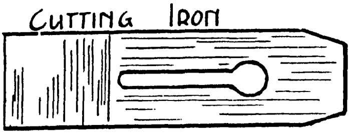


FIG. 22

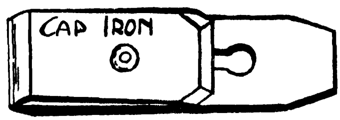


FIG. 23

Spokeshaves. — Fig. 24 is a wooden spokeshave which to some extent combines the action of the chisel and plane. Wooden spokeshaves are rather inclined to wear rapidly near

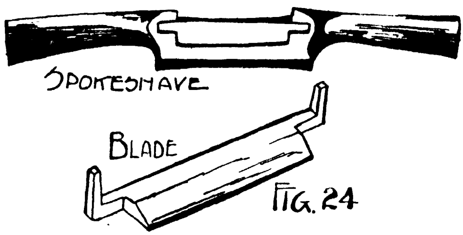


FIG. 24

the mouth of the blade. Iron spokeshaves are much superior, and can be easily adjusted to suit both quick and flat curves.

BORING-TOOLS—*Centre Bit.*—The centre bit shown in Fig. 25 is generally used in wood across the grain. The spur point A has a sharp edge and makes a clean cut through the fibres. The

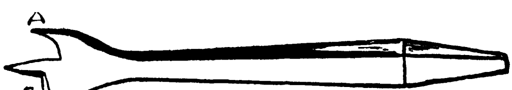


FIG. 25. CENTRE BIT

surplus wood is removed by the cutting-lip B, which has a chisel edge in form and action, but operates with a circular motion.

Auger Bit.—A common type of auger bit, which can be used across or in the direction of the grain, is shown in Fig. 26. This bit is self-feeding. With each revolution the screw point draws the bit into the wood a distance equal to the pitch of the screw. The bit is provided with double cutters, which, along with the parallel sides, are a great assistance in directing the bit and maintaining its direction when boring with the grain. Some auger bits are made to

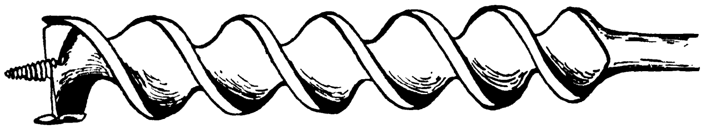


FIG. 26. AUGER BIT

be used with a straight handle, for which an eye is arranged at one end as shown in Fig. 27 as well as for the brace.

An "Irwin" auger bit is shown in Fig. 28: the special advantage claimed for this form is that it does not choke.

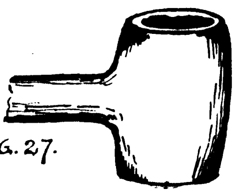


FIG. 27.

FIG. 28. "IRWIN" AUGER BIT

Spoon Bit.—A spoon bit is shown in Fig. 29. It is used for boring across the grain. The fibres are cut very rapidly with this bit, and a clean hole is produced. Both this and the centre bit require force, and are said to be pressure-fed,

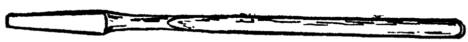
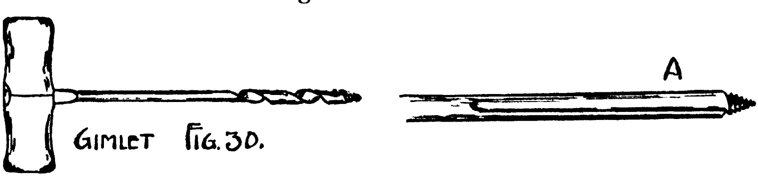


FIG. 29. SPOON BIT

the pressure being applied by the workman at the head of the brace.

Nose Bit.—A nose bit is similar to the last, but with the addition of a cutter at the end, which enables it to be used in the direction of the grain.



GIMLET FIG. 30.

Gimlet.—A twist gimlet is shown in Fig. 30. It has a screw feed, but this in some woods tends to split the fibres, the more so if the groove for the escape of the surplus wood is not large enough. A shell gimlet A, Fig. 30, does not possess these disadvantages.

SAWS.—A cross-cut saw used for cutting across the grain is shown in Fig. 31. These saws are usually about 26 ins.

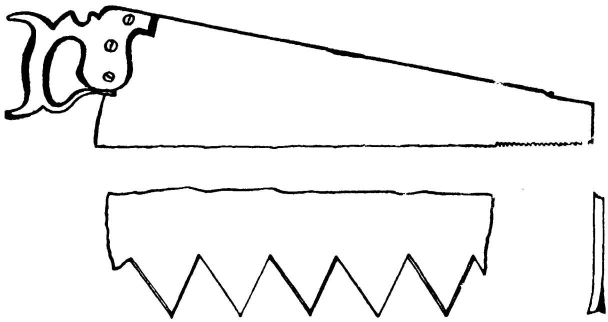


FIG. 31.

long with about four teeth to the inch. The front edge of each tooth as AB, CD Fig. 32, is inclined at about 70°, and the teeth are filed with sharp points. For greater ease in cutting, the teeth are sometimes arranged in the form of equilateral triangles, called peg-teeth, as shown, Fig. 33.

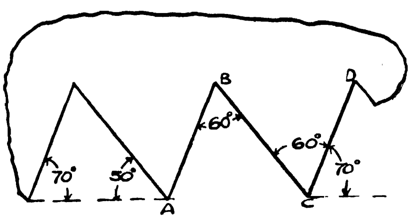


FIG 32.

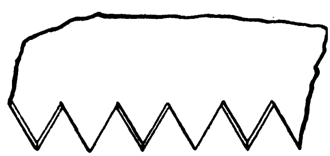


FIG. 33.

Rip saws, for cutting along the grain, are about 28 ins. long, and have about three teeth to the inch.

The front edges of the teeth are at right angles, or nearly so, to a line touching their points, Fig. 34. When sharpening the file is held almost at right angles to the saw to obtain square points.

The set of the teeth is shown in Figs. 31 and 35. Alternate teeth are bent outwards in one direction and the others in the opposite direction This enables the saw to clear itself as it passes through the timber.

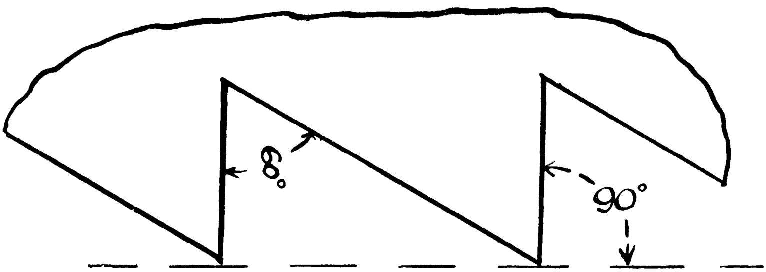


FIG. 34

The Cutting-action of Saws.—Each tooth of a cross-cut saw operates as a chisel or marking knife would, when drawn

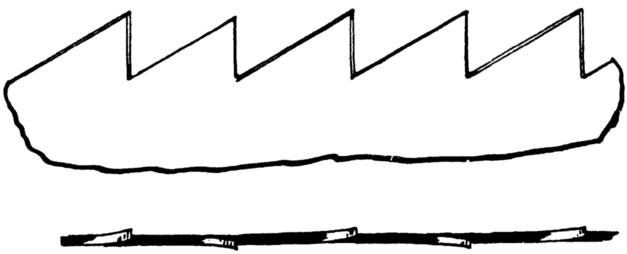


FIG. 35.

across the wood in an inclined position as in Fig. 36. If we can imagine two such chisels acting close together in reverse

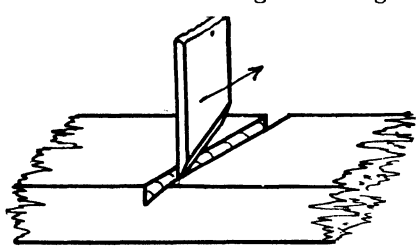


FIG. 36.

positions, as Fig. 37, the result would be closely similar to that produced by the cross-cut saw teeth—excepting that the material at A is not pushed away, as would be the case where there are a number of teeth following each other and acting jointly Fig. 38 shows a saw kerf cut with a cross-cut saw

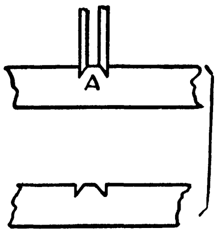


Fig. 37.

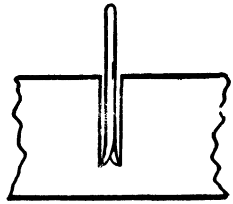


Fig. 38.

The action of rip-saw teeth differs very materially from that just described. Each tooth scrapes and tears away the fibres in much the same way that a chisel would if used as in Figs. 39 and 40.

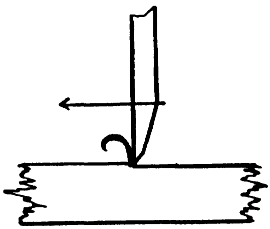


Fig. 39.

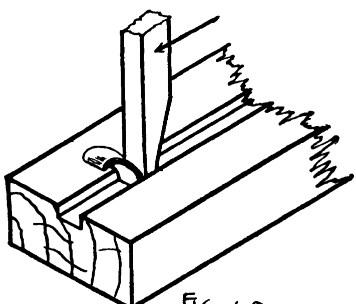
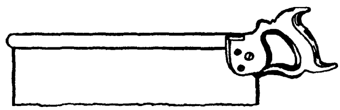


Fig. 40.

Tenon Saw.—The teeth of the tenon saw, Fig. 41, are, in shape, similar to those of the cross-cut saw. There are about sixteen teeth to an inch, and their smallness, together with the thinness of the blade, renders the saw suitable for very delicate work. A steel or brass back is necessary to enable the saw to withstand the thrust when in use.



TENON SAW FIG. 41.

Bow Saw.—The bow saw consists essentially of a narrow steel blade, A, Fig. 42, fixed in a frame and rendered taut

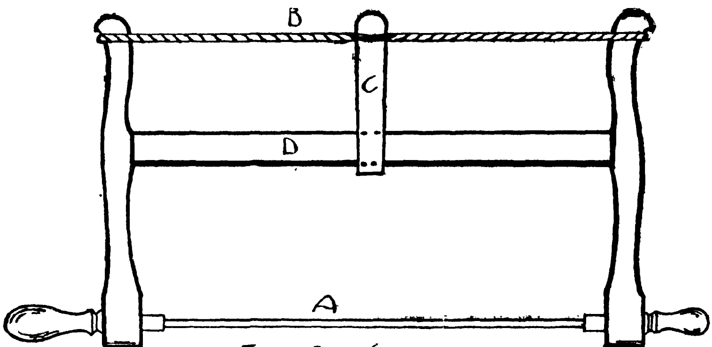


FIG. 42 BOW SAW

by the tension of the twisted string B, which is held by the slip C.

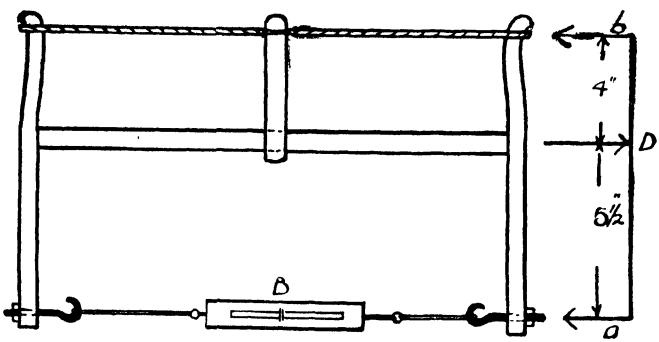


FIG. 43

The spreader D will be subject to a compressional stress due to the tension of the string and the saw. These stresses may be measured by fixing one or two strong balances in the place of the saw and string. If the spreader were half way between the string and saw, the stresses in the latter would be equal.

If in the experiment the balance B, Fig. 43, reads 25 lbs.

$$\text{Then } b \times 4 = a \times 5\tfrac{1}{2}$$
$$b \times 4 = 25 \times 5\tfrac{1}{2}$$
$$b = \frac{25 \times 5\tfrac{1}{2}}{4}$$
$$= \frac{137 \cdot 5}{4}$$
$$= 34 \cdot 375$$
$$\text{And } 34 \cdot 375 + 25 = 59 \cdot 375 \text{ lbs.}$$
$$= \text{total stress on spreader.}$$

ABRADING TOOLS—*Rasps, Files.*—The object of the use of abrasives is to put a fine finish on the work. They scrape or wear off the uneven portions of wood in a granular state by the incision of numerous minute scratches.

Rasps and woodworkers' files are made generally half-round in section and in different lengths. The rasps are coarse cutters, and to some extent may be used for shaping the work, though of course this is not their primary object.

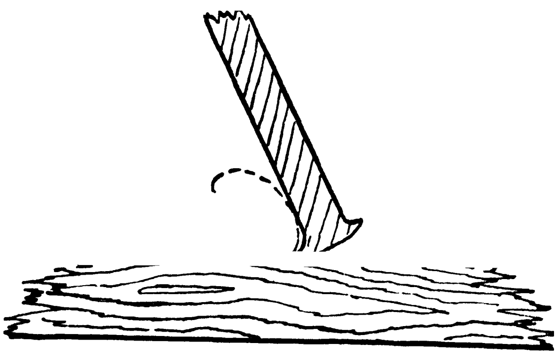


FIG. 44.

Scrapers are thin plates of spring steel, about 4 or 5 ins. long and 2½ ins. wide. Sometimes a piece obtained from a disused saw answers very well.

The scraper is "set" by rubbing the edge on an oilstone and then working the edges over, generally with the convex side of a gouge, as shown in Fig. 44. The action of the scraper is to cut away the wood in very fine shavings, but if the keenness of the cutting-edge is not maintained, it is reduced to a scraping or abrading action.

Glasspaper.—Glasspaper is made by glueing the surface of strong paper and covering with ground glass. There are various grades, number 0 is the finest, and the numbers advance up to 3, which is the coarsest.

Glasspaper, though not really a tool, is one of the most important abrasives used. It is usually wrapped close to a piece of cork, which is the best kind of rubber.

OILSTONES. — *Arkansas* and *Washita* oilstones are fine-grained white sandstones. They are obtained near hot springs in the State of Arkansas, North America. The Arkansas stone is very fine grained and slow cutting, but produces a fine keen edge.

The Washita stone is more generally used than the Arkansas. It is cheaper, coarser in grain, and more rapid in cutting.

Charnley Forest. — A stone obtained from quarries in Leicestershire. It is grey in colour and sometimes has red streaks. A moderately fine edge can be produced with the stone, and it has found much favour amongst users.

Turkey Stones.—The best quality is an excellent stone. It has a fine close grain, and produces a fairly fine edge with comparatively little pressure.

Canada Stones.—This is a sandstone of fine grain, but rather porous, and it wears away rather quickly.

The abrading action of oilstones depends upon the particles of silica (the chief constituent of all sandstones), and these are easily rendered useless by allowing oil to remain on the surface too long, or by using thick oil. "Sweet" oil, sperm and neats'-foot oil are the best. The surface of the stone should be kept clean and as straight as possible. It may be necessary to grind down inequalities from time to time, and this may be done on the side of a grinding stone.

Carborundum Oilstones have come into more general use of late. Carborundum is a carbide of silicon and is considered to be one of the hardest of abrasive substances. It is made in specially constructed electric furnaces where the mixture, which contains salt, soot, sand, and sawdust, is subjected to a very high temperature. Various kinds of binding materials also come in the mixture, such as shellac, glue, rubber, etc.

These stones are fast-cutting and will, no doubt, be used more when they are better known.

GRINDSTONES.—The grindstone best suited for woodworking tools is moderately soft and fairly fine-grained. A good stone for the purpose is quarried rather extensively at Bilston in Staffordshire.

Water should be supplied to the surface of the stone in order to prevent the heating of the iron by friction, which would, of course, injure the temper of the steel. A drip feed can be arranged by having a vessel containing water fixed above the stone, the supply being regulated by means of a tap. If the stone has a trough frame, the water can be placed in the trough for the stone to run in, the surface being kept constantly wet. The water should not be allowed to remain in the trough when the stone is not in use, on account of the softening effect and the consequent irregular wearing of the stone.

The speed of the grindstone should not be such as would cause the water to be thrown from its face. It should have a surface velocity of from 600 to 1,000 ft. per min.

A 3 ft. diameter power-driven stone running at 65 revs. per min. would have a surface velocity of

$$3' \times 3.1416 \times 65 = 612.6 \text{ ft. per min.}$$

Carborundum wheels are coming into use for grinding purposes, especially for small tools.

The abrasive action of such wheels depends upon sharp-edged particles of an exceptionally hard substance. During the operation of grinding the abrasive particles become gradually released from their cementing material and fly off the wheel, thus allowing fresh particles to act upon the steel.

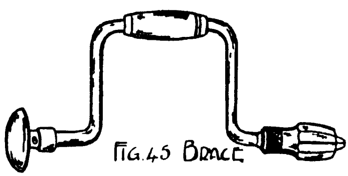


FIG. 45 BRACE

OTHER TOOLS. BRACE AND BIT.—The brace shown in Fig. 45 is the American pattern. The crank of the brace gives a leverage greatly in excess of that of the bit, and therefore the resistance caused by the cutting of the latter is easily overcome by the user. The bit is held by the jaws, Fig. 46, which close on the shank of the bit when the socket is screwed down. Some braces of this type have a ratchet arrangement, enabling the operator to bore in awkward corners where the handle of the brace cannot be turned a complete revolution.

FIG. 46

PINCERS.—Fig. 47 shows a pair of pincers which are twofold in their action, viz.: (*a*) gripping the nail, and (*b*) withdrawing it.

A mechanical advantage is obtained by the difference in

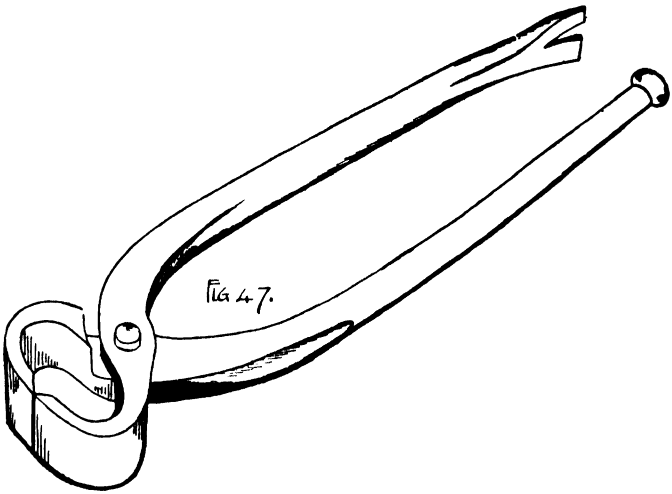


FIG. 47.

length of the power arm and the resistance arm both in gripping and withdrawing the nail.

In principle the action is related to that of the first order of levers as shown by Figs. 48 and 49, where $P \times a = W \times b$.

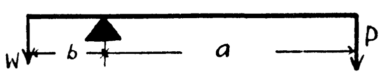


FIG. 48.

Similarly in gripping the nail, Fig. 50, where R is the pressure on the nail

$$\text{then } P \times a = R \times b$$

so that a grip of 20 lbs. by the operator would give—

$$R = \frac{P \times a}{b}$$

$$= \frac{20 \times 4}{1}$$

$$= 80 \text{ lbs.}$$

In withdrawing the nail Fig. 51 the length of the resistance arm may change during the process: assuming an average length of $\frac{3}{4}$ in. and a pressure of 40 lbs. at P,

$$\text{then } R = \frac{P \times a}{b}$$

$$= \frac{40 \times 5}{\cdot 75}$$

$$= \underline{366.6 \text{ lbs.}}$$

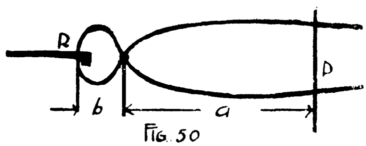


FIG. 50

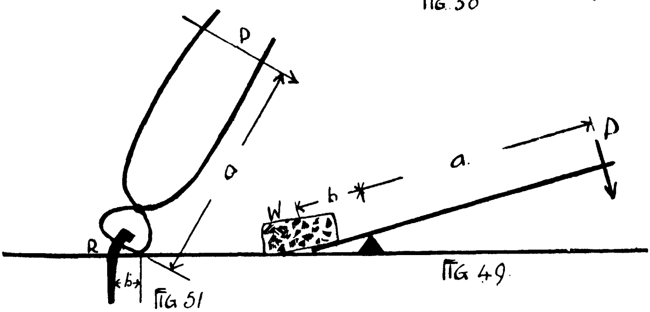
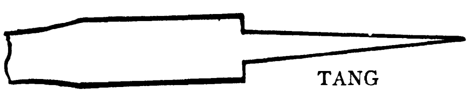


FIG. 51 FIG. 49

SCREW-DRIVER.—A London pattern screw-driver is shown in Fig. 52. It consists of a steel blade provided with a "tang" for fixing into the handle. A brass ferrule is tightly fitted on the handle and is notched to receive the shoulders of the blade.

SCREWDRIVER FIG. 52.



This prevents the blade twisting in the handle. The handle is usually made of beech, but some of the smaller screw-drivers have handles of boxwood or some other hard wood.

In its use there is a mechanical advantage which is in proportion to the width of the oval head of the handle where the turning force is applied. The centre of the driver fitting in the notch of a screw head is the fulcrum or axis of rotation, sometimes termed the line of fulcra. A plan of the screw-driver is

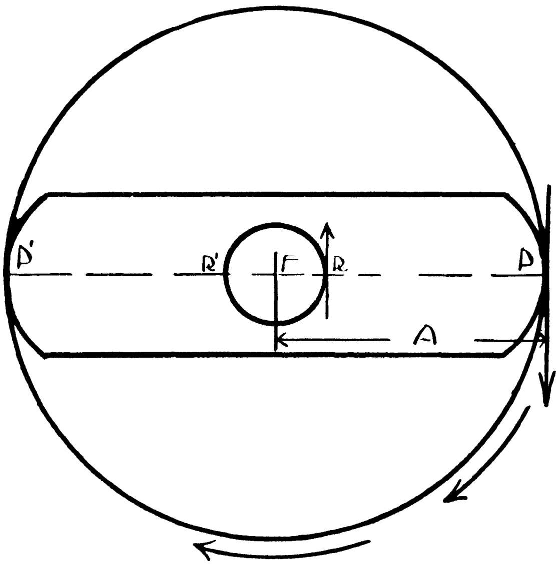


FIG. 53.

shown in diagram, Fig. 53, with the plans of the paths of the power arm and resistance arm. The diameter of the large circle is the width of the handle. In rotating the driver, the power is applied at PP^1, and the resistance acts at R and R^1.

$$\text{Hence } P \times \text{distance } PF = R \times \text{distance } RF.$$

HAMMERS AND MALLET.—Figs. 54 and 55 represent a hammer and mallet respectively. The hammer shown is that

FIG. 54

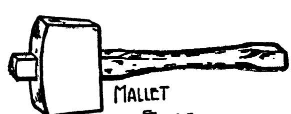
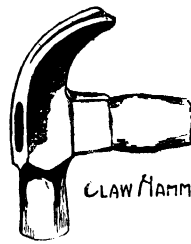


FIG. 55.

known as the Warrington pattern. In effect a blow from a mallet is totally different from that given by a hammer. The latter is faced with hard cast steel, the density of which is much greater than that of the wood of the mallet. A blow from the hammer is more or less local in its effect, particularly when it is brought into contact with wood such as a chisel handle, where the force is spent by impressing or damaging it. The mallet has more of a pushing action, the energy of which is more conserved and is delivered gradually.



CLAW HAMMER. FIG. 56

Claw Hammer (Fig. 56).—This is a useful hammer, and is used for general carpentry work.

WING COMPASSES are used for marking out curved work, and for marking work by simultaneously traversing the mould with one leg of the compass and marking

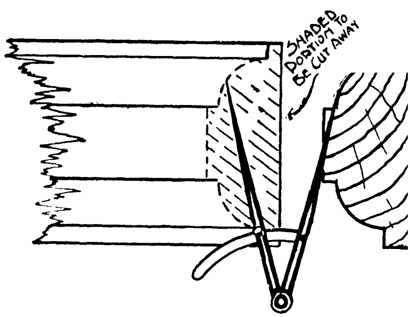
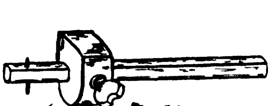
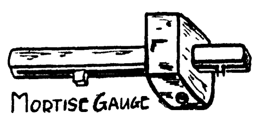


FIG. 57. SCRIBING WITH WING COMPASSES.

its shape on another piece of wood for scribing (*see* Fig. 57). The points of the legs can be held at any distance required by tightening the thumb-screw.



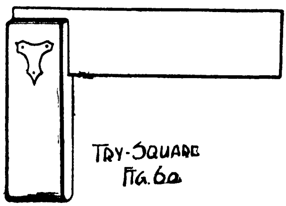
GAUGE FIG. 58.



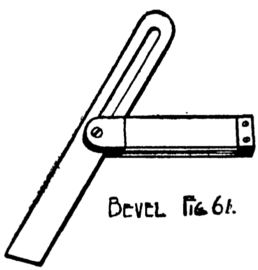
MORTISE GAUGE FIG. 59.

GAUGES.—The ordinary marking gauge and mortise gauge are shown in Figs. 58 and 59.

TRY-SQUARE AND BEVEL (Figs. 60 and 61).—Both consist of a stock and blade; the blade of the try-square is fixed in the stock at an angle of 90°, and, as its name implies, it is used for "trying" or testing the accuracy of adjacent surfaces.



TRY-SQUARE FIG. 60



BEVEL FIG. 61.

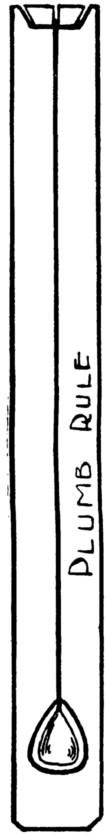
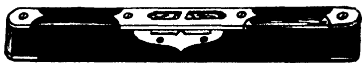


FIG. 62

The bevel may be used for the same purpose, but the blade can be fixed at any angle with the stock.

PLUMB RULE.—The plumb rule, Fig. 62, consists of a piece of wood usually from 5 ft. to 6 ft. long, and $4'' \times \frac{3}{4}''$, the edges of which are trued parallel and straight. A hole is cut through the rule as shown at the bottom, for the reception of the plumb bob, thus allowing the cord to strike the side of the rule. In testing the accuracy of upright posts or similar vertical work, the cord when hanging freely should coincide with the line marked in the centre of the rule.

SPIRIT LEVEL.—Fig. 63 represents a spirit level, which consists of a slightly curved small glass tube containing some



SPIRIT LEVEL FIG 63.

liquid such as spirits of wine or chloroform. The freezing point of either of the substances named is much lower than that of water, and chloroform is an extremely mobile liquid.

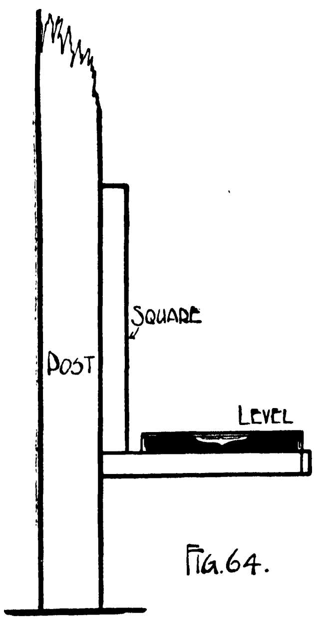


FIG. 64.

The tube is hermetically sealed and contains a bubble of air. The stock, which may be of hardwood, is cut out to receive the tube which is bedded in a mixture of plaster-of-paris and linseed oil. The tube should be fitted with its convex side uppermost, so that when the stock is level the bubble will rest

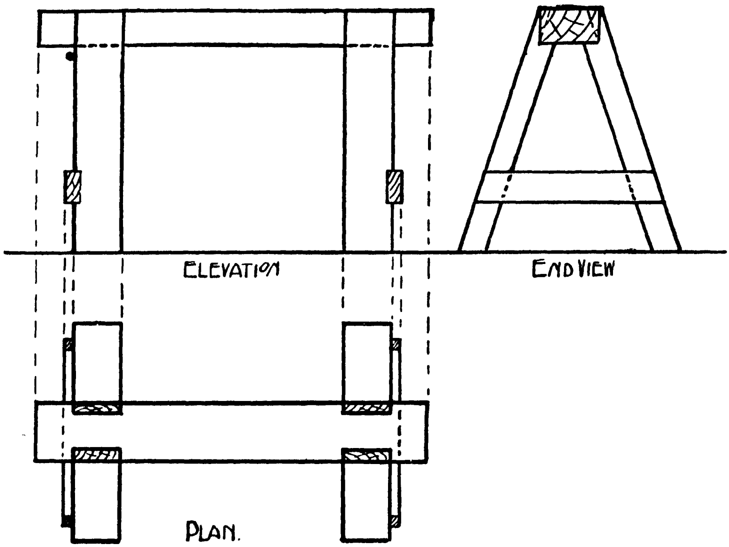


FIG. 65.

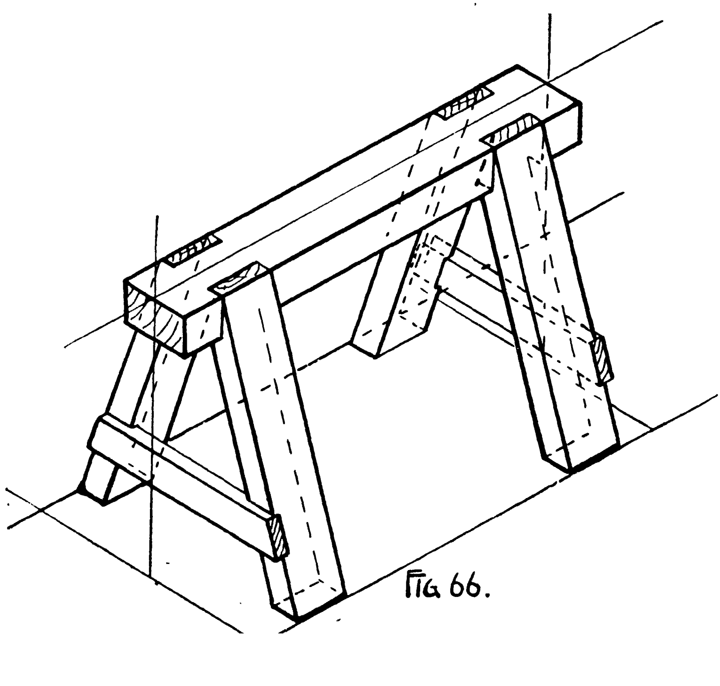


FIG. 66.

at the top of the tube; if the curvature is considerable the movements of the bubble will be rapid.

The level is used for testing the accuracy of horizontal surfaces, and may also be used in the absence of a plumb rule for obtaining the true vertical position of upright members. The method of doing this is shown in Fig. 64 where the blade of a square is placed against the upright and the level on the blade.

SAWING STOOL.—Fig. 65 represents plan, elevation, and end view of a sawing stool or trestle used for supporting timber when sawing. Fig. 66 is an isometric view of the same.

QUESTIONS ON CHAPTER II

(1) Compare the cutting action of a chisel with that of a plane iron.

(2) Splitting in wedge-shaped tools is inevitable. Discuss this statement in all its bearings; pointing out how the splitting-action may be modified in some tools.

(3) Classify the following tools according to their cutting action:—Saw, centre bit, axe, gouge, and scraper.

(4) Sketch a jack plane. Give also a section through the mouth of the plane showing the two irons and wedge in position. What is meant by "chattering," and how is it prevented?

(5) Explain fully why the angle of the cutting-iron in a rebate plane is greater than that of the smoothing plane. In what cases would it be an advantage to have the cutting-iron of the smoothing plane increased?

(6) Sketch a cross-cut saw. Explain and show by sketches the essential differences in shape and action between the teeth of the cross-cut and the rip saw.

(7) Sketch a tenon saw. Say how many teeth there are to the inch. What is the purpose of the brass or steel back? How does a saw clear itself when passing through timber?

(8) Sketch a bow saw. If the distances between the cord and the spreader, and the latter and the blade are $3\frac{1}{2}$ ins. and $4\frac{1}{2}$ ins. respectively, find the tension in the saw where the twisted cord exerts a pull of 30 lbs.

(9) Draw a pair of pincers and explain the mechanical advantage in withdrawing a nail.

(10) Sketch an American pattern brace, and explain the mechanical advantage in its use. Suppose the power applied at the handle to be 5 lbs. and a 1-in. centre bit is being used; find the amount of resistance overcome.

(11) Sketch a centre bit and auger bit. State what particular advantages there are in using the auger in preference to the centre bit.

(12) Make sketches of, and describe the following tools and their uses:—try square, bevel.

(13) Sketch the following: mortise gauge, bevel edge paring chisel, mortise chisel, and a scribing gouge.

(14) Sketch a hammer and mallet, and explain how a blow from each differs in effect.

(15) Name three abrasives and describe their action in each case.

(16) Describe the construction and use of a spirit level.

(17) A 30-in. power-driven grindstone is required to have a circumferential speed of 700 ft. per min. How many revolutions should it make?

(18) Explain the reason why water is used when grinding. Discuss the relative merits of the drip and trough feeds respectively.

(19) Is it possible to obtain a mechanical advantage in the use of a screw-driver by inclining it to the face of the work? If so, explain why; and would you prefer a long or short screw driver?

CHAPTER III

FENCING

In country districts especially, the carpenter is often required to erect fences to enclose land about to be built on.

Two plots of land of different size and shape will be considered. The first will be enclosed by a post and wire fence, and the second by a paling fence.

The following is a specification for a post and wire fence:—

Erect a post and wire fence on the north and west of site (*see* Fig. 67). The site to be 135 ft. deep and to

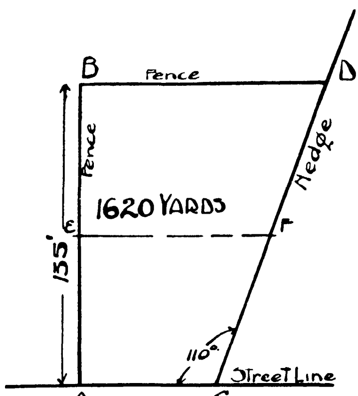


FIG. 67.

contain 1620 sq. yds. The posts to be of larch 6′ × 4″ × 4″, 2 ft. 6 ins. in the ground, and creosoted in vacuum—10 lbs. per cubic foot injected. Fix the posts at not more than 6 ft. 6 ins. apart, the corner and end posts to be properly stayed with 4″ × 4″ stays and proper stakes driven in ground.

Run one length of galvanized solid drawn steel wire, No. 6 S.W.G., pulled taut.

QUANTITIES.—The student should draw the boundary for the plot of land to contain 1,620 sq. yds., and mark the position of the posts according to the specification.

It is assumed that CD is a hedge separating two fields, and AC is another hedge on the street line. The depth of the site or the distance from A to B = 135 ft. or 45 yds.; therefore the average width of the site or frontage is

$$1620 \div 45 = 36 \text{ yds.}$$

The distance (36 yds.) will be measured along the line EF, which is parallel to AC, and at a distance half way in the depth (AB) of the site.

It will be seen by scaling the two distances BD and AC that distance $EF = \frac{1}{2}(AC + BD)$

The boundary AB must be at right angles to the street line. It may be set off as follows:—

Measure with the tape 30 ft. AX along AC (Fig. 68). From A and X stretch two tapes or cords of the length of 40 and

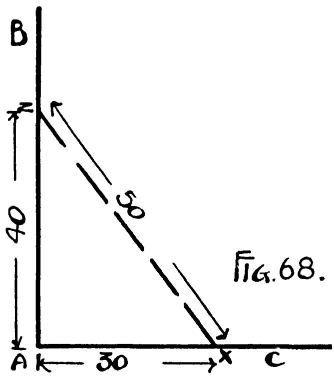


FIG. 68.

50 ft. respectively, and let them meet at Z as shown. Then AZ is at right angles to AC and gives the direction of AB, because

$$(30)^2 + (40)^2 = (50)^2$$

The distances may be modified by taking any multiple of 3, 4, and 5, as 12, 16, and 20.

In taking off the quantities the paper should be ruled as shown below. The dimensions of each post $6' \times 4'' \times 4''$ are placed in the column D, and the number of posts or the number of times the same measurement occurs (of the same thing), in column A. The product of these, *i.e.*, 41 times $6' \times 4'' \times 4'' = 27'\ 4''$, is given in column C, and this, of course represents the number of cubic feet of timber in the posts.

The quantities for the fence are as follows :—

A	D	C	
41/	6 0 4 4		
		27 4	Creosoted larch posts to fence
4/	5 6 4 4		
		2 5½	„ „ in stays.
	No. 4	4	„ „ in stakes 2′ × 4″ × 2″
	136 0	136 0	Galvanised solid drawn steel wire No. 6 S.W.G.
	132 0	132 0	„ „ „

Posts 6′ 0″
4″

2′ 0″
4″

41) 8″ = 27′ 4″

Stays 5′ 6″
4″

1′ 10″
4″

4)0′ 7″ 4‴ = 2′ 5½″ nearly

29′ 9½″

Stakes
2′ × 4″ × 2″

No. 4

No. 6 S.W.G.
Wire
136 0
132 0

3)268 0
89⅓ say 90 yds. = 26.5 lbs.

Say 30 cubic feet at 2/8 (including creosoting)	£4	0	0
4 Stakes at 2d.	0	0	8
90 yds. wire No. S.W.G. = 26½ lbs. at 12/6 cwt.	0	3	0
	£4	3	8
15% profit .	0	12	7
	£4	16	3

Timber is usually sold to the builder at so much per

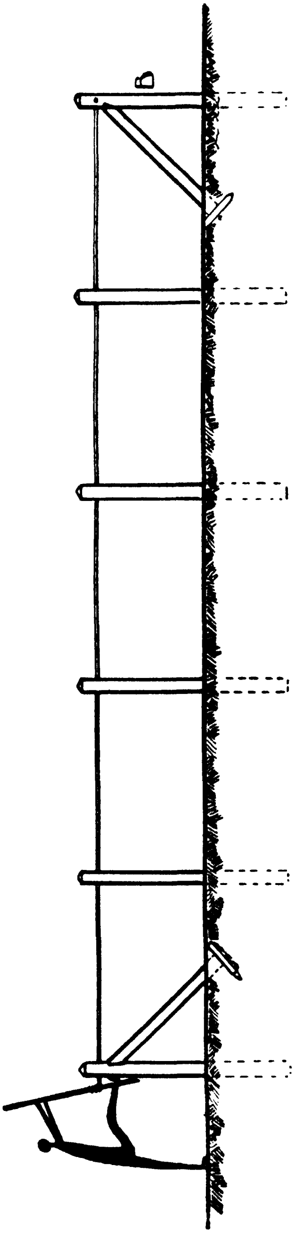


FIG. 69.

St Petersburg standard. A St Petersburg standard contains 165 cu. ft. of timber, so that our fence contains rather more than one-fifth of a standard.

The posts for the fence are $4'' \times 4''$. Suppose we require to know the number of lineal feet of this section per standard:

$$4'' \times 4'' = 16 \text{ sq. ins.}$$

and $$\frac{144}{16} \times \frac{165}{1} = 1485 \text{ lin. ft.}$$

Similarly, the number of square feet of 1-in. boards per standard:

$$\frac{144}{12} \times \frac{165}{1} = 1980 \text{ ft.}$$

Also the number of lineal feet of $9'' \times 4''$ planks.

$$9'' \times 4'' = 36 \text{ sq. ins.}$$

$$\therefore \frac{144}{36} \times 165 = 660 \text{ ft.}$$

A London standard contains 270 cu. ft.

Fig. 69 shows a length of such fencing with stays to the end posts. The wire may be pulled tight by means of a crow-bar as shown, a mechanical advantage being obtained by the difference in lengths of the power arm and the resistance arm.

Fig. 70 is a diagram of the lever, the end C of the bar pressing against the post is the fulcrum, the wire offering resistance R, is attached at B, and the power (P) applied at A.

If a pull of 30 lbs. is applied at A, the tension in the wire will be given by

Power × power arm = Resistance × resistance arm

or $P \times AC = R \times BC$

$$\therefore R = \frac{P \times AC}{BC}$$

$$= \frac{30 \times 30}{9}$$

$$= 100 \text{ lbs.}$$

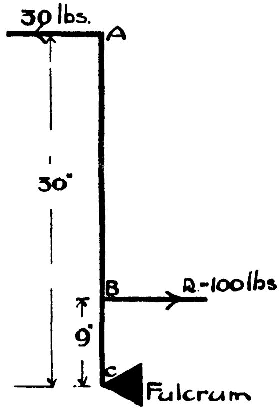


FIG. 70.

There will be certain stresses set up in both stays and posts due to the tension of the wire; but before proceeding to the examination of these stresses it will be necessary to carry out a few experiments in the laboratory or workshop.

On a table or horizontal board arrange the three spring balances (Fig. 71) so that each will be pulling away from point O.

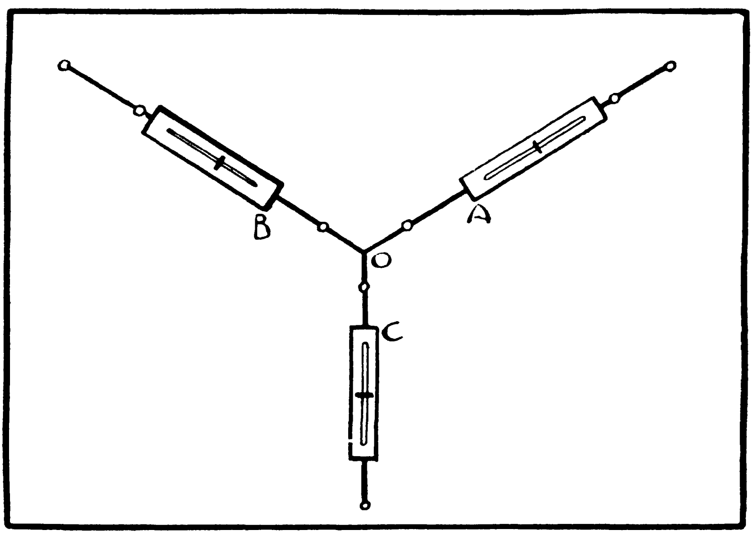


FIG. 71.

Place on the board and under the balances a sheet of drawing paper; on it mark the directions of the cords and note the amount of pull indicated by the spring balances.

Remove the drawing paper, and, assuming that the balance C indicated a pull of 6 lbs., produce CO to D (Fig. 72) using a scale of ½ in. to 1 lb. and making OD 6 units in length. Now draw DB parallel to AO, and DA parallel to BO. Then the

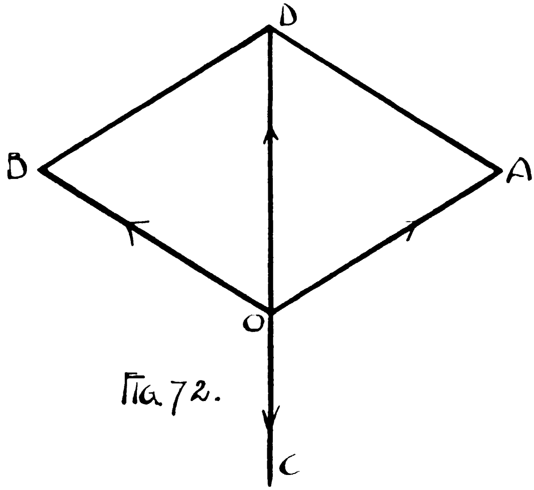


FIG. 72.

lengths of OA and OB measured on the ½ in. scale should be equal to the pull in lbs. indicated by the balances A and B respectively.

Regarded as the downward force of 6 lbs. OC is the equilibrant of the two forces OA, OB, which are acting away from point O. A force of the same magnitude acting in the opposite direction, as OD, would be the resultant of OA, OB. The resultant and the equilibrant are necessarily equal and opposite forces, for the equilibrant is the force necessary to produce a state of rest or equilibrium at the point O, and therefore it must balance the resultant of the other forces.

We have, then, the rule that where two known forces act in different directions at a point, their resultant is found by constructing a parallelogram on the lines representing the forces and drawing the diagonal through the point of application of the two forces. The length of the diagonal is the magnitude of the resultant.

The experiment should be repeated, but with the lines of action and the amounts of the forces modified.

Tabulate the results as follows:—

Magnitude of Resultant.		Magnitude of Force OA.	Magnitude of Force OB.
By Experiment.	By Drawing.		

TRIANGLE OF FORCES.—Arrange spring balances on the board as before (Fig. 71); then attach to the board a sheet of

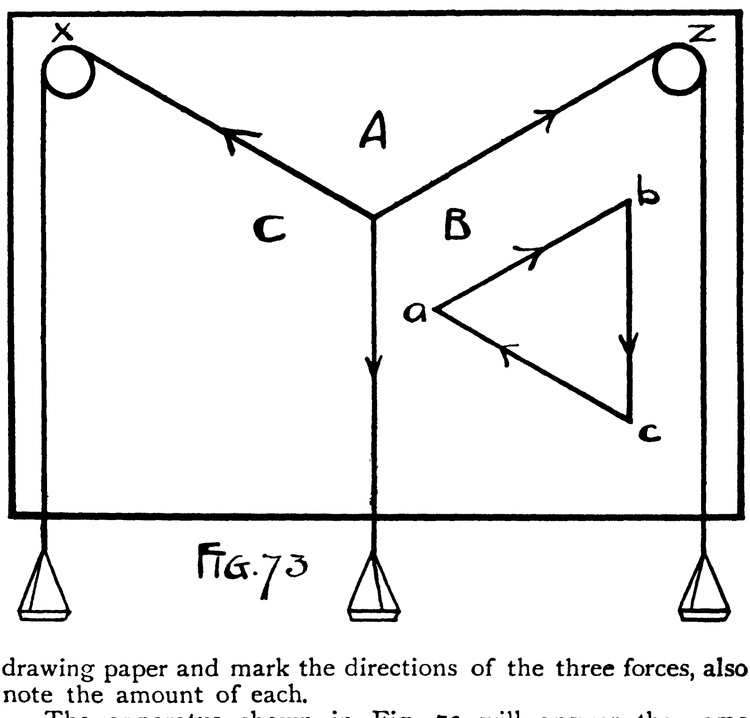


FIG. 73

drawing paper and mark the directions of the three forces, also note the amount of each.

The apparatus shown in Fig. 73 will answer the same purpose. It consists of a vertical board fixed in any convenient position with pulleys at X and Z. Cords are arranged as shown, and carried over the pulleys to scale-pans, in which weights are placed.

Letter the spaces between the forces A, B, C (Fig. 73). From any point *a*, draw a line *ab* parallel to and representing in magnitude the force AB. From *b* draw a line *bc* parallel to and representing in magnitude the force BC. Join *ca*, which should be parallel and equal in magnitude to CA. Repeat the experiment using different weights.

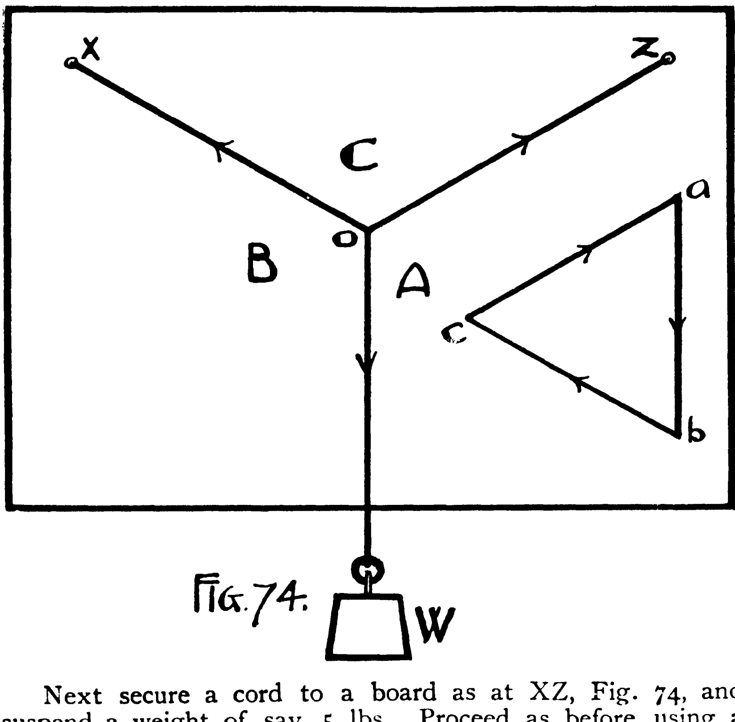


FIG. 74.

Next secure a cord to a board as at XZ, Fig. 74, and suspend a weight of, say, 5 lbs. Proceed as before, using a sheet of drawing paper. The magnitude of one force only (AB) is known, but the two forces BC and CA, Fig. 74, can be found as described above.

When the magnitude of each force is obtained, verify the results by cutting the strings and fixing spring balances between OZ and OX, keeping point O in exactly the same position.

The principle of the triangle of forces may now be stated thus: if three forces acting at a point are balanced or are in equilibrium, a triangle can be drawn whose sides are respectively parallel to and proportional in magnitude to the forces taken in order.

It will be seen that there is no real distinction between the triangle and the parallelogram of forces. The triangle is only an abbreviation of the parallelogram construction, and may be used to obtain either the resultant or equilibrant. For instance, AB, Fig. 73, may be regarded as the equilibrant of the forces BC and CA, or AB taken as a force of the same magnitude but acting in the opposite direction would be the resultant of BC and CA.

Fig. 75 is a diagram representing the wire (W), the stay (S), and the post (P). A letter is placed in each space or on each side of the forces as A, B, and C, so the pull in the wire may be denoted by AB, the stress in the stay by AC,

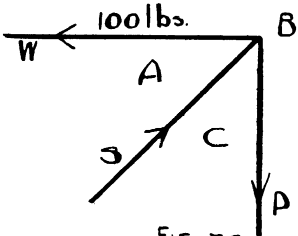


FIG. 75.

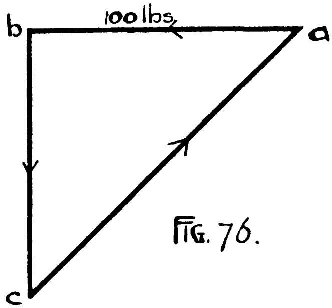


FIG. 76.

and so on. Now draw a line *ab*, Fig. 76, parallel to and representing on some scale, say, 25 lbs. to an inch, the force AB (100 lbs.) of Fig. 75; from *b* draw a line *bc* of any length but parallel to BC, Fig. 75; then from *a*, Fig. 76, draw a line parallel to AC, Fig. 75, to cut line *bc* in *c*. This completes the triangle, and reading from *a* to *b*, *b* to *c*, *c* to *a*, the direction of each force is obtained; also by scaling *bc* and *ca* the magnitude or amount of force in the post and in the stay respectively will be found.

If one stay only is used for the corner post instead of two, it will be fixed as shown in Fig. 77, and in plan and elevation by Fig. 78. The true shape of the top face of the stay is shown at A and the bevels required at B and C. The stress on the stay in this position will be found by using first the parallelogram of forces, and secondly the triangle of forces.

The two wires are pulling at right angles to each other as OA, OB, Fig. 79, and the magnitude of each is 100 lbs.

These two forces must now be resolved into one; *i.e.*, we must find their resultant, which is a force acting somewhere between the two and calculated to produce the same effect. OA and OB are drawn at right angles and each represent-

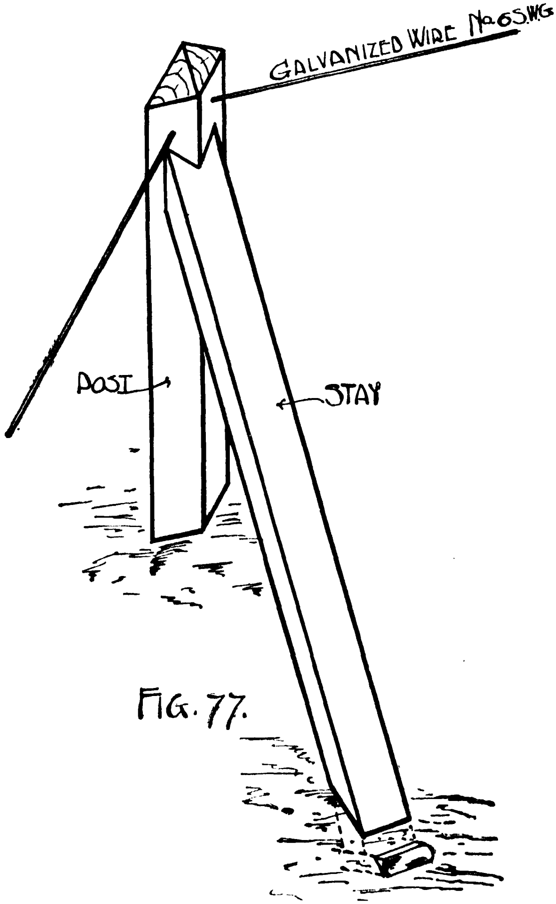


FIG. 77.

ing in magnitude, on some scale, 100 lbs.; then AC is drawn parallel to OB, and BC parallel to OA.

Now the diagonal OC is the direction and magnitude of the resultant force (R), and will equal on the same scale 141.4 lbs.

In Fig. 80 we have again the relative positions of the wire (W), post (P), and stay (S). The spaces are lettered A, B, and C, so that their order will be clockwise. The resultant pull of the two wires is given as AB. Parallel to

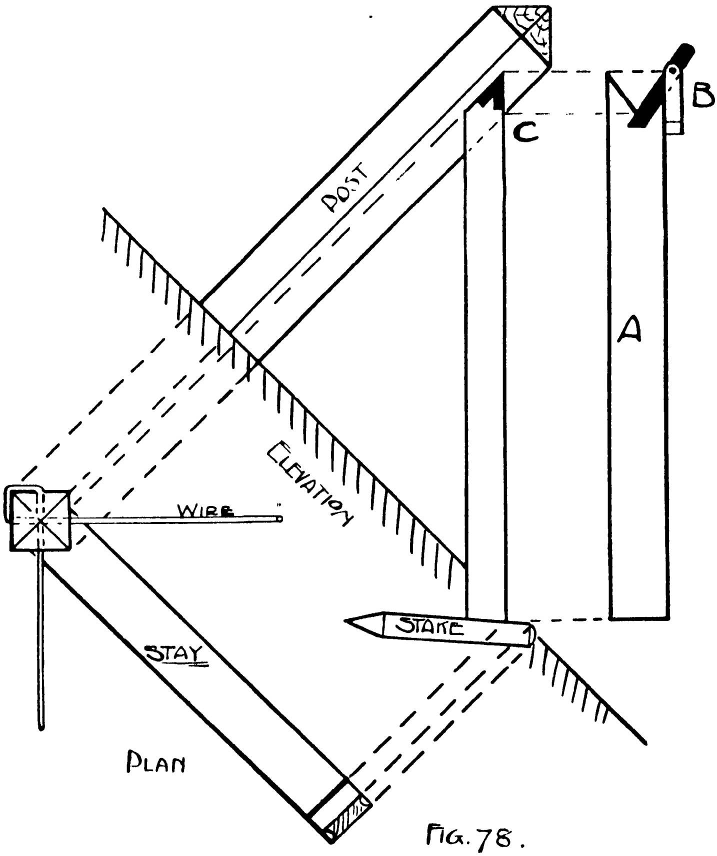


FIG. 78.

this force is drawn a line *ab*, Fig. 81, say in the same scale as before, viz., 25 lbs. to the inch, representing it in magnitude, and lettered so that the direction from *a* to *b* corresponds with the arrow on force AB, Fig. 80, and the triangle of forces is completed as shown. From this force diagram (Fig. 81) may be found the direction and amount of stress on the post and on the stay as in the case previously dealt with.

DEAL PALING FENCE—*Specification.*—The paling fence to be of deal, and to have 4″ × 3″ posts fixed at intervals of 8 ft. The rails to be triangular Δ section 5″ × 2½″, and to have 3″ × 1″ flat palings 2 ins. apart pointed at the top.

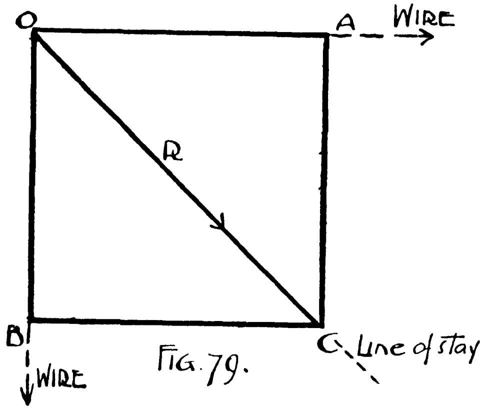


FIG. 79.

One pair of gates 3 ft. wide, with 4″ × 3″ stiles, 3″ × 2½″ rails, and 2½″ × 2½″ braces, and hung with 18-in. bands and gudgeons to 5″ × 5″ pitch pine posts.

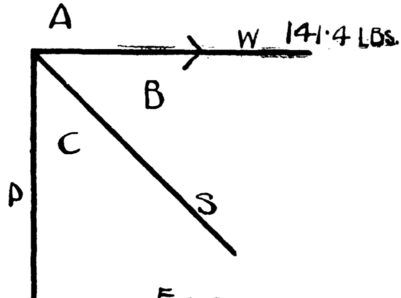


FIG. 80.

The whole of the fencing to receive three coats of good oil paint.

MATERIALS—*Pitch Pine.*—The timber for the gate-posts—pitch pine—comes from the south of North America, and is shipped from Savannah, Darien, and Pensacola. It is heavier, more dense, and more resinous than other pines or firs. Its specific gravity (*c*. chap. vii. p. 83) is 631, whereas that of red deal is about 530, and of yellow pine 435, taking water as 1000. It is straight grained, free from knots and shakes,

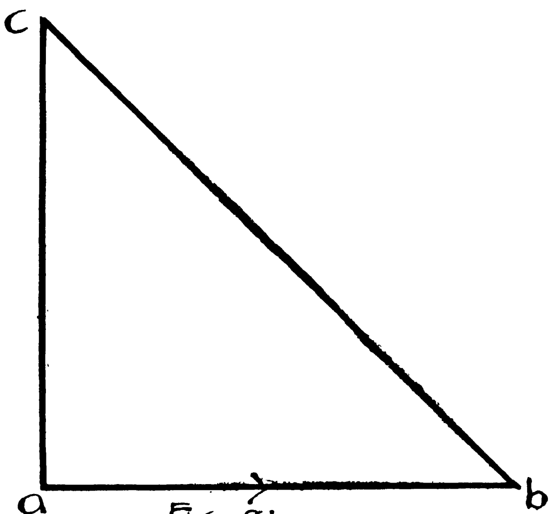


FIG 81.

and the annual rings are distinctly marked. It is used for stair treads and risers, school and church furniture and fittings, wood block flooring, doors, etc. By cutting or converting the log tangentially to the annual rings the best markings are obtained, and any irregularity in the growth will add to the effect. It is very suitable for beams, roof trusses, and structural work generally, but it diminishes slightly in strength owing to the hardening of the resin, which causes the wood to become more brittle.

Nails.—Fig. 82 is a round wire nail used for the lags.

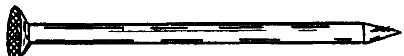


FIG 82. ROUND WIRE NAIL

The deal paling fence is to enclose a plot of land in the form of a trapezium, Fig. 83, no two of its sides being parallel.

The number of square yards enclosed can be found by dividing the figure into two triangles; the sum of their areas will represent the total area of the plot.

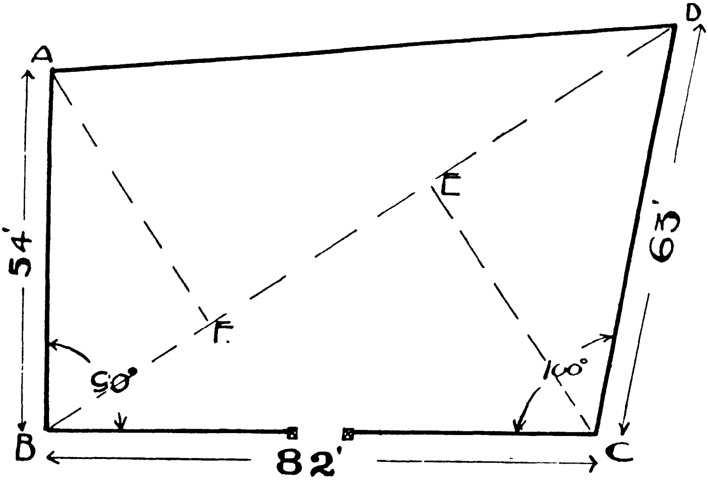


FIG 83.

Now the area of any triangle is found by the rule :—

$$\text{Area of triangle} = \frac{\text{Base} \times \text{Perpendicular}}{2}$$

Therefore the sum of the triangles ABD and BCD =

$$\text{Area of ABCD} = \frac{\text{AF} + \text{CE}}{2} \times \text{BD}$$

$$= \frac{45 + 45}{2} \times 112$$

$$= 45 \times 112$$

$$= 5040 \text{ sq. ft.}$$

$$= 560 \text{ sq. yds.}$$

CONSTRUCTION.—Fig. 84 shows the gateway and part of fencing. The rails are housed into the gate-posts and notched to the ordinary posts (Fig. 85). The rails of the gate are tenoned into the stiles (Fig. 86) or they may be housed and tenoned (Fig. 87).

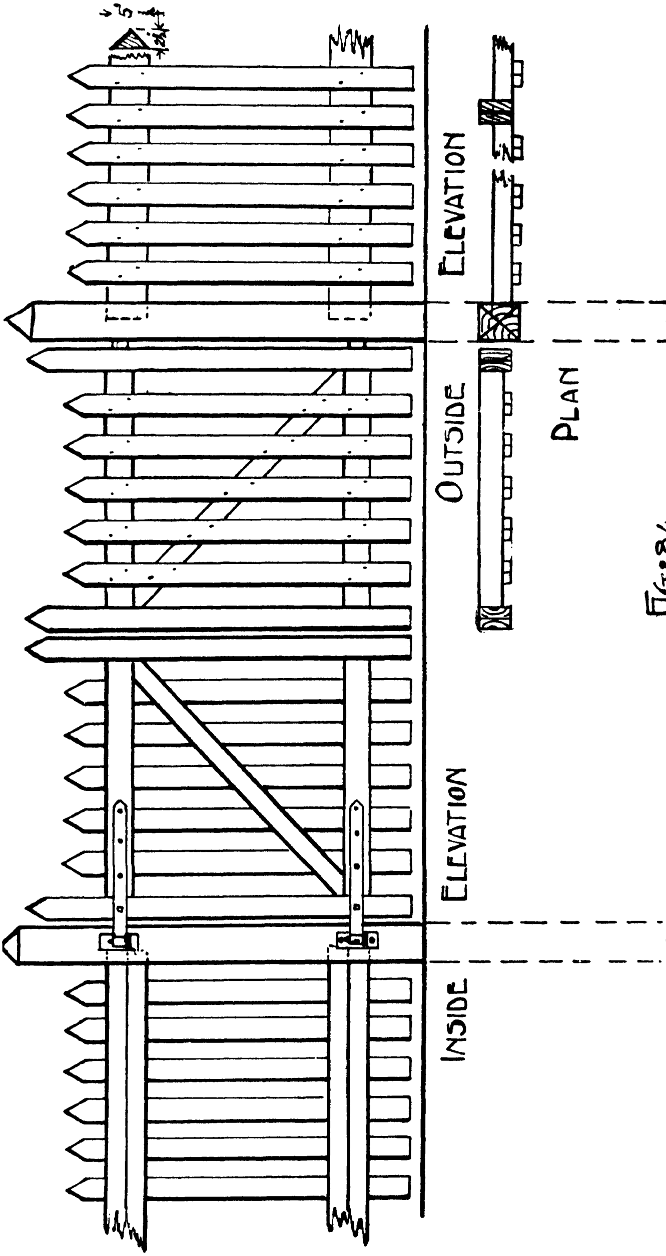


FIG. 84.

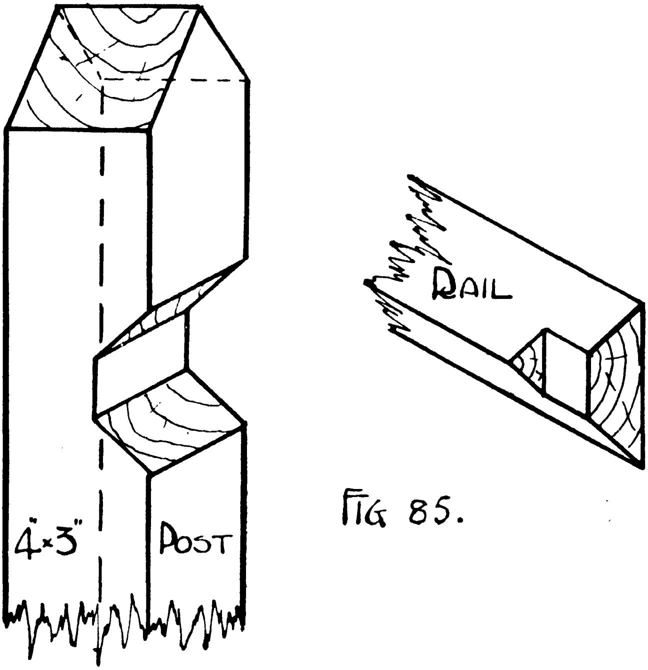


FIG 85.

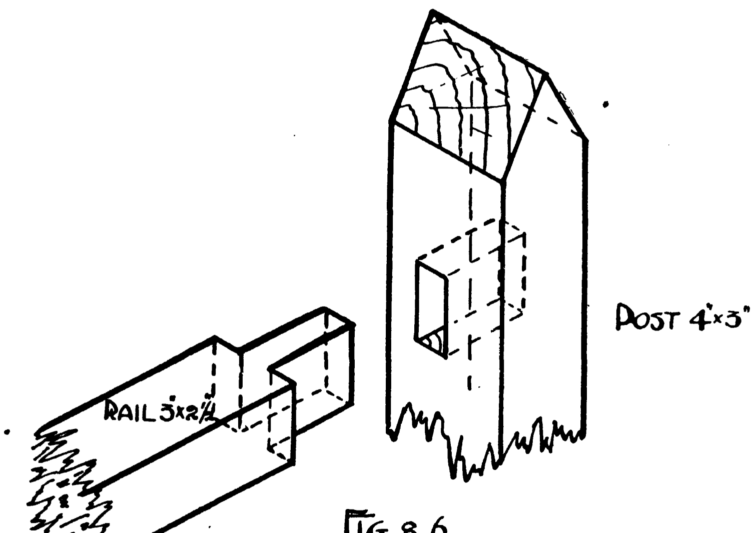
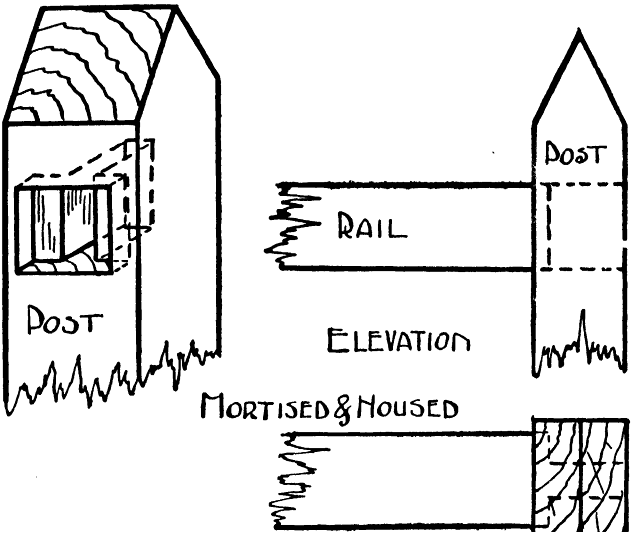


FIG. 86.

The section of the rails to the fence affords a good weathering surface; quickly carrying off the water from the top edge.



Such rails are not infrequently obtained by dividing 4″ × 3″ scantlings diagonally (*see* Fig. 88).

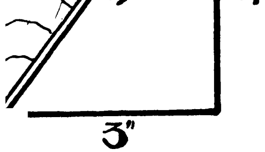


FIG. 88.

The framework of the gate is shown in diagram Fig 89. The gate will be hinged at HH, and the brace B is employed to prevent the outer portion dropping. In all cases where the members used in framing are necessarily narrow, bracing or strutting must be resorted to. By introducing a brace the

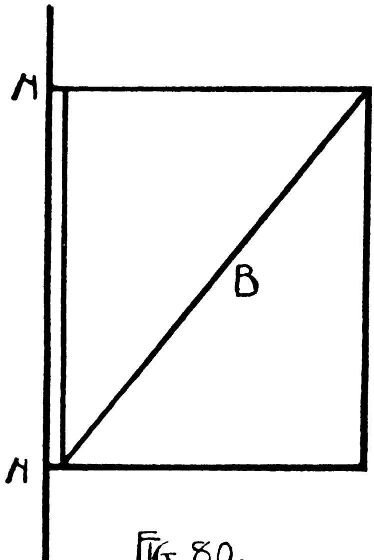


FIG. 89.

arrangement of the frame is that of two triangles, making it perfectly rigid; and the student should note that all kinds of framework intended to resist stresses will be, or should be, triangulated in design.

QUESTIONS ON CHAPTER III

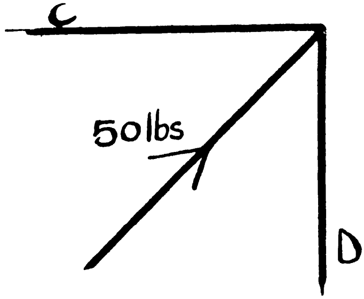
(1) Find the number of cubic feet of timber in the following :—

$$16\begin{cases}12'\ 0''\\ 6''\\ 3''\end{cases}\qquad 9\begin{cases}8'\ 0''\\ 7''\\ 4''\end{cases}\qquad 22\begin{cases}4'\ 0''\\ 6''\\ 1''\end{cases}$$

(2) How many lineal feet per standard are there of the following :— $6'' \times 3''$, $9'' \times 3''$, and $14'' \times 12''$?

(3) Find the resultant of two forces of 12 lbs. and 20 lbs. acting upon a point at right angles to each other.

(4) By the triangle of forces find the two unknown forces C and D as shown in the diagram.



QUESTION. 4

(5) How may an 8-ft. crow bar (neglecting its weight) be used by a man, whose weight is 12 stones, to move a block of stone weighing 2 tons?

(6) A room is 25 ft. 6 ins. long, 13 ft. 6 ins. wide at one end, and 18 ft. 4 ins. at the other. What is its area? (C and G, 1901).

(7) What is the area of a triangle having a base 4 metres long and an altitude of 3 metres? (C and G, 1903.)

Note.—A metre = 39.37 ins. and 2.54 cms. = 1 in.

(8) (*a*) What is the area of a regular octagon having a side 3 ft. long? (*b*) Make an irregular pentagon, and construct an oblong of equal area (C and G, 1899).

(9) Draw oblique views of a mortise and tenon joint showing the pieces separated. Sketch a band and gudgeon.

(10) Explain and show by sketches how you would find the direction of a fence which is to be at right angles to a street line.

(11) Show how you would construct a frame of a rigid form for a paling gate, and give your reason for selecting this particular form.

(12) Describe the general characteristics of pitch pine. State where it is grown, and the chief ports of shipment.

CHAPTER IV

BEAMS—THE REACTIONS OR PRESSURES ON THE SUPPORTS

MANY of the most important structures in carpentry, such as simple beams, floors, bridges, and roof trusses, have to serve the purpose of carrying weights over an intervening space. Some of the simpler of such structures will be considered in the following chapters. The design of the structures themselves and of the supports for them depends on the stresses to which the loads give rise, and the determination of such stresses must therefore be considered. In the present chapter the determination of the pressures on the supports—or as they are termed when regarded from the standpoint of the forces acting on the beam or other structure, the *reactions*—will be considered.

In chap. iii. we obtained the tension R in the wire of the fence from the equation $P \times AC = R \times BC$, Fig. 70. The product $P \times AC$ is called the moment of the force P about the point C: if P is measured in lbs. and AC in feet the moment will be in lb.-feet; if P is in tons and AC in feet it will be expressed in ton-feet, and so on. The equation expresses the fact that when the lever is in equilibrium the moment of the force P about the fulcrum is equal and opposite to the moment of the force R, or in other words, the sum of the moments of the two forces is zero. To take another illustration consider the case of a door. Let us suppose that two persons are pushing in opposition to each other at a hinged door (Fig. 90), but that A pushes at the muntin, while B pushes at the stile. Assuming that the door subject to these respective forces remains stationary, it is clear that A must have to exert more force than B, since B is further away from the hinge or fulcrum.

Suppose B pushes with a force of 80 lbs. and his distance from the hinge is 2 ft. 3 ins., then the moment of force exerted by B about the hinge $= 80 \times 2\frac{1}{4} = 180$ ft.-lbs.

For equilibrium A must exert an equal moment about the hinge, and he must push with a force of

$$\frac{180}{1'\ 3''} = 144 \text{ lbs.}$$

The principle may be expressed quite generally in the form:

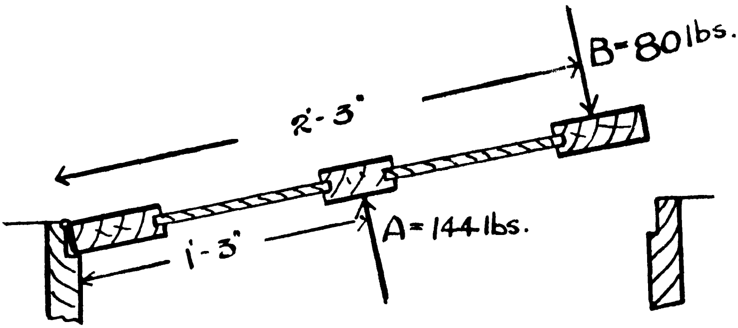


FIG. 90.

if a body is in equilibrium under any number of parallel forces, the sum of their moments about any point must be zero.

If there are only two forces, as in Fig. 91, we have—

$$W_1 \times l_1 - W_2 \times l_2 = 0$$
$$\text{or } W_1 \times l_1 = W_2 \times l_2$$

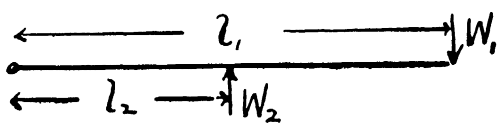


FIG. 91.

Thus in the lever of Fig. 70, p. 33, we obtain the pull in the wire by taking moments about the fulcrum—

$$30 \times 30 + R \times 9 = 0$$
$$R = -100 \text{ lbs.}$$

i.e., R is a force of 100 lbs. in the direction opposite to the pull at the top of the lever A, or we can take moments about the point of attachment of the wire B, and get the force exerted by the fulcrum.

$$30 \times 21 - F \times 9 = 0$$
$$F = 70 \text{ lbs.}$$

or finally, this result may be obtained equally briefly by taking moments about A—

$$F \times 30 - 100 \times 21 = 0$$
$$F = 70 \text{ lbs.}$$

The student should particularly notice that, for the body in equilibrium, the moments must be zero about every point.

This principle of moments may be applied in finding the reactions of variously loaded beams: for the beam is in equilibrium—the moment of all forces on it about any point must therefore be zero. In the first case, Fig. 92, it is obvious

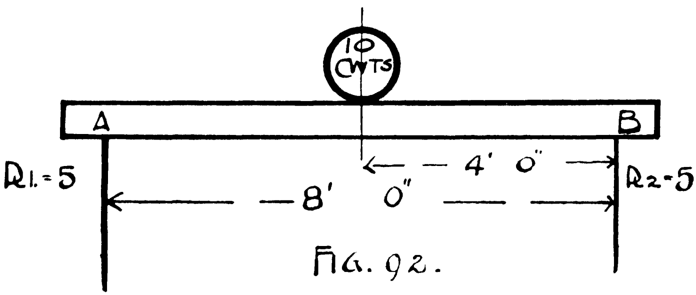


FIG. 92.

that the load being placed in the centre, half will be carried by each support, but following the process useful for more complex cases, we have, taking moments about B—

$$R^1 \times 8 = 10 \times 4$$

$$R_1 = \frac{10 \times 4}{8}$$

$$= 5 \text{ cwts.}$$

and $R_2 = 10 - 5 = 5$ cwts.

Case 2, Fig. 93. To find the reactions at A by taking moments about B.

Then $R_1 \times 8 = 10 \times 6$

$$R_1 = \frac{10 \times 6}{8}$$

$$= 7\tfrac{1}{2}$$

$$R_2 = 10 - 7\tfrac{1}{2} = 2\tfrac{1}{2} \text{ cwts.}$$

A simple piece of laboratory or workshop apparatus for finding the reactions is shown by Figs. 94 and 95, and consists

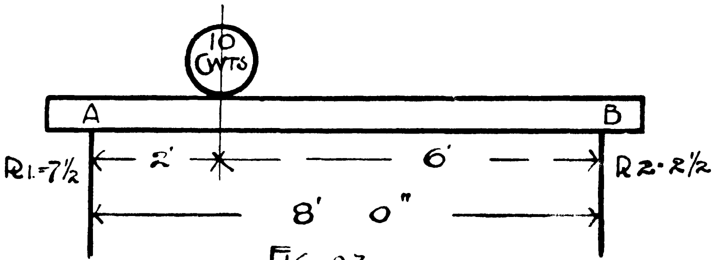


FIG 93.

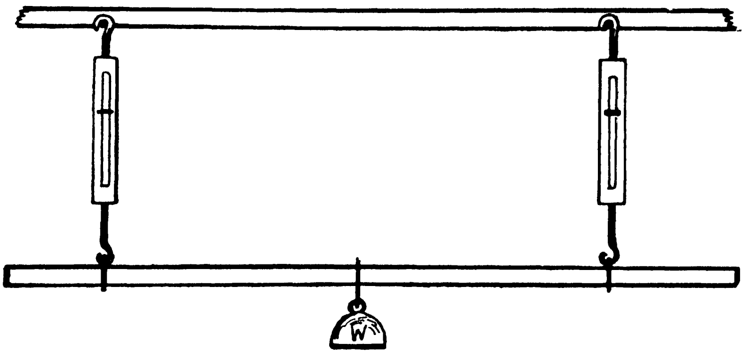


FIG. 94.

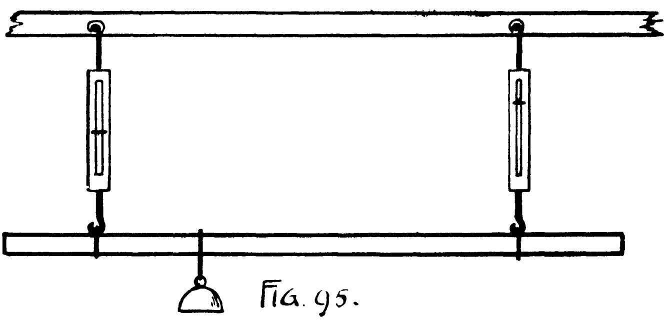


FIG. 95.

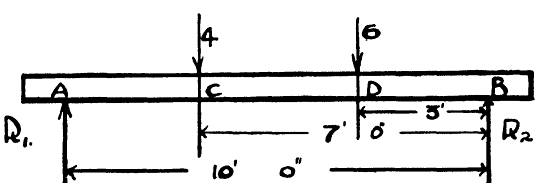


FIG. 96.

of two spring balances, a lath, and some weights; a number of experiments for beams loaded in different ways can be carried out with this apparatus.

Fig. 96 shows a beam loaded in two places, with 4 cwts. at C and 6 cwts. at D.

We shall find the reactions (*a*) experimentally as before (Fig. 97); (*b*) by the principle of moments; and (*c*) graphically.

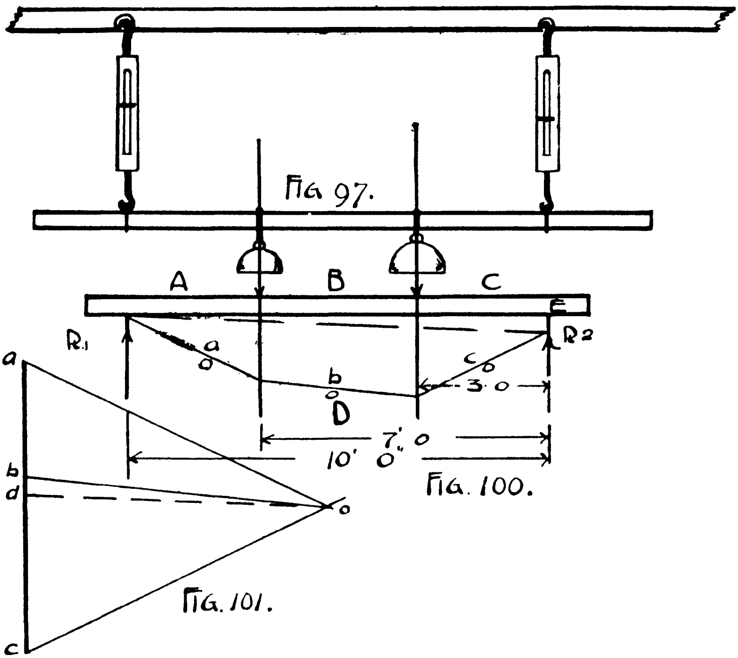


FIG. 97.

FIG. 100.

FIG. 101.

By calculation.—Taking moments about point E, Fig. 100, we get—

$$R_1 \times 10 = 4 \times 7 + 6 \times 3$$
$$= 28 + 18$$
$$= 46$$
$$R_1 = \frac{46}{10}$$
$$= 4.6$$
$$\text{and } R_2 = 10 - 4.6$$
$$= 5.4$$

By graphic statics.—The graphical method of solving these problems is quite as important as that of the method of moments.

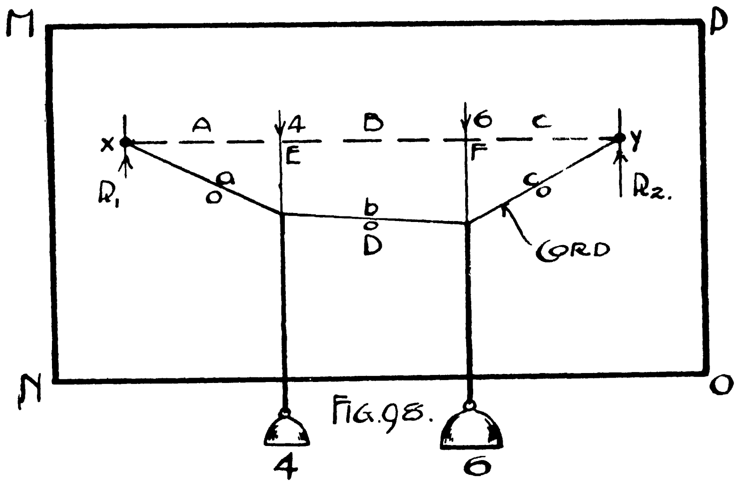


FIG. 98.

In Fig. 98 MNOD is a vertical board, on which pin a sheet of drawing paper. Secure a cord at *x* and *y* of sufficient length to enable it to take the form shown when the weights 4 lbs. and 6 lbs. are suspended in the same relative positions from the

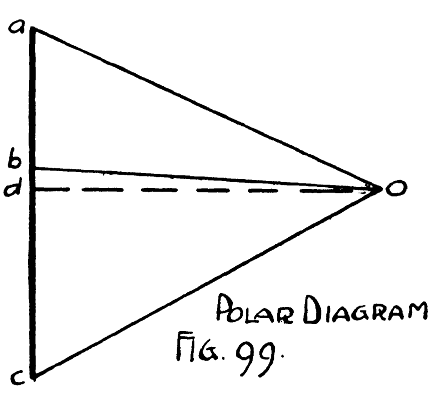


FIG. 99.

reactions, as in Fig. 97. Mark the positions of the cords on the drawing paper, which can then be removed.

Now draw a load line (Fig. 99) $ab = 4$, $bc = 6$. From *a* draw a line parallel to the cord line *ao*; from *b* a line parallel to cord *bo*; and from *c* a line parallel to cord *co*: these three lines should meet at the point *o*; then from *o* the broken line is drawn to *d*, parallel to the closing line of the polygon, which in this case is the horizontal *xy*, Fig. 98. Then *cd*, Fig. 99, is the reaction R_2, and *da* is the reaction R_1. For in the triangle of forces *oab*, *ab* represents the weight of 4 lbs., and therefore *bo oa* represent the tensions in the corresponding strings acting at the point *z*. Similarly in the triangle *odc*, *dc* represents the weight of 6 lbs., and *co ob* represents the tensions in the corresponding strings acting at the point *w*. Therefore the triangle *oad* represents the forces in action at the point *x*, viz., the tension in OA and the vertical reaction *da*.

Note that *xy* need not necessarily be horizontal.

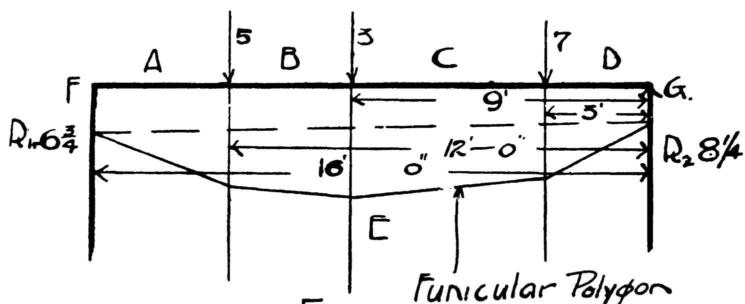


FIG. 102

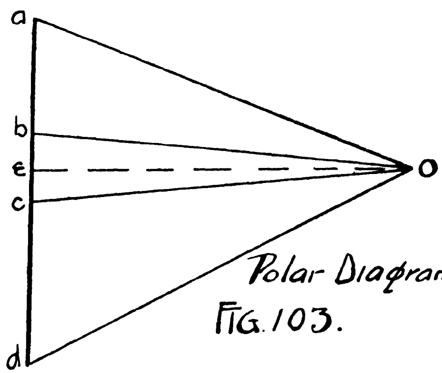
The polygon (Fig. 98) is known as the Funicular Polygon (from the latin *funiculus*, a cord), and Fig. 99 is known as the polar diagram.

Applying this method of working without the use of a cord, set off the line of loads *a*, *b*, *c*, as before (Fig. 101); fix a point *o* anywhere, and join *oa*, *ob*, and *oc*. Parallel to these draw the lines *ao*, *bo*, *co* of the cord forming the funicular polygon (Fig. 100), and close the polygon with a broken line, parallel to which draw the broken line *od* in the polar diagram, thus finding point *d*. Then we have $R_2 = cd$ and $R_1 = da$.

Fig. 102 represents a beam of 16 ft. span loaded in three places as shown. The reactions R_1 and R_2 are found graphically as before, by drawing the polar diagram (Fig. 103), and from this the funicular polygon. Then *de* is reaction R_2, and *ea* is reaction R_1.

Taking moments about G we get—

$$R_1 \times 16 = 5 \times 12 + 3 \times 9 + 7 \times 3$$
$$= 60 + 27 + 21$$
$$R_1 = \frac{108}{16}$$
$$= 6\tfrac{3}{4}$$
$$R_2 = \text{total load} - 6\tfrac{3}{4}$$
$$= 15 - 6\tfrac{3}{4}$$
$$= 8\tfrac{1}{4}$$



Polar Diagram
FIG. 103.

R_2 may be found, of course, by taking moments about F.

Then $R_2 \times 16 = 5 \times 4 + 3 \times 7 + 7 \times 13$
$$= 20 + 21 + 91$$
$$R_2 = \frac{132}{16}$$
$$= 8\tfrac{1}{4}$$

QUESTIONS ON CHAPTER IV

(1) A water cistern 5 ft. wide rests on a beam at a distance of 8 ft. 9 ins. from the left-hand support. The supports are 16 ft. apart. Find the two reactions due to the weight of the cistern.

(2) Loads of 2 and $2\frac{1}{2}$ cwts. rest on a beam at intervals of 3 ft. 6 ins. from the left-hand support. Find the reactions at the supports, graphically and arithmetically, when they are 13 ft. apart.

(3) A beam has three concentrated loads of 5, 4, and 7 cwts. at distances from the right-hand support of 2 ft., 4 ft. 9 ins., and 11 ft. 6 ins. respectively, the supports being 15 ft. apart. Find the reactions by two methods.

(4) Two concentrated loads of 3 cwts. each are placed on a beam with 4 ft. between them. The supports are 14 ft. apart, and one of them bears 0.65 of the total load. Find the positions of the loads on the beam.

CHAPTER V

WOODEN BEAMS: STRENGTH AND CONSTRUCTION

THE student should take a piece of wood about 2′ × ½″ × ½″ and place it across two supports. Load it at the centre as in Fig. 104, gradually increasing the weight until the wood breaks.

The fracture will show crushed fibres in the upper half, which has been strained under a compressional stress, and torn fibres in the lower half, where they have been strained under a tensional stress.

Where the opposite stresses meet at the centre of the depth, the fibres are without stress, or they may be said to be neutral,

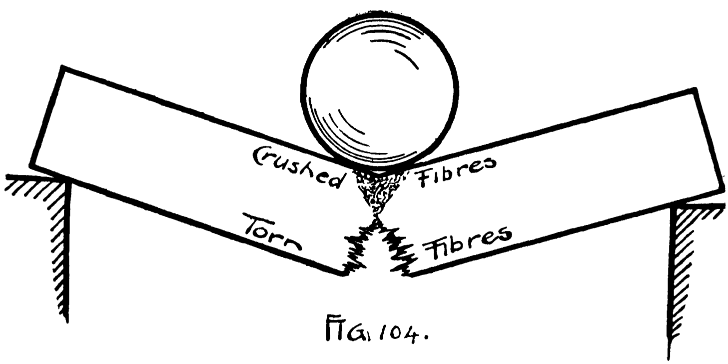


FIG. 104.

being subject to neither tension nor compression. From this fact the central fibres are sometimes termed the "neutral layer."

Further, it follows that the maximum compression and maximum tension will be at the top and bottom edges respectively. This may be seen in the actual bending of a beam. If two lines be drawn across its side as AA BB (Fig. 105) these will be seen to come nearer together at the top and further apart at the bottom, remaining approximately at their original distance in the centre, so that the distribution of stress is that represented in Fig. 106.

In connection with beams, floor joists, and other timbers which are to resist cross strains, it is useful to know how the

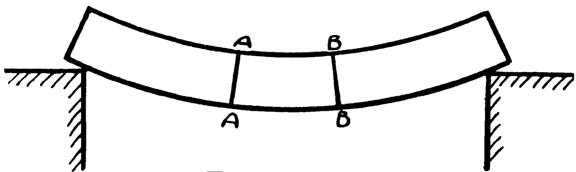


FIG. 105.

breadth, depth, and the length of span from wall to wall affect their strength.

In the laboratory or workshop the student should obtain a few pieces of wood all of equal quality, say—

1 piece 2′ 1″ × ½″ × ½″
2 pieces 2′ 1″ × 1″ × ½″

Place the piece ½″ × ½″ across two supports at a distance of 2 ft. apart and suspend a weight at the centre as before, gradually

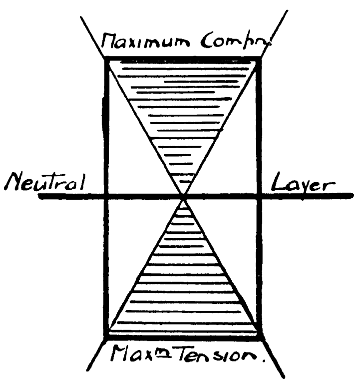


FIG. 106.

increasing it until the piece breaks. Record the breaking weight in a table such as is shown, Fig. 107. Next place one of the pieces 1″ × ½″ across the same supports, but in a flat position, so that its depth is ½ in. and breadth 1 in.; now break this at the centre and record the result as before. Deal with the third piece similarly, but let its depth be 1 in. and breadth

$\frac{1}{2}$ in., and note the weight necessary to break it. It will be seen that the different amounts required to break the pieces are in the proportion of 1, 2, 4. That is, the second is twice as strong as the first, and the third four times as strong, so that the strength varies as the breadth and as the depth squared or as bd^2, where b = breadth, d = depth.

By this rule the relative strengths of any two pieces which are intended to span from wall to wall can be ascertained. For

FIR

	DIMENSIONS	SECTION	BREAKING WEIGHT IN CENTRE	RELATIVE STRENGTHS
1.	2 FT. × ½" × ½.		30 lbs	1.
2.	2 FT. × 1" × ½"		60 "	2
3	2 FT. × ½" × 1"		120 "	4

FIG 107.

example, compare two pieces, one 5″ × 4″ and the other 6″ × 3″ in section: the breadth being 4 ins. in the first case and 3 ins. in the second.

Then (1) $bd^2 = 4'' \times 5'' \times 5'' = 100$
(2) $bd^2 = 3'' \times 6'' \times 6'' = 108$

Here the piece 6″ × 3″ is the stronger of the two, though, as will be noticed, it is the smaller in section.

Again, comparing 7″ × 4″ and 9″ × 3″—

(1) $bd^2 = 4'' \times 7'' \times 7'' = 196$
(2) $bd^2 = 3'' \times 9'' \times 9'' = 243$

Here again the smaller, viz., 9″ × 3″, is the stronger section.

The usual market sizes for floor joists are 2 ins. to 3 ins. thick, and $4\frac{1}{2}$ ins. to 11 ins. or 12 ins. deep.

Now cut the following pieces:—

1 piece 4′ 1″ × ½″ × ½″
2 pieces 4′ 1″ × 1″ × ½″

Break these as before, but over an increased span (4 ft.) and record the breaking weights in each case. Comparing them with the previous results, it will be found that the breaking weights at the centre are approximately half in each case. Longer pieces may be cut again, say 8 ft. 1 in., and the breaking weights tabulated, which in this case would be found to be one quarter of those in the table, Fig. 107.

This shows then that a beam spanning, say, 6 ft., would carry only $\frac{1}{6}$th the weight which would be carried by a beam of the same breadth and depth, but spanning 1 ft. Stated briefly, the strength of a beam varies as the breadth, as the depth squared and inversely as the length, or as $\frac{bd^2}{L}$ where

b = breadth in inches
d = depth "
L = span in feet

The strongest beam that can be cut from a log of circular section has the breadth and depth in the ratio:—

$$\frac{\text{breadth}}{\text{depth}} = \frac{1}{\sqrt{2}} = \frac{1}{1.414} = \frac{5}{7} \text{ nearly.}$$

That is to say, the breadth and depth should be approximately as 5 is to 7.

If the diameter AB is divided into three equal parts as 1 2 (Fig. 108) and lines are drawn from these at right angles to AB cutting the circumference in C and D, ADBC is the section of the strongest beam.

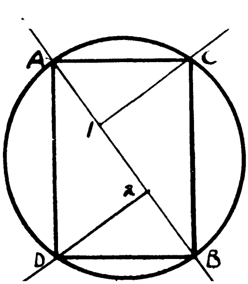


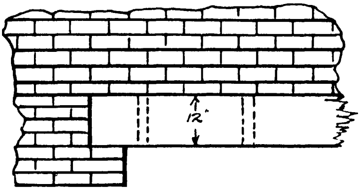
FIG. 108.

The student should cut out or mark out a number of sections obtainable from a given circular section, say, 15 ins. diameter. Then compare one with another by the formula bd^2 until the strongest section is obtained, and then see whether this agrees with the above ratio, *i.e.*, 5 is to 7.

The form of beam known as a bressummer (Fig. 109) may be described as a large lintel, and is used principally to support brickwork over large openings—say, up to 10 or 12 ft.

These beams are sometimes built up of three 9″ × 3″ planks bolted or spiked together as shown in section, Fig. 110, and in the sketch, Fig. 111, with distance pieces between to increase the breadth. The extra breadth obtained does not add to the strength, but only facilitates the carrying of walls of greater thickness than the net thickness of the three pieces.

We have seen that the strength of a beam varies as the breadth and as the depth squared (bd^2), therefore it is obvious that a greater advantage is obtained by building up to increase



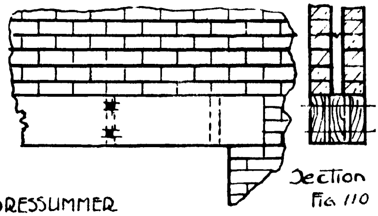


FIG. 109. BRESSUMMER

FIG. 110

the depth rather than the breadth. But a beam made up of any number of pieces forming unconnected laminations, as in

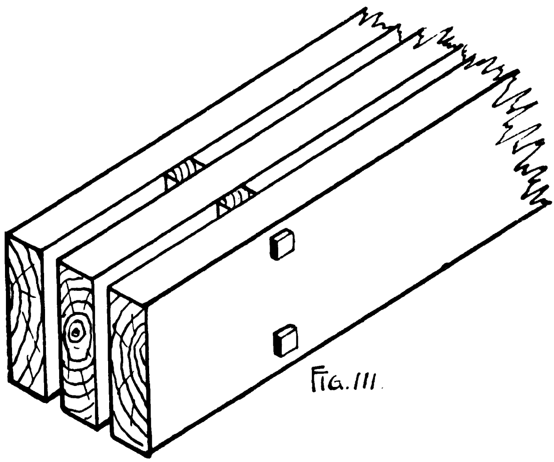


FIG. 111

Fig. 112, would have relatively little strength. One lamination would simply slide over the other, and each would act as a

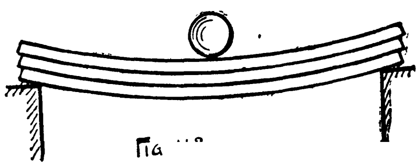


FIG. ..

separate beam. In the deflection of such a composite beam the bottom of one lamina would be in tension, and therefore tend to lengthen out, whilst the top of the one below would be in compression and tend to contract. In a solid beam this tendency is resisted by the strength of the material; *shearing stress*, as it is termed, being set up in the direction of the length of the beam.

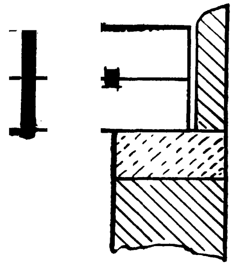


FIG 113.

The tendency can be similarly counteracted in built-up beams either by inserting keys, as in Fig. 113, or by cutting indentations, as in Fig. 114.

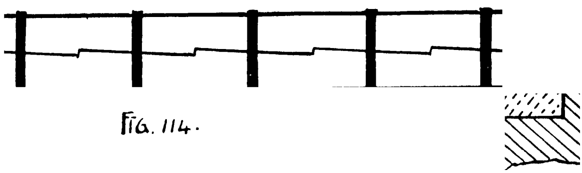


FIG. 114.

The keys may be cut in the form of folding wedges and placed about 20 to 30 ins. apart. The horizontal shearing stress is not so great near the centre of the beam as at the ends, and therefore the keys need not be so close together there.

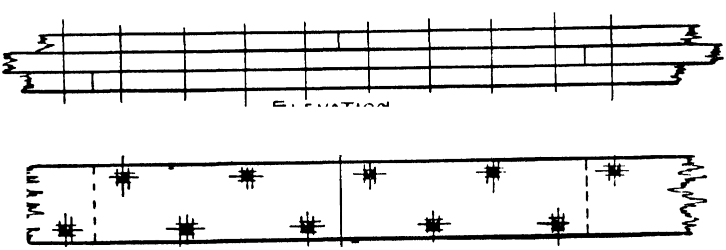


FIG 115.

The indents for the beam (Fig. 114) are about 2 ft. or 2 ft. 6 ins. long, and in depth about $\frac{1}{24}$th their length. In both beams the two pieces are held firmly together by wrought iron straps as shown.

Fig. 115 represents plan and elevation of a method of building up and lengthening, adopted very largely in the construction of ribs for temporary work, such as centring, or for booms in trussed girders.

FLITCHED BEAMS.—Where timber beams are not sufficiently strong in themselves, if a reasonable size in depth and breadth

FIG. 116.

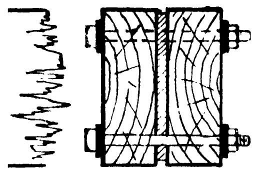


FIG. 117. SECTION

is to be retained, they can be strengthened by the use of an iron plate sandwiched between two halves of the beam and then bolted together.

Figs. 116 and 117 show part elevation and section of a flitched beam. The beam is sawn down the centre, and one

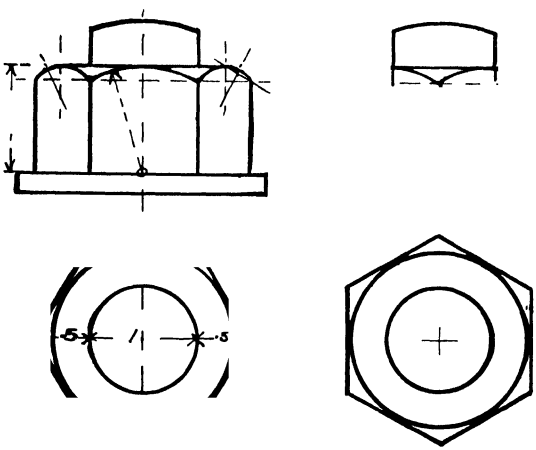


FIG. 118 · HEXAGONAL NUT · FIG. 119.

piece reversed end to end. This ensures uniformity of strength as the lower or butt end of a tree is considered to be stronger than the upper end, and the otherwise detrimental effect of merely local defects in the balk will be reduced to a minimum.

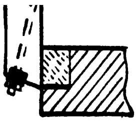
The heart of each piece is turned outside, as will be seen by the markings representing the annual rings in the section (Fig. 117). The wrought iron flitch plate should be less than the depth of the timber by about $\frac{1}{2}$ in., so that it will clear the stone templets and not ride on them should the timber shrink. The thickness of the plates will be from $\frac{1}{16}$th to $\frac{1}{12}$th the thickness of the beam. Bolts are 2 ft. apart, and placed in zigzag order and must be provided with washers beneath the nuts and bolt heads.

Plans and elevations taken with the hexagonal nut in two different positions are given in Figs. 118 and 119. The thickness of the nut is equal to the diameter of the bolt, and the distance across the nut diagonally is twice the thickness of the bolt.

TRUSSED BEAMS.—A wooden beam may be strengthened very substantially by adding a tie-rod of steel, and a strut, on its lower side, in the form of a truss. This very materially reduces the amount of cross stress on the timber by allowing the steel tie-rod to take the tensional stresses for which it is eminently suited.

The trussed beam shown in Fig. 120 and detail, Fig. 121, consists of two pieces 10" × 4", with a cast iron strut secured to the above by four coach screws (Fig. 122), and a tie-rod passing between the timbers at their ends, and there secured with nuts screwed tight against metal straps.

The effect of trussing may be seen by taking a piece of wood about 26 ins. long and $\frac{5}{8}$ in. square. About 1 in. from each end bore holes with a bradawl or gimlet. In the centre screw a piece of brass bent as shown, Fig. 123 (or use a piece of wood) to form a strut with a hole bored through at the lower end for string to pass through. Secure the string, but not quite taut, and then place the beam on two supports, gently load at the centre and note the result. It is evident that the string is under a tensional stress and the



strut and timber beam under a compressional stress—though the latter will to some extent be subject to a cross stress also.

FIG. 121.

If the trussed beam be assumed to be carrying a load of 4 tons at the centre, the stresses on the members can be found graphically as follows.

COACH SCREW FIG. 122.

Fig. 124 represents a line diagram or frame diagram of the beam, and the spaces between the forces and members are numbered—

Force 1—2 = 4 tons.
" 2—3 = 2 "
" 3—1 = 2 "

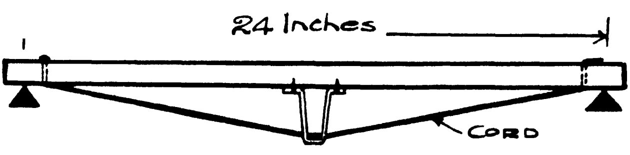


FIG. 123.

and these together make up the load line (Fig. 125). The stress diagram is completed from this as shown, commencing at the joint A, and drawing the triangle of forces, as 1—4, 4—3, 3—1 (Fig. 125). Each of the remaining joints is dealt with similarly.

The arrows affixed to each member of the frame diagram (Fig. 124) show the directions of the forces acting on each

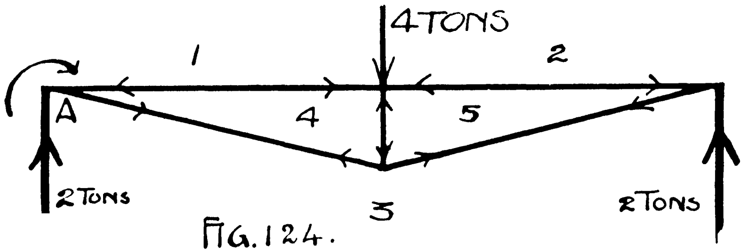


FIG. 124.

joint of the frame owing to the stresses set up in the members due to the external loading or forces. The nature

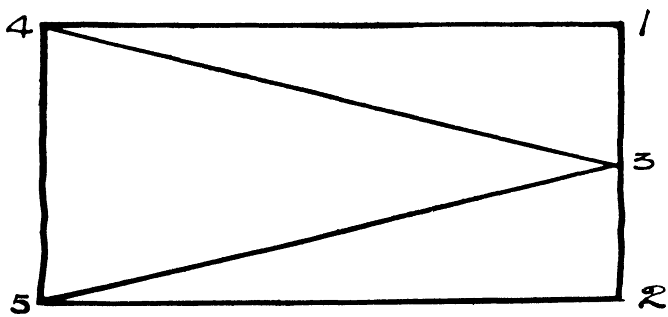


FIG. 125.

of these stresses and the amounts or magnitudes are tabulated below :—

BAR	COMPN.	TENSION
1-4	8·6	——
2-5	8·6	——
4-5	4	——
4-3	——	8·8
5-3	——	8·8

The length of the strut in such beams may vary according to circumstances; sometimes it is not convenient to have it so long as is represented in Fig. 120. In the event of a short strut being used a block of wood will act in place of the cast iron strut (*see* Fig. 126), but it should be observed that such

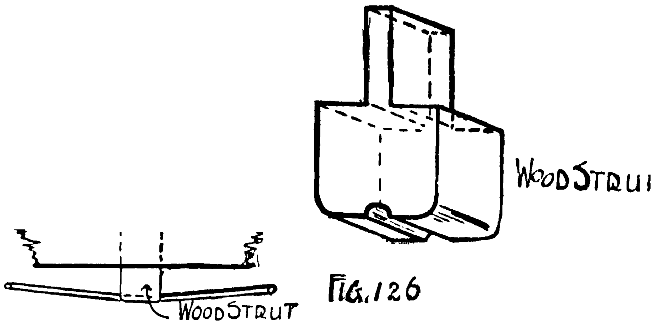


FIG. 126

a shortening of the strut places a greater tensional and a greater compressional stress on the tie-rod and beam respectively. The student may substantiate this by working examples.

QUESTIONS ON CHAPTER V

(1) Explain and illustrate how you would conduct an experiment to find the breaking weight of a piece of fir 1″ × 1″ over a span of 12 ins.

(2) Other conditions being equal, can you show that a piece of wood 14″ × 8″ is stronger than a piece 12″ × 10″ when used for beams?

(3) Find the number of cubic feet of timber in a log 22 ft. long, 15 ins. diameter at one end and 18 ins. at the other. Draw a section to show the strongest section obtainable from this log, and calculate the number of cubic feet it contains.

(4) Show how you would strengthen a wooden beam 20 ft. long, 12″ × 8″ without trussing. Give details of all metal work used.

(5) Show two methods of building up wooden beams to increase their depth. How may the beam fail if not properly designed? Why would you increase the depth rather than the breadth where strength is the chief consideration?

(6) A trussed beam for a span of 28 ft. has a strut 3 ft. long. A load of 3 tons is placed at the centre. Find the nature and amount of the stresses in the members.

CHAPTER VI

JOINTS FOR LENGTHENING LARGE TIMBERS

THE difficulty and expense involved in obtaining very long pieces which are sometimes required for members in roof trusses and trussed girders of large spans, necessitates the use of two or more pieces jointed together. In designing the joints for such members the possible stresses which may be placed upon them should be taken into consideration. To resist a tensional stress the two pieces to be joined may be hooked together in some way. To resist a compressional stress the maximum of abutting surface at right angles to the pressure should be secured. Prof. Rankine suggests that the joints should be cut so as to weaken, as little as possible, the timbers that they connect, and in order to distribute the

FIG. 127 FIG. 128.

pressure equally all adjacent surfaces should be accurately fitted. Accurate fitting, of course, depends upon workmanship, but at the same time, the possible shrinkage of the timber after the work is finished and put in position should be considered.

It will be seen from chap. i. p. 4, that planks sawn from the log as Fig. 127 will shrink much more in width than those cut as in Fig. 128. The effect of shrinkage is shown in the joint, Fig. 129, where one piece (A) has been affected. Fig. 130 shows the lengthening of a beam by means of a lapped joint. The two pieces are bolted together, and hardwood keys with the grain running across the joint are inserted

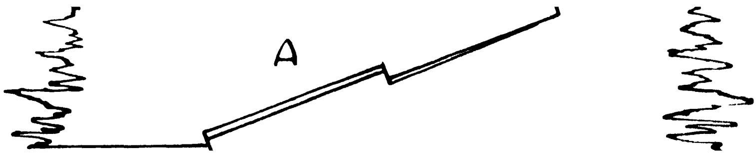


FIG. 129.

to help the bolts in resisting the tendency for one piece to slide over the other. The lapped joint is, however, more

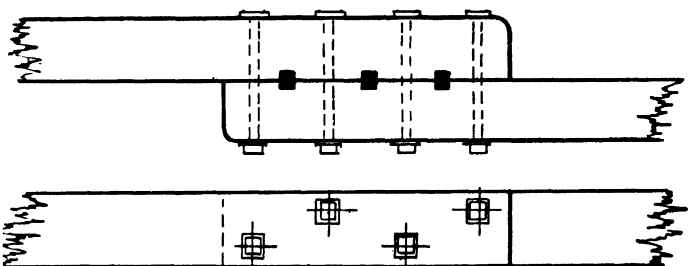


FIG. 130. LAPPED JOINT

generally used to resist cross strains, for which purpose it is better adapted.

In Fig. 131 the two ends are secured by fish plates

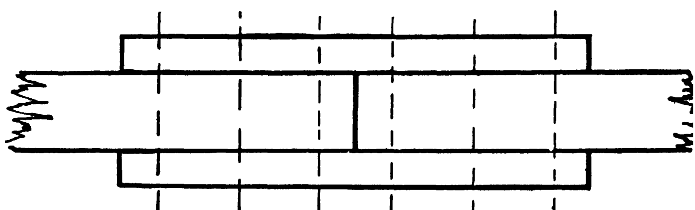


FIG. 131. FISHED JOINT

and bolted through. The combined depth of the plates should equal the depth of the pieces joined. This joint and the next one, Fig. 132—a scarfed joint—are suitable for resisting compression and cross strains. A raking scarf, as Fig. 133, is considered to be capable of resisting cross strains well.

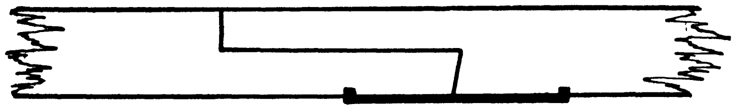


FIG. 132.

Fig. 134 is a raking scarf with folding wedges and is suitable for tension and cross strains.

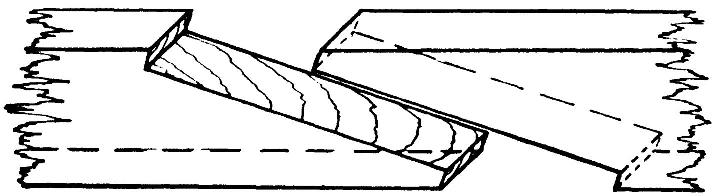


FIG. 133. RAKING SCARF

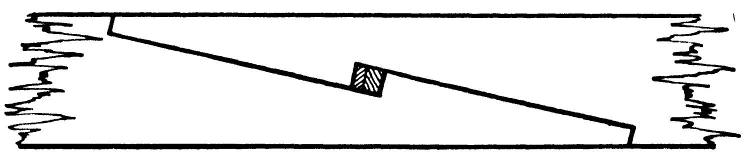


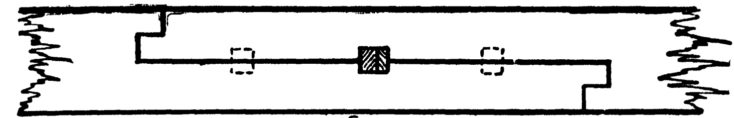
FIG. 134.

Fig. 135 is a scarf suitable for both tension and compression, though for tension two more hardwood keys fixed across the joint would be necessary.

Fig. 136 is a tabled joint suitable for tension and compression.

The joints here dealt with may be, and are mostly, strengthened by the use of steel or iron fish plates bolted through as in Fig. 132. Joints under cross strains should be provided with such plates to take the tensional strain at the under side, and it is an advantage to turn the ends of the plate at right angles into grooves as shown in the same figure.

The length of the scarf and other proportions are determined according to the relative strengths of timber in compression, tension, and, where it applies, to the ability to resist a shearing



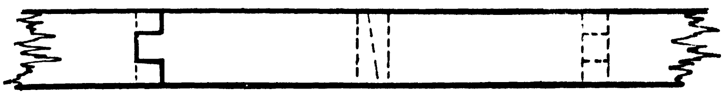
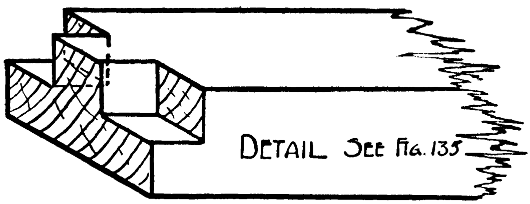


FIG. 135. PLAN



force along the grain or what is known as detrusion. The safe resistances for fir are :—

Compression per square inch.	Tension per square inch.	Shearing per square inch.
10 cwts.	12 cwts.	1.3 cwts.

In the tabled joint, Fig. 136, where, for a tensional stress on

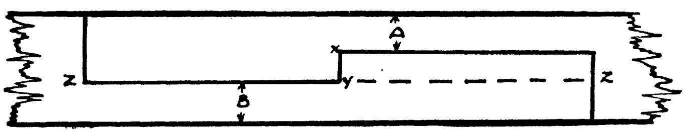


FIG. 136.

the beam, the portion *xy* would be subject to compression, and distances A and B would be subject to tension, the distance

A is to *xy* as 5 is to 6
or $A : xy :: 5 : 6$

and if the total depth were 8 inches,

$$\text{then } A = 2\tfrac{1}{2}'' = 5 \text{ parts}$$
$$B = 2\tfrac{1}{2}'' = 5 \quad ,,$$
$$xy = 3'' = 6 \quad ,,$$

Also the distance yz is to A as 10 is to 1

$$\text{or } yz : A :: 10 : 1$$

$$\therefore yz = 10 \times 2\tfrac{1}{2} = 25 \text{ ins.}$$

Total length of scarf $= 25 \times 2 = 50$ ins., or rather more than 6 times the depth of the beam.

The scarf should be further strengthened by plates and bolts.

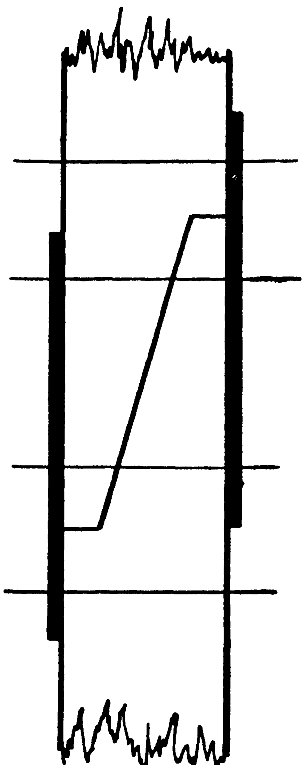


FIG. 137.

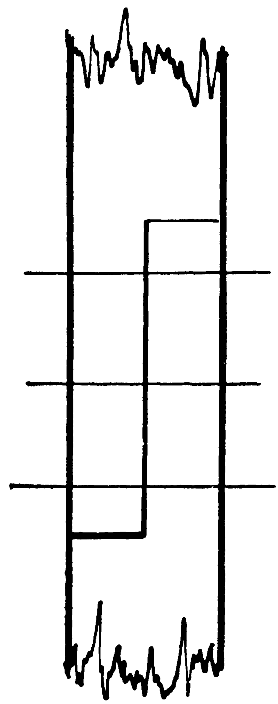


FIG. 138.

JOINTS FOR LENGTHENING POSTS.—Figs. 137 and 138 represent suitable joints for the lengthening of posts, and the arrangement shown in Fig. 129 is very often used in joining purlins and ridge pieces at the principals.

QUESTIONS ON CHAPTER VI

(1) Draw two scarfed joints suitable for connecting two pieces for both tensional and cross stresses, and include any necessary metal fastenings.

(2) How would you arrive at the length of a scarf used in joining two pieces together? What is meant by "detrusion"?

(3) In what cases would you use a raking scarf in preference to a tabled joint? Give your reasons fully.

(4) Design a joint suitable for resisting a cross stress. If metal is used in the form of plates, say what stresses they will be called upon to withstand, and explain and illustrate how they may be used to the best advantage.

(5) The shrinkage of two pieces joined by a scarf may affect the efficiency of the joint very materially. What precautions would you take to prevent this?

CHAPTER VII

RAISING BEAMS BY MEANS OF PULLEY BLOCKS

RAISING A TRUSSED BEAM.—Heavy beams, girders, roof trusses, etc., may be raised by placing one or more poles secured by guy ropes in an almost upright position, as Fig. 139. A set of treble-sheave lifting blocks is secured near to the top of the pole (though in the case illustrated double-sheave blocks would be ample), and to the beam at the lower end.

Assume the trussed beam to be 32 ft. long, and to have 2 oak flitches 12″ × 8″, 1 oak strut (*see* Fig. 140), and 1 tie rod and plates.

To find the approximate weight of the beam, we must first obtain the number of cubic feet of timber.

2 pieces 32′ 0″ × 12″ × 8″ =

32 0
8
2)21 4 = 42 8

Strut part A. 13″ × 12″ × 1½″

1 1
1 0
1 1
1 6
1 1
6 6
1 7 6

1 7 6

Carry forward 42′ 9″ 7‴ 6⁗

Brought forward 42′ 9″ 7‴ 6⁗

Strut part B. 13″ × 13″ × 3″

```
1  1
1  1
------
1  1
   1  1
---------
1  2  1
   3
---------
   3  6  3
                    3  6  3
```

Strut part C (a truncated pyramid).
3′ long, 13″ square at base.
6″ „ lower end.

The average of the two ends =

$$\frac{13+6}{2} = 9\tfrac{1}{2}''$$

Cubic contents = 3′ 0″ × 9½″ × 9½″

```
3  0
   9  6
---------
2  3
   1  6
---------
2  4  6
   9  6
------------
1  9  4  6
   1  2  3
------------
1 10  6  9
                  1 10  6  9
                 ---------------
                 44′ 11″ 8‴ 6⁗
```

Say 45 cu. ft.

Weight of English oak = 50 lbs. per cubic foot.

45 × 50 = 2250 lbs. = 20 cwts. 10 lbs.

Tie rod = 34 ft., 1 in. in diameter.
Area of section = πr^2.
= .7854.

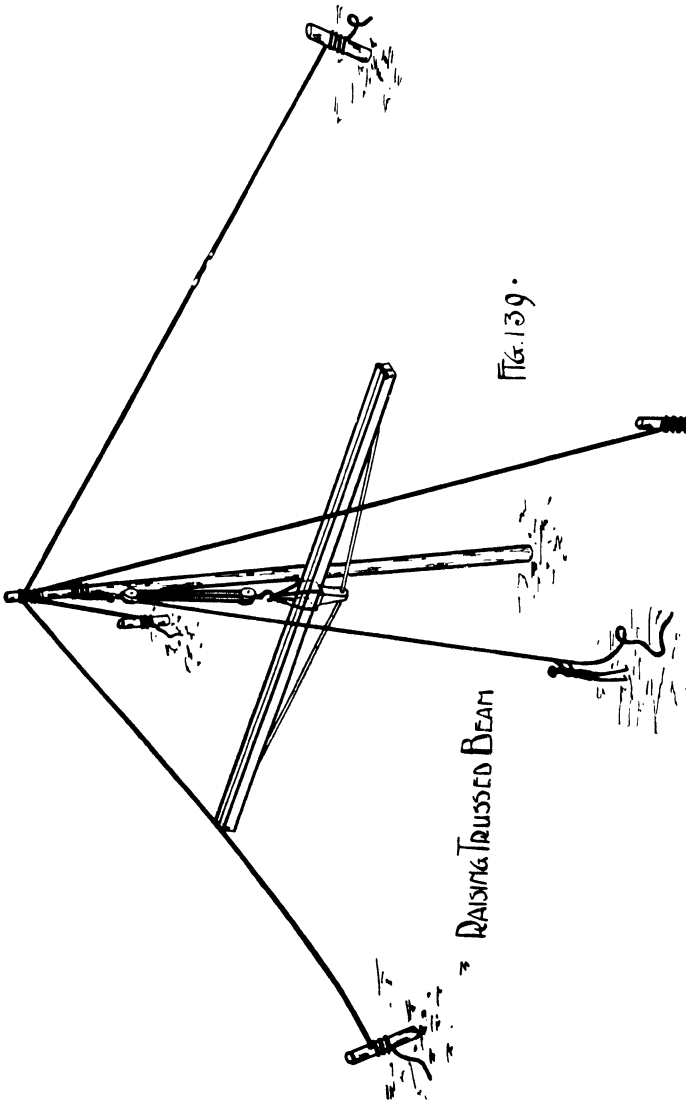


FIG. 139.

RAISING TRUSSED BEAM

The weight per foot of length may be found by multiplying the sectional area by 3·4.

Therefore total weight of rod $= 34' \times .7854 \times 3.4$
$= 90.69$ lbs.

Then total weight $=$ 20 cwts. 10 lbs. $+$ 90.69 lbs.: say 21 cwts.

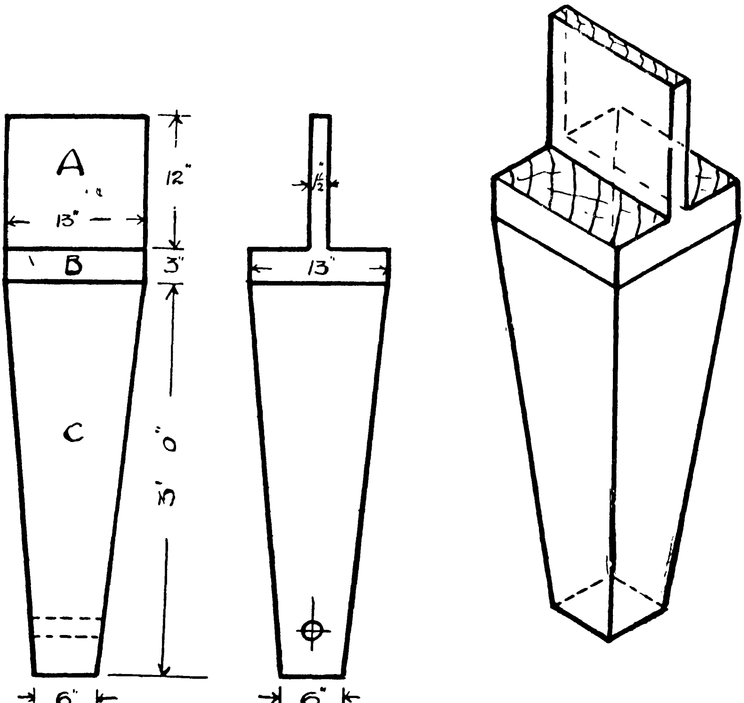


FIG. 140. STRUT

Taking the weight of beam to be 21 cwts. it will be found that the pull at the rope (Fig. 139) is (neglecting friction)—

$$\frac{21}{6} = 3\tfrac{1}{2} \text{ cwts.}$$

A consideration of the theory of pulleys will make this clear.

Fig. 141 shows a fixed pulley with equal weights attached to the rope, the pull or tension in which is equal to one of the weights, or the pull (P) (Fig. 142) will be equal to the weight, whilst the total weight on the pulley is equal to the sum of the weights or W + P.

In Fig. 143 the rope is fixed to a hook and passed round a

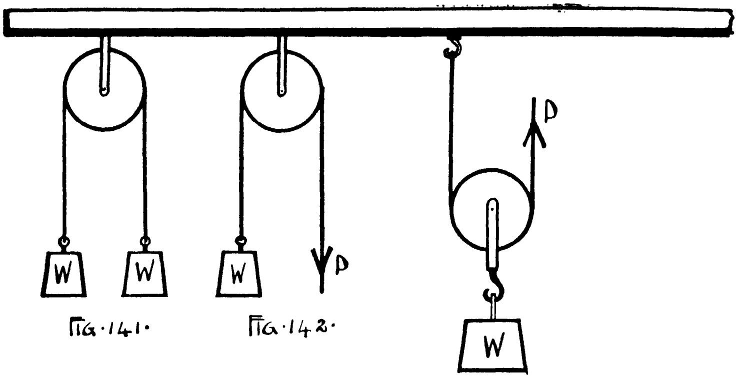


FIG. 141. FIG. 142. FIG. 143.

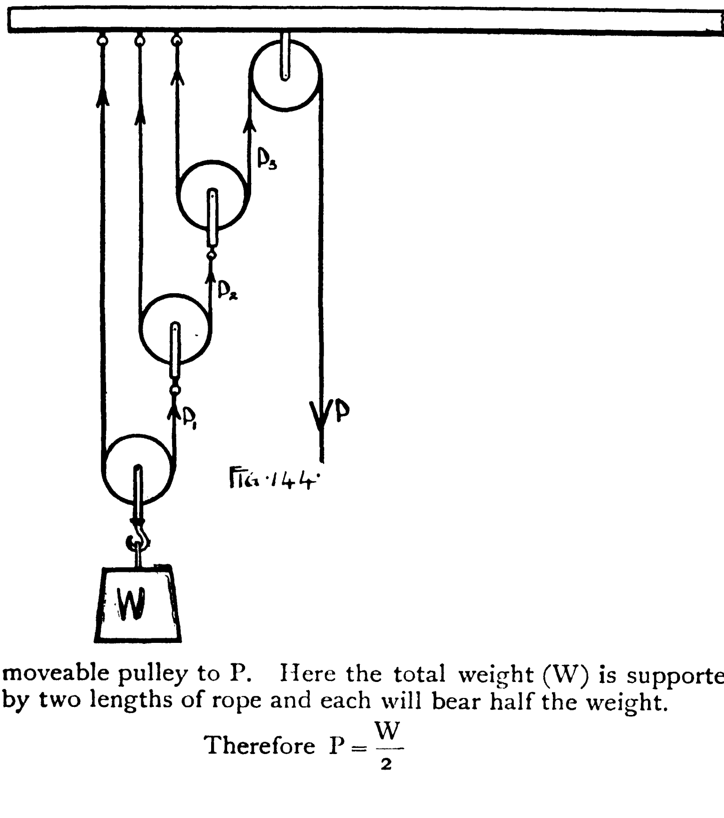


FIG. 144.

moveable pulley to P. Here the total weight (W) is supported by two lengths of rope and each will bear half the weight.

$$\text{Therefore } P = \frac{W}{2}$$

Again in Fig. 144 we have three moveable pulleys.

$$\text{The pull at } P_1 = \frac{W}{2}$$

$$\text{,, ,, } P_2 = \frac{W}{4}$$

$$\text{,, ,, } P_3 = \frac{W}{8}$$

Hence the pull at P is only one-eighth of the total weight.

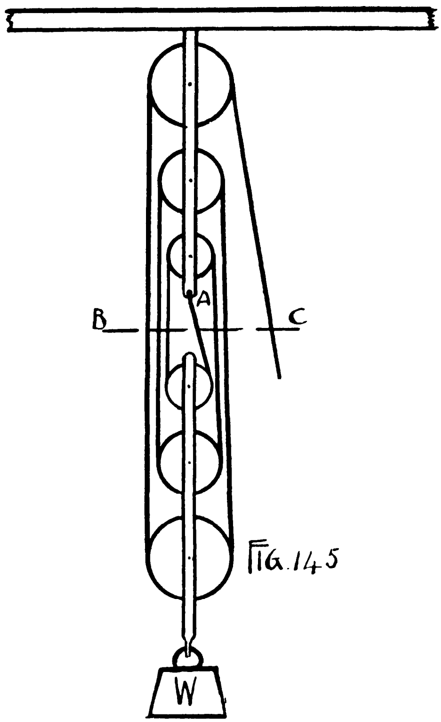


FIG. 145

In the system of our lifting blocks only one cord is used (Fig. 145), but there are three moveable pulleys in the lower block (Figs. 145 and 146).

The rope is tied at A, and it will be seen by drawing a line BC that the weight below is virtually supported by six ropes, each rope bearing only one-sixth of the total weight.

$$\text{Therefore pull at } P = \frac{W}{6} = \frac{21}{6} = 3\tfrac{1}{2} \text{ cwts.}$$

and the tension in the rope is the same throughout its length.

Now the amount of pull found (viz. $3\frac{1}{2}$ cwts.) is a theoretical value, because friction has not been allowed for, and in practice the pull necessary to balance the weight would be greater, as some part is expended in over-coming the frictional resistances. If the blocks are kept well lubricated their efficiency may be taken at .75.

$$\text{Therefore the pull} = \frac{100}{75} \times 3.5 = 4.66 \text{ cwts.}$$

Experiments to find the efficiency of pulley blocks should be carried out by the student in the laboratory. The top block may be attached to a hook which should be fixed to a beam in the ceiling. Then the lower block is weighted, and a spring balance is secured to the end of the rope. The reading of the balance is taken when the pull is just sufficient to raise the weight.

The following table contains the results of experiments made with pulley lifting tackle of two blocks, the lower block containing two sheaves, and the upper one three sheaves. The rope is attached in this case to the lower block, which, it will be seen in Fig. 147, is then supported by 5 ropes.

$$\text{Therefore the theoretical pull or effort } (P) = \frac{W}{5}$$

Weight (W) lifted in lbs.	Actual Effort (F) in lbs.	Theoretical Effort (P) in lbs.	Efficiency.
10	$5\frac{1}{2}$	2	.36
15	7	3	.43
20	$8\frac{1}{4}$	4	.48
30	11	6	.54
40	14	8	.57
50	$16\frac{1}{2}$	10	.60
60	$19\frac{1}{2}$	12	.61
70	22	14	.63
80	$24\frac{1}{2}$	16	.65
90	$26\frac{3}{4}$	18	.67
100	29	20	.69
120	34	24	.70
150	42	30	.71

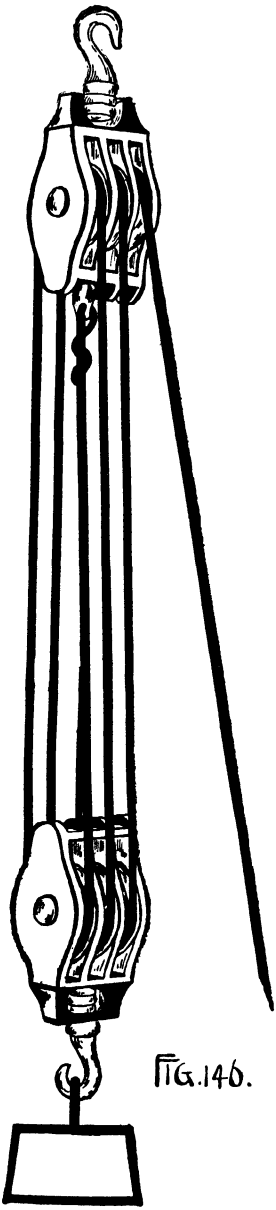


FIG. 146.

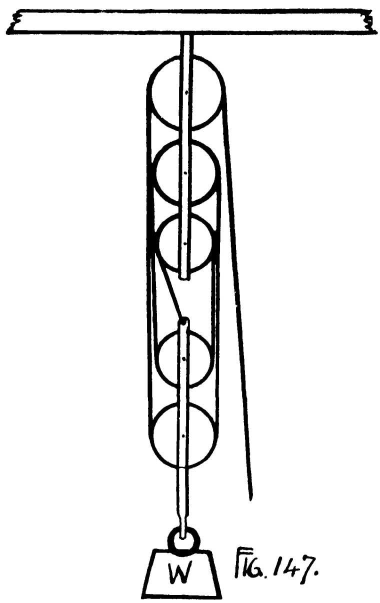


FIG. 147.

To find the efficiency we will take for an example :—

$$\text{Weight lifted (W)} = 40 \text{ lbs.}$$

$$\text{Actual effort (F)} = 14 \text{ lbs.}$$

$$\text{Theoretical effort (P)} = \frac{W}{5} = \frac{40}{5} = 8 \text{ lbs.}$$

$$\text{The mechanical advantage} = \frac{W}{F} = \frac{40}{14} = 2.85$$

$$\text{Friction} = F - P = 14 - 8 = 6 \text{ lbs.}$$

$$\text{and Efficiency} = \frac{P}{F} = \frac{8}{14} = .57$$

Again from our table we get :—

$$\text{Weight lifted (W)} = 100 \text{ lbs.}$$

$$\text{Actual effort (F)} = 29 \text{ lbs.}$$

$$\text{Theoretical effort (P)} = \frac{W}{5} = 20 \text{ lbs.}$$

$$\text{The mechanical advantage} = \frac{W}{F} = \frac{100}{29} = 3.44$$

$$\text{Friction} = F - P = 29 - 20 = 9 \text{ lbs.}$$

$$\text{Efficiency} = \frac{P}{F} = \frac{20}{29} = .69$$

We gather from the table that the efficiency increases with the load, and it will continue to do so until its maximum is reached, but beyond this point an increase of load causes a decrease in the efficiency of the blocks.

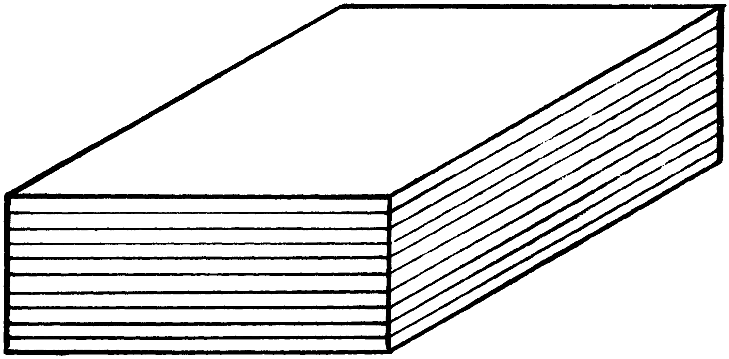
SPECIFIC GRAVITY.—The weight of timber and other substances is often compared with the weight of an equal bulk of water, and the ratio is known as the specific gravity. If the specific gravity is known, the approximate weight of any quantity of timber can be ascertained. In a general way also, the respective weights of different timbers are an indication of their relative strengths, the heavy timber usually being the strongest.

Fresh water weighs 62.5 lbs. per cubic foot; another substance we will suppose weighs 250 lbs. per cubic foot.

$$\text{Then } \frac{250}{62.5} = 4$$

The specific gravity of the substance therefore is 4, and the weight of a given volume is understood to be four times the weight of an equal volume of water.

To ascertain the specific gravity of any particular kind of wood, cut a piece about 4″ × 4″ × 2″, and gauge marks all round to show 10 equal divisions (Fig. 148). Should this piece of



FIG·148·

wood sink in the water until the top face is at water level, its specific gravity is 1; because

$$\frac{\text{weight of submerged part of wood}}{\text{weight of water}} = 1$$

If the wood sinks to the fourth division up, then its specific gravity is 0.4, therefore $0.4 \times 62.5 = 25$ lbs. is the weight per cubic foot.

The pieces experimented with must be thoroughly dry, and the grain stopped with a coating of shellac, otherwise some allowance should be made for capillarity.

As stated in chap. iii. the specific gravity of pitch pine (taking water as 1000) is approximately 631, of red deal about 530, and yellow deal 435. The specific gravity of oak may be taken as 832.

QUESTIONS ON CHAPTER VII

(1) A weight of 30 cwts. is to be raised by a block and fall. If a combination of two pulleys is employed in the lower block, what weight must be applied? Friction and the weight of the blocks may be disregarded. (C. and G. 1908.)

(2) Sketch the necessary tackling for the raising of a flitched beam weighing 18 cwts., by means of double-sheave blocks. What

would be the amount of pull necessary at the rope, neglecting friction?

(3) An oak balk 30 ft. long, 18 ins. square is to be lifted by two sets of treble-sheave pulley blocks. One rope is attached 3 ft. from the end, and the other 7 ft. from the end of the balk. Taking 0.832 as the specific gravity of oak, find the pull at each rope.

(4) How would you determine the density of a piece of wood submitted? Describe fully the means you would adopt to obtain the best practical results. (C. and G. 1911.)

(5) The specific gravity of oak is 0.845. A block of oak when placed in water floats with 100 cu. ins. submerged. How many cubic inches does the block contain? (C. and G. 1907.)

(6) Yellow pine and pitch pine weigh 27 lbs. and 38 lbs. per cubic foot respectively. Find the specific gravity in each case.

CHAPTER VIII

FLOORS

TIMBERS. — Red deal, white deal, and pitch pine are the timbers generally used in floor construction.

Red and white deal are obtained chiefly from Norway, Sweden, Russia, and Prussia, where pines and firs grow abundantly. The best qualities of red deal are shipped from Christiania, Gefle and Soderhamm, St Petersburg, Archangel and Omega, and Dantzig.

The medullary rays, or silver grain, of pines and firs are small and indistinct, and practically all the varieties contain more or less resin.

Pinus sylvestris is also known as northern pine, red or yellow deal, and Scotch fir, because it is found in Scotland. The wood varies according to climatic conditions and the nature of the soil. It is of a pale straw colour, but when more resin is present, and particularly after seasoning, its colour is of a reddish cast. The annual rings are distinct; and, where uniform and fairly compact, with not too much resin present, the wood is usually of good quality. Russian timber is the best for building work, being generally free from knots, shakes, and sap. It can be obtained up to 18 ins. square and 40 ft. long.

White deal or spruce (*Abies excelsa*) is lighter in weight and not so strong or durable as red deal. It is generally imported into this country as deals and battens 2 ins. to 3 ins. thick and up to 9 ins. wide. It is lighter than red deal in colour and some of the best varieties are quite clean, free from knots, and when planed present a silky lustre. The knots are usually small, very dense, and dark in colour. The annual rings are distinct but thinner and rather more compact than those of red deal. The sapwood is not always distinguishable, except that it drags rather when being tooled, and is more spongy. The wood is fairly easy to work, takes glue well, and will stain and polish. The inferior or common varieties are used for packing cases, scaffold poles and boards, etc. Spruce of good quality is used for floors, roofs, etc., and general joinery.

GROUND FLOORS.—Where there is no basement or provision for rooms or cellars below ground level, the ground floor is partly supported on sleeper walls. The joists used are usually $4\frac{1}{2}'' \times 3''$ or $5'' \times 3''$, and for these the supporting walls should be at intervals of not more than 7 ft. 6 ins. The ends of joists should not be built into walls; offsets in the brickwork will provide for their support. If, however, joists are built in, as is often the case, a clear space should be left in the brickwork about their ends, and the joists coated with some preservative where they enter the wall to prevent decay.

Fig. 149 shows the arrangement of joists for a room 18 ft. long and 14 ft. wide. The joists in front of the chimney breast are carried by the fender wall. An offset is arranged in the brickwork to all walls, including the fender wall, for carrying the ends of joists, and $4\frac{1}{2}'' \times 3''$ wall plates are bedded on the offsets in hair mortar, as shown in section, Fig. 150. A sleeper wall with wall plate forms an intermediate support for the $4\frac{1}{2}'' \times 3''$ joists. The joists are notched to the wall plate, but this is merely done as a necessity in levelling the joists.

The maximum stiffness and economy in the size of joists is obtained by placing the joists so as to span the short distance of the room.

If the joists are supported at each end on offsets they are cut 1″ less than the distance across, to prevent contact with the brickwork. Where they are to be built into the wall at each end the joists should be cut at least 14 ft. 9 ins., allowing $4\frac{1}{2}$ ins. in the brickwork.

The end joists are placed $1\frac{1}{2}$ ins. from the walls and the remaining joists are placed 15 ins. between centres (and should not be more than 16 ins.). If the floor boards are $1\frac{1}{4}$ ins. thick, the joists could be 16 ins. centre to centre.

In all cases of ground floors, as a necessary precaution against dry rot, care should be taken that the area below the joists is properly ventilated by the provision of $9'' \times 6''$ air bricks in the external walls. The sleeper walls should be honeycombed, and everything possible done to induce a good circulation of air. Sometimes even the provision of air-bricks does not prove sufficient to ensure good ventilation, and it would appear that a better result could be obtained by providing an air duct or shaft to the back of the fireplace in the room above.

A 6-in. bed of concrete should cover the whole of the ground below wooden floors, and in all cases care should be

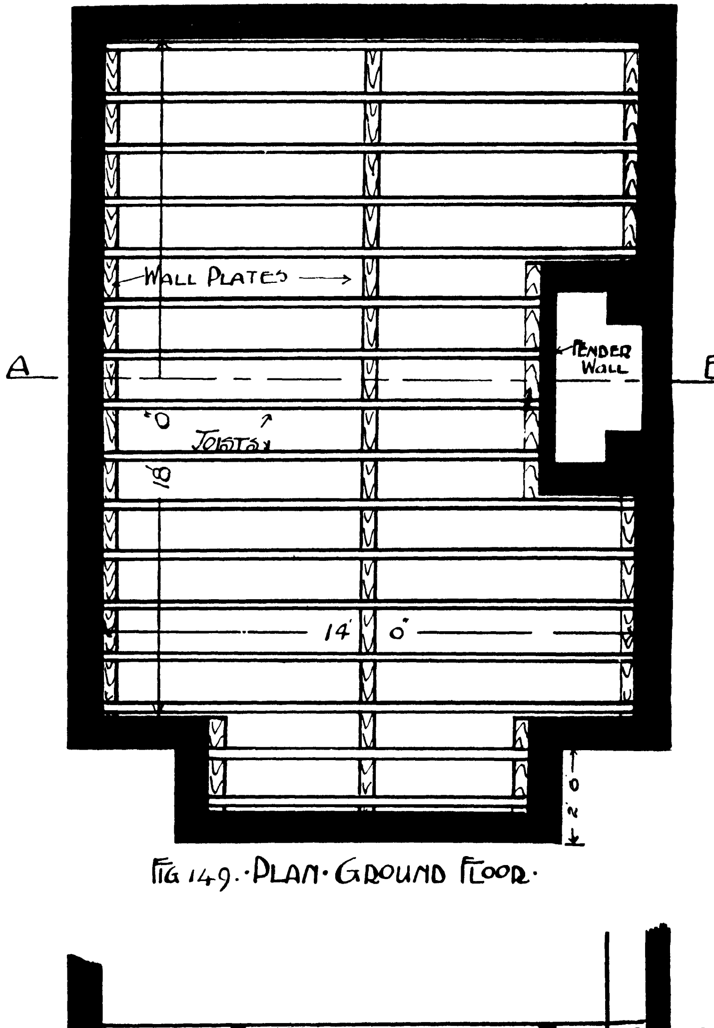


FIG 149. PLAN. GROUND FLOOR.

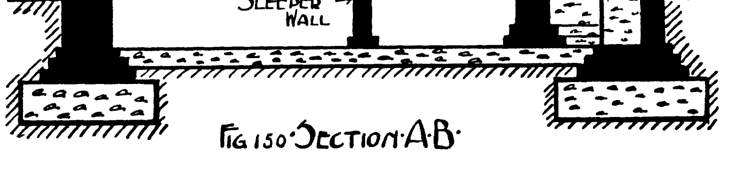


FIG 150. SECTION. A.B.

taken that all vegetable and other organic matter is entirely removed before the joists are covered with floor boards. Further, the joists should be quite free from moisture and well seasoned, and all sapwood should be removed.

The quantities for this floor including boards are as follows :—

3/	20 6 4½ 3	5 9	Fir in wall plates.	18 0 2 6 20 6	6 0 6 0 6 0 2 6 20 6
10/	14 0 4½ 3	13 1½	Fir in floor joists.		
4/	11 6 4½ 3	4 3¾	,, (to fender wall).		
2/	8 6 4½ 3	1 7	,, (bay).		
	18 0 14 0	252 0	1" T. and G. boards.		
	8 6 2 6	21 3	,, (bay).		

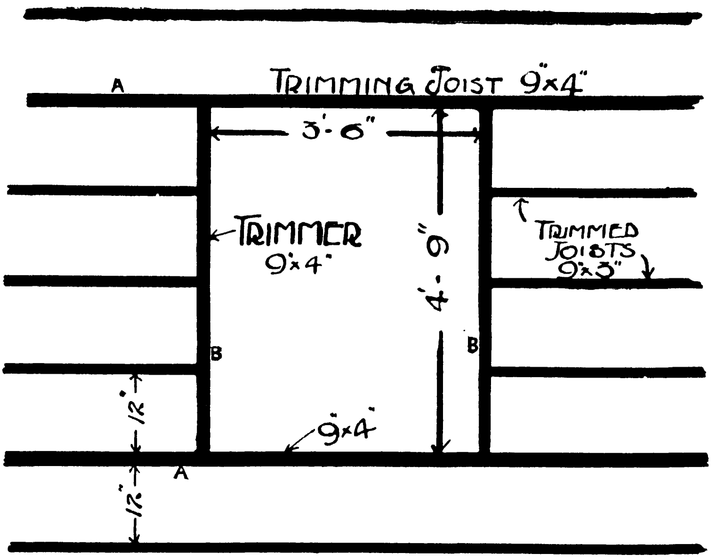
Fir in Plates. Cubic Feet.	Fir in Joists. Cubic Feet.	T. and G. Boards 5" × 1" Super.
5 9	13 1½ 4 3¾ 1 7 19 0¼	252 0 21 3 100)273 3 2.73 squares.

Yards.	Feet.					
	5¾ cubic	Fir in plates	2/6	£0	14	4½
	19 ,,	Fir framed in 4½" × 3" floor joists	3/3	3	1	9
2¾ squares		White deal T. and G. flooring with splayed headings; nails punched, holes puttied, and the floor dressed off at completion	24/-	3	6	0
				£7	2	1½

SINGLE FLOORS.—Single floors include all floors whose supporting members consist of one row of joists spanning from wall to wall.

The joists are placed at intervals of 15 ins. from centre to centre, and are usually 3 ins. thick—a very common market size. In depth they vary from 7 ins. for 12 ft. span to 11 ins. for 16 ft. span. It is necessary to frame or "trim" round fire-places, stairways, and other voids.

Fig. 151 shows the method of trimming for a space which is left in the floor for a hoist or lift. The trimming joists AA will



TRIMMING TO VOID IN FLOOR. FIG. 151.

have to carry part of the weight of other joists and the weight bearing thereon, and must necessarily be stronger. In this case they are shown 1 in. thicker than the ordinary joists.

The same applies to the trimmers BB, each carrying the ends of three other joists, and, as they are mortised, extra thickness is required. The amount of extra thickness usually allowed for trimmers is $\frac{1}{8}$ in. for every joist tenoned into them.

Fig. 152 is the plan of a single floor for a room 14' × 12' 6".

The joists are resting at their ends on $4\frac{1}{2}'' \times 3''$ wall plates,

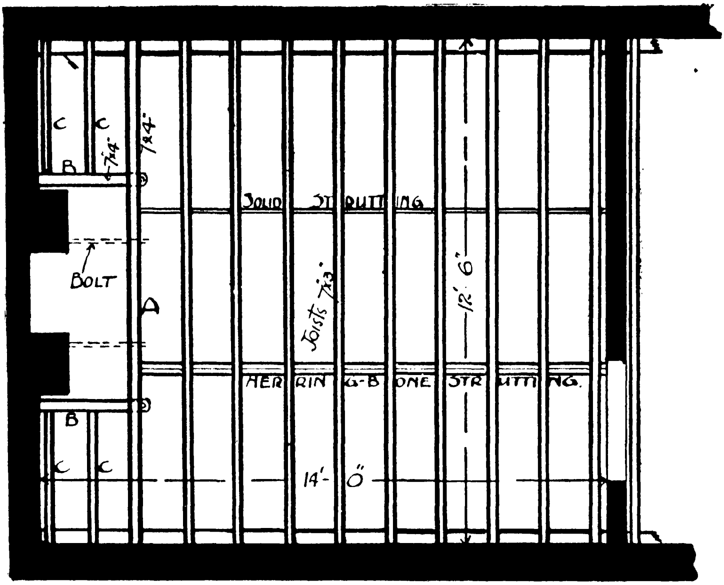


FIG. 152. PLAN SINGLE FLOOR.

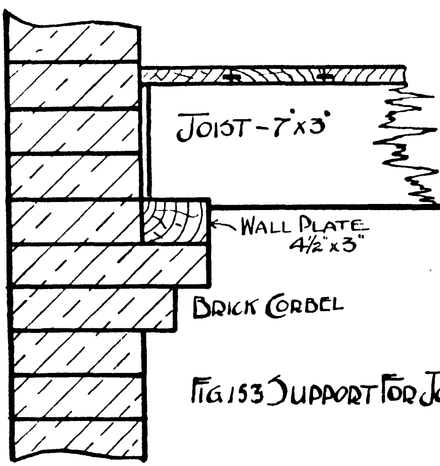


FIG 153 SUPPORT FOR JOISTS

which are carried by corbelling out the brickwork, as in Fig. 153. An alternative method is to carry the wall plate on wrought iron corbels, built into the wall at intervals of 2 ft. or 2 ft. 6 ins., as in Fig. 154.

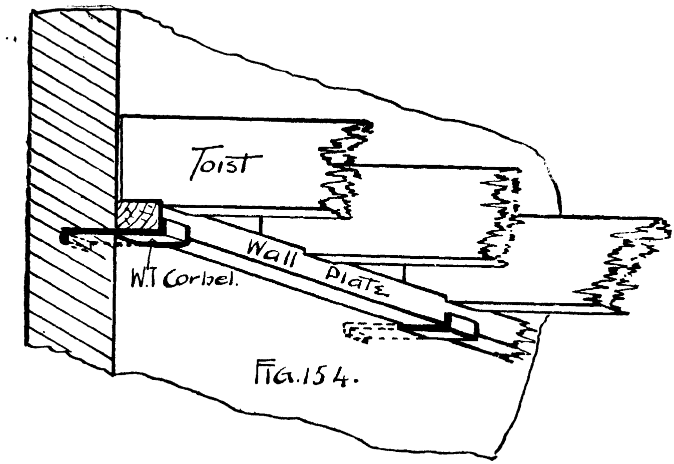


FIG. 154.

The nearest joist in front of the chimney breast—in this case the trimming joist A, Fig 152—must be 18 ins. away.

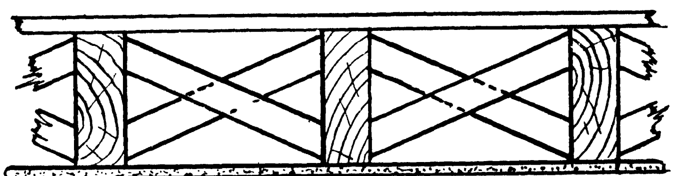


FIG. 155. HERRING-BONE STRUTTING.

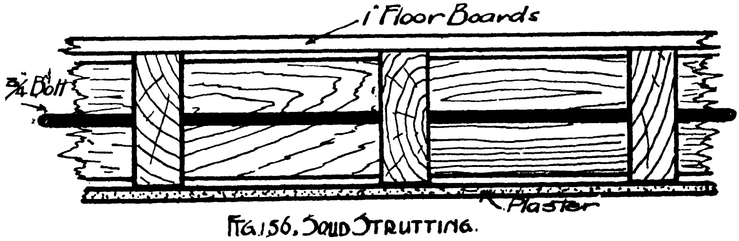


FIG. 156. SOLID STRUTTING.

This joist is 4 ins. thick, the trimmers BB are tenoned into it, and into the trimmers are tenoned the trimmed joists CC CC.

STRUTTING.—Floors can be very substantially stiffened by the use of suitable strutting placed at intervals of 4 or 5 ft., the effect of which is to spread any concentrated weight over

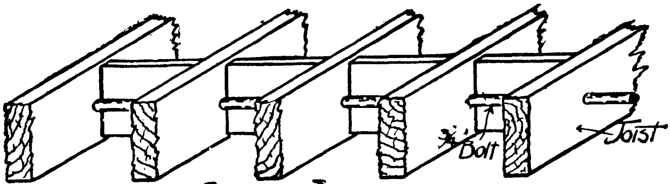


Fig. 157. Solid Strutting

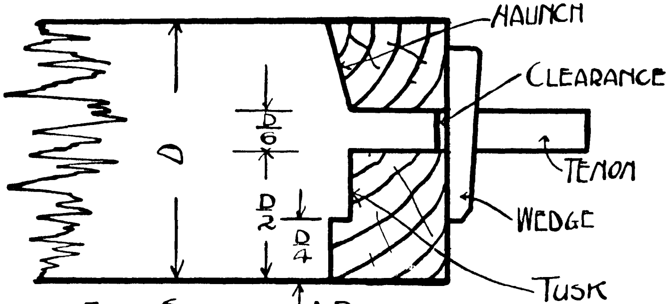
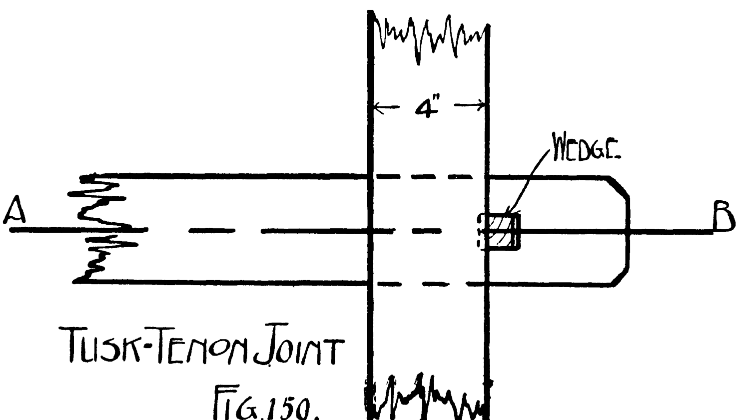


Fig. 158 Section AB



Tusk-Tenon Joint
Fig. 159.

a number of joists. Both herring-bone and solid strutting are shown in the floor (Fig. 152), and details are given in Figs. 155, 156, and 157.

Herring-bone strutting is considered the most effective, as the shrinkage of the joists in the direction of their depth tends to tighten rather than to loosen the inclined pieces.

Solid strutting is also very effective, especially when a bolt is passed through the joists as shown, and drawn up tightly.

TUSK-TENON JOINT.—The type of joint used in framing floors is known as the tusk-tenon joint, and is shown in Figs. 158 to 161. The proportions given should be carefully noted (*see* Fig. 158). The mortise hole is cut through just above the

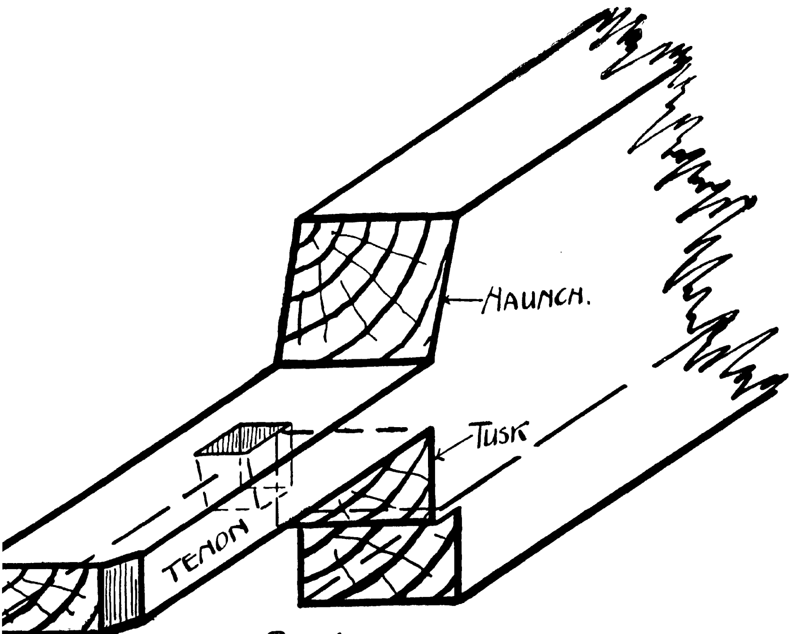


FIG. 160.

centre line. It has already been pointed out (p. 57) that the fibres at or near the centre of a beam have the least amount of stress. Further, it was seen that the fibres above the centre of the depth are subject to a compressional stress, and those below the centre are subject to a tensional stress. From these conclusions it is found that the joist is least affected by cutting the mortise hole in the position shown, and that by making the tenon to fit tightly the resistance to compression is only very slightly impaired.

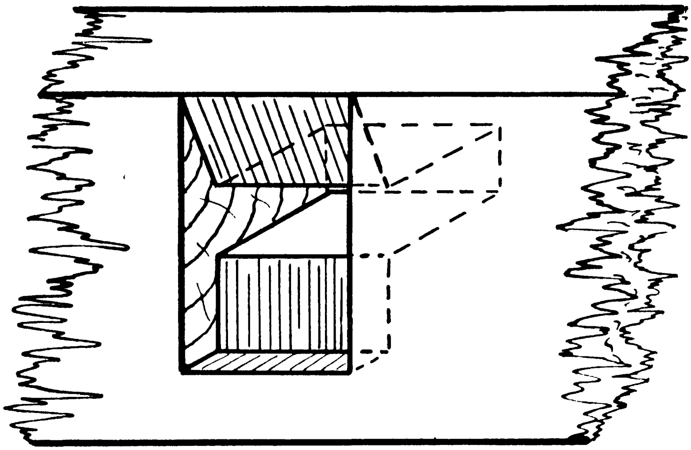


FIG. 161.

SUPPORT OF THE HEARTH.—The hearth at the fireplace is supported by a brick trimmer arch resting on the chimney breast and the trimming joist, as shown in section, Fig. 162. Where the joists are parallel to the fireplace the trimming joist requires some support to enable it to withstand the side thrust

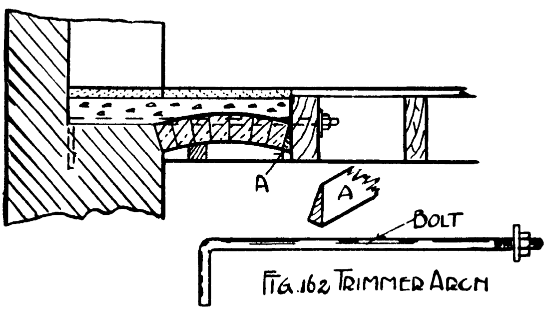


FIG. 162, TRIMMER ARCH

from the trimmer arch. For this purpose one or two bolts are inserted, turned down at one end into the brickwork of the chimney breast, passed through the trimming joist, and bolted at the other end. The bolt is shown enlarged (Fig. 162), and A is a portion of the feather edge slip (F.E.S.) fixed along the joist for the support of the arch. Fig. 163 is a part plan and section of the fireplace for floor shown Fig. 164, and Fig. 165 is another view of the same. An alternative method of supporting the hearth is shown in Fig. 166, concrete being used with wire netting, expanded metal, or other form of reinforcement. This is very suitable where the joists are under 9 ins. deep.

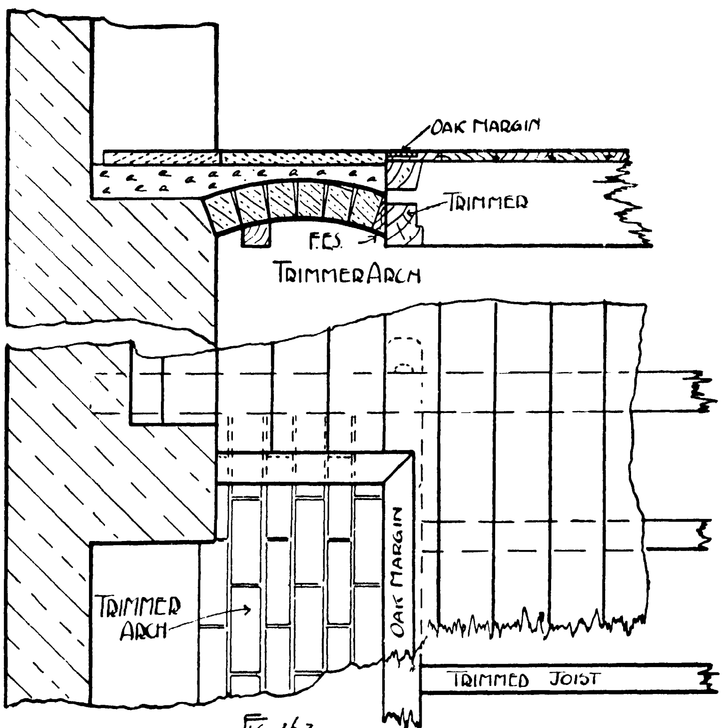


FIG 163

SOUND BOARDING AND PUGGING.—By the use of sound boarding and pugging the passage of sound through floors is to some extent prevented. Rough boards, about ¾ in. thick, resting on fillets nailed to the sides of the joists, are used to support the pugging (Fig. 167). The latter should, for preference, be light in weight, sanitary, and, if possible, fire-resisting. Slag wool or slabs of fibrous plaster are among the best materials used for the purpose. Other materials used are coarse-stuff, 2 or 3 ins.

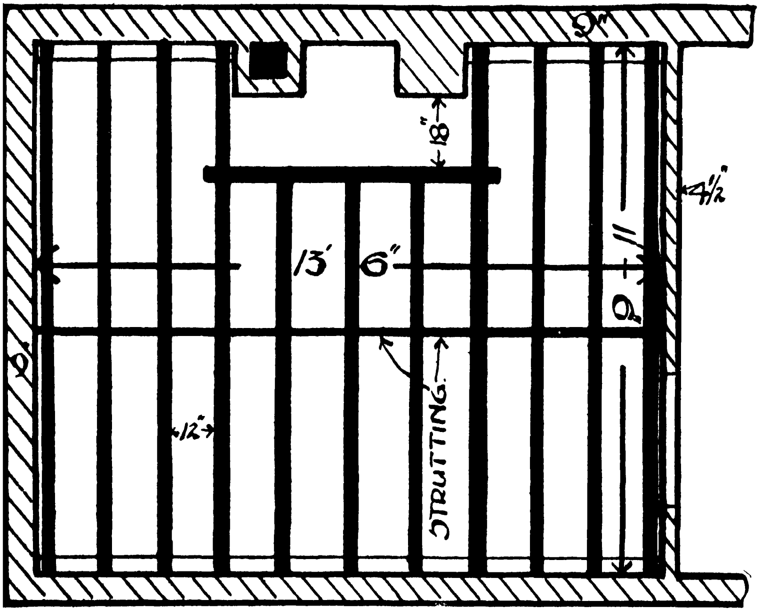


FIG. 164. PLAN SINGLE FLOOR

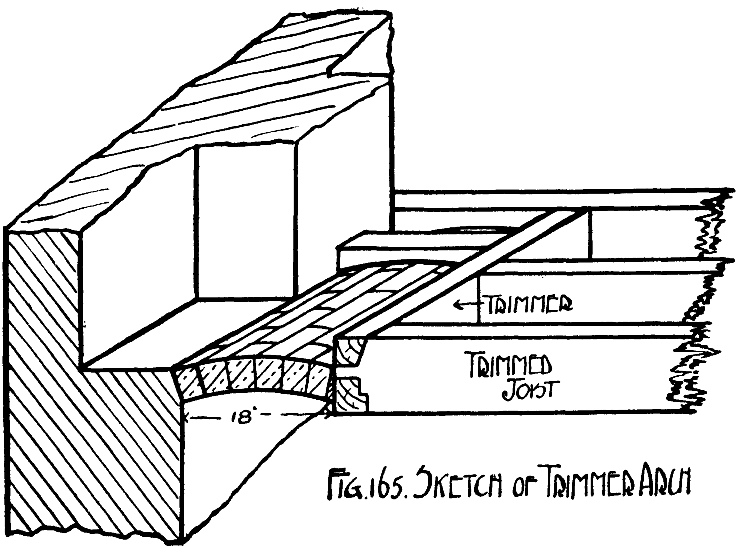


FIG. 165. SKETCH OF TRIMMER ARCH

thick, rough mortar, mixed with ashes or sawdust. There is a danger, however, of the latter materials setting up dry rot; it is,

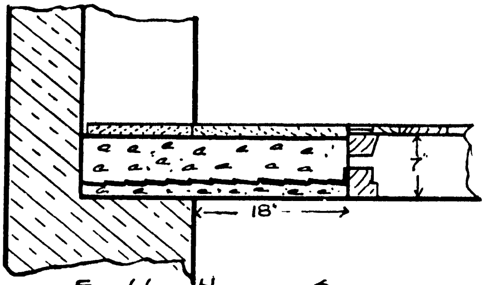


FIG. 166. HEARTH SECTION

therefore, imperative that all traces of damp should be removed before the pugging is closed in.

A very effective means of preventing the passage of sound is that of placing strips of felt under the ends of all supporting members to the floor, and between the joists and floor boards.

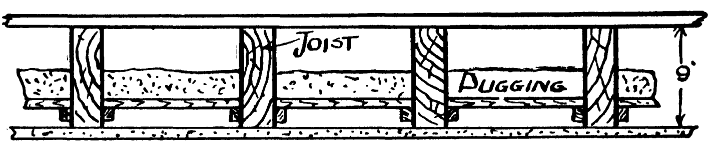


FIG. 167. SOUND BOARDING & PUGGING.

FLOOR BOARDS.—White deal, red deal, pitch pine, and sometimes oak, are the chief materials used for flooring.

Pitch pine is a first-class flooring material, but is expensive, and is imported only in logs and deals.

White deal is the most commonly used because of its adaptability and cheapness.

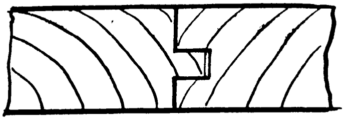
Red deal is also much used for floors, perhaps more especially for rooms other than bedrooms and kitchens where white deal is used.

Narrow boards are better than wide ones, shrinkage and defects being reduced to a minimum—a point which should be borne in mind in connection with most forms of joinery.

Common sizes for boards are $\frac{7}{8}$ in., 1 in., $1\frac{1}{4}$ ins., $1\frac{1}{2}$ ins. thick, and $4\frac{1}{2}$ ins., 5 ins., 6 ins. and 7 ins. wide.

Joints in floor boards.—Square edge jointed floor boards would, in shrinking, leave the joints open, which is undesirable.

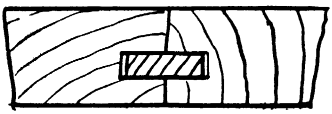
Fig. 168 is a tongued and grooved joint, and one most commonly used for flooring boards.



TONGUE & GROOVE FIG 168.

Fig. 169 shows a ploughed and tongued joint—the tongue is made to fit loosely in the groove and is made with the grain running lengthway.

Fig. 170 is the same as above, but the tongue is of metal



PLOUGHED & TONGUED FIG 169

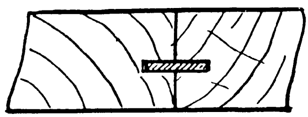
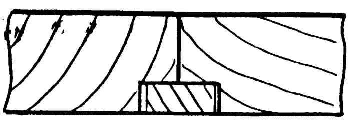


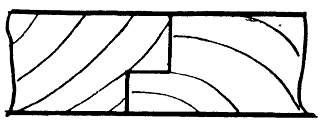
FIG 170.
PLOUGHED & METAL TONGUE

which is better adapted for thinner boards. The tongues and grooves should be low in the edges of the boards to afford greater wearing thickness above them.

A rebated and filleted joint is shown in Fig. 171; the



REBATED & FILLETED FIG 171



REBATED FIG 172.

fillet may be $\frac{3}{8}$ in. or $\frac{1}{2}$ in. thick. This joint facilitates the removal of boards when required without damaging their edges.

Fig. 172 is a rebated joint.

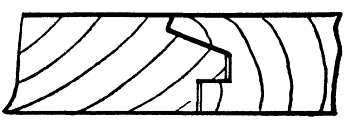
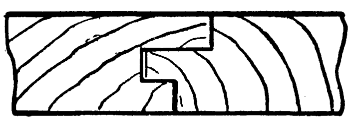


FIG 173 BEVELLED TONGUED & REBATED



REBATED T. and G. FIG 174.

The bevelled, tongued, and rebated joint of Fig. 173 is for secret nailing, and is fastened at one edge only; the other edge is free to expand and contract, and is held down by the adjoining board.

The rebated, tongued, and grooved joint (Fig. 174) is a joint very similar to the above, but does not use so much material.

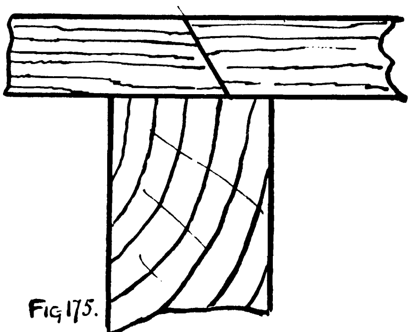


Fig 175.
SPLAYED HEADING JOINT

Fig. 175 is a splayed heading joint.

Laying floor boards.—Floor boards are usually laid in batches of four or five and cramped tightly by means of floor cramps used on every alternate joist.

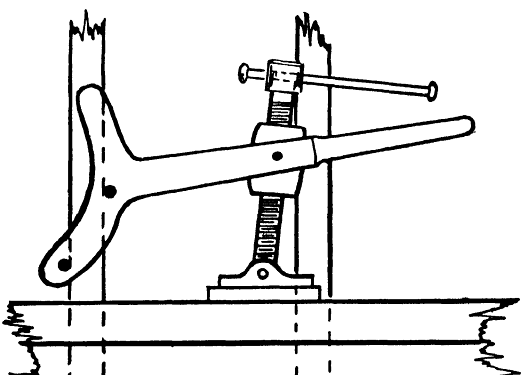


Fig. 176.

Fig. 176 is one form of floor cramp known as the single prong pattern. Another method, now practically out of date, is that where the boards are said to be "laid folding" as shown

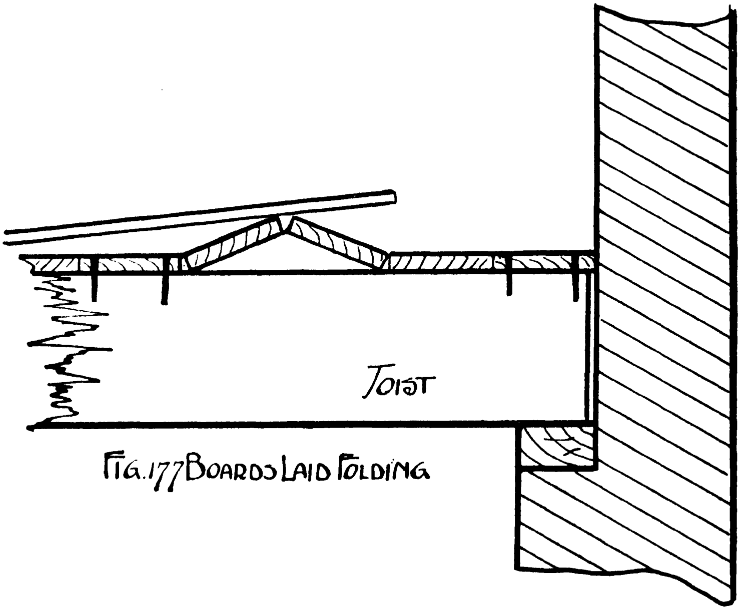


FIG. 177 BOARDS LAID FOLDING

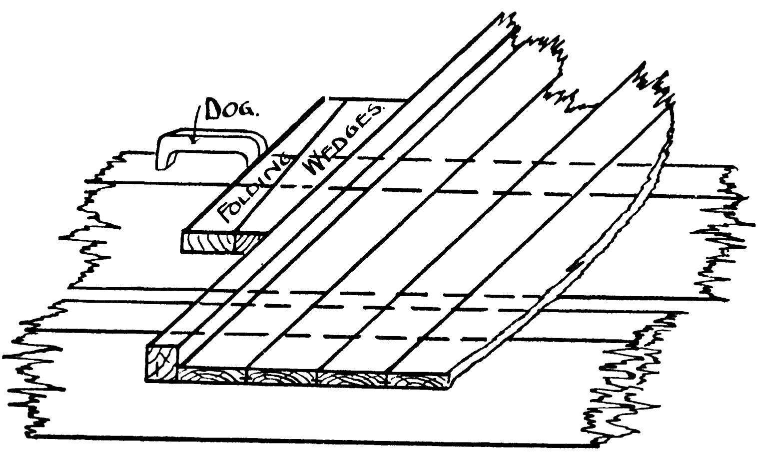


FIG. 178 CRAMPING FLOOR-BOARDS

in Fig. 177. A ¼ in. less than the width of, say, five boards, is marked on the joists, and the fifth and first boards being nailed, the intermediate ones are sprung in place by jumping on any rough board laid across at right angles.

Floor boards may be tightened by using a number of wrought iron dogs and folding wedges. These dogs are driven into the joists a few inches away from the edge of the board, and the wedges are tightened up between the dogs and a rough piece of wood which is placed against the edge of the brad for protection (Fig. 178).

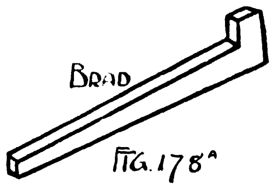


FIG. 178a

Fig. 178*a* shows a floor brad used in nailing the boards to the joists; these are driven about 1 in. away from the edges of the boards.

QUESTIONS ON CHAPTER VIII

(1) Name the chief ports of shipment of red deal and white deal. Compare their general characteristics and state their uses.

(2) Why would you select 9″ × 3″ rather than 7″ × 4″ as the section for floor joists?

(3) What precautions are necessary where the ends of joists are built in the brickwork? Show two different methods of supporting the ends of joists.

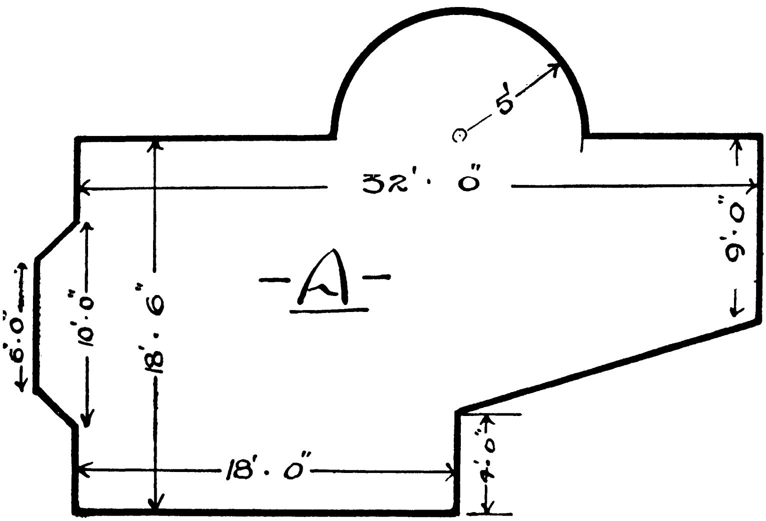
(4) How would you prevent dry rot in floors?

(5) What materials are used in preventing the passage of sound through floors? Illustrate the methods of applying them.

(6) To a scale of 1 in. to 1 ft. draw a true plan and section to show how you would trim round a fire-place; and make a detail of a tusk-tenon joint.

(7) Sketch solid and herring-bone strutting and state what purpose they serve.

(8) How many square feet of floor boards would be required for the room shown at A?



(9) Draw full-size sections of four different joints used for the edges of floor boards, and explain any particular advantage each may have.

(10) Sketch a form of joint suitable for the secret nailing of floor boards. Show two methods of drawing up boards when laying, and sketch a floor brad.

CHAPTER IX

PARTITIONS

WOODEN partitions for the division of rooms consist of upright members of suitable size fixed between floors or floors and ceilings. They may be supported by the floor, or they may be framed in the form of trusses to be not only self-supporting but strong enough to support floors.

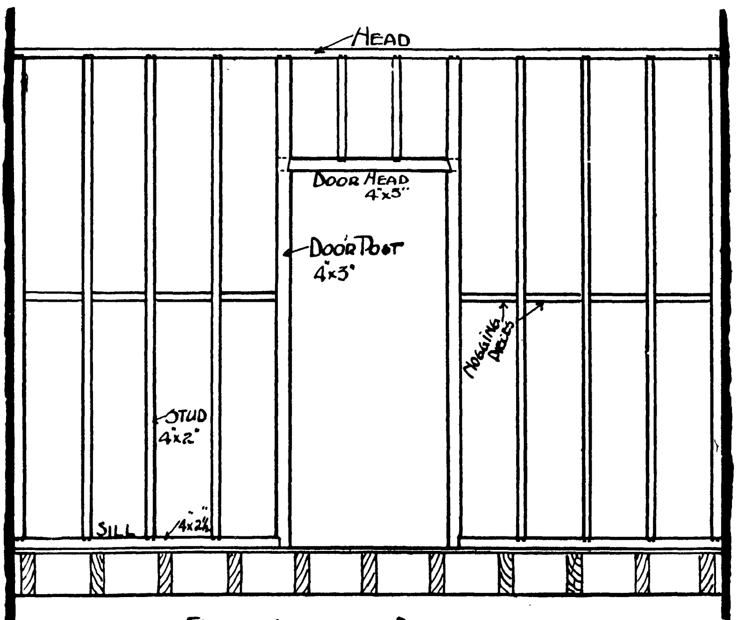


FIG. 179 COMMON PARTITION

Fig. 179 is a supported partition placed at right angles to the floor joists. The sill ($2\frac{1}{2}'' \times 4''$) is resting on the floor boards, and the head is fixed under the ceiling joists. A wall piece is fixed—and may be plugged—against each wall, and strong pieces (4″ × 3″) are used for door posts, which in this case are placed 2 ft. 9 ins. apart. The intermediate members (4″ × 2″),

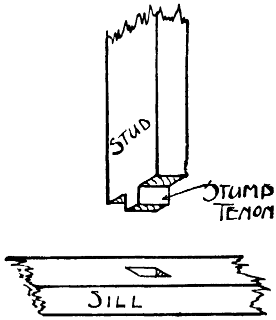


FIG. 180.

called quarterings or studs, are stump tenoned into the head and sill (Fig. 180).

The studs are stiffened by fixing nogging pieces between as shown, at intervals of about 4 or 5 ft. in the height.

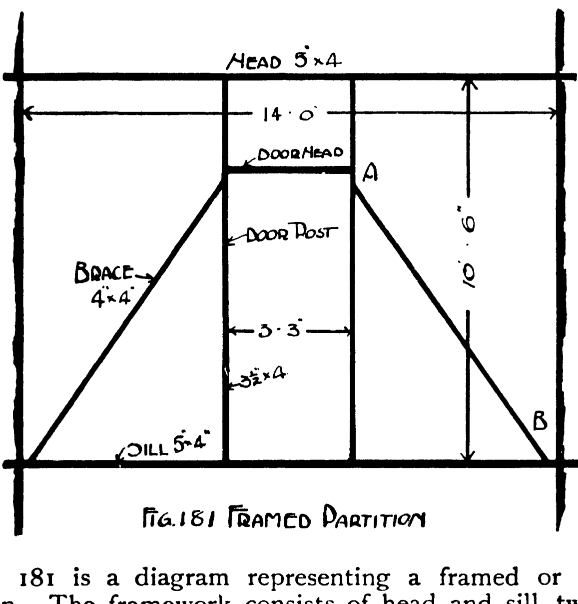
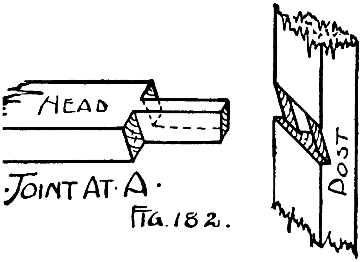
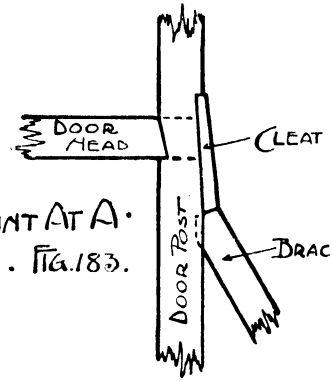


FIG. 181 FRAMED PARTITION

Fig. 181 is a diagram representing a framed or trussed partition. The framework consists of head and sill, two door posts with head, and two braces which are intended to direct the weight from the centre of the partition on to the walls



·JOINT AT·A·
FIG. 182.



·JOINT AT A·
. FIG. 183.

or supports. The size of the members varies according to span and weight to be carried, if any. The spaces between the framework will be filled with ordinary 4″ × 2″ studs placed

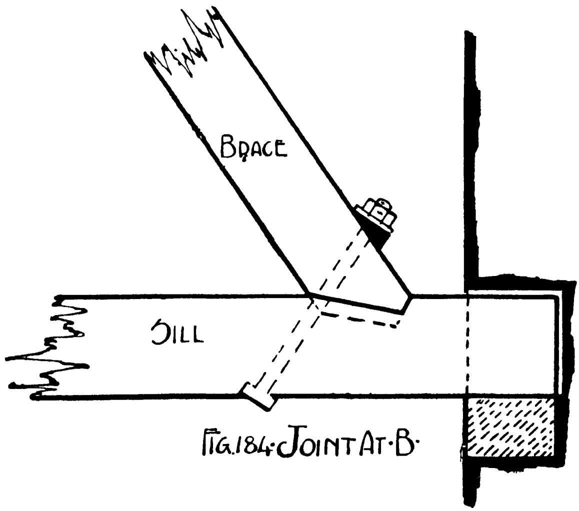


FIG. 184·JOINT AT·B·

12 ins. apart. The joint at A is shown in detail in Figs. 182 and 183, and that at B in Fig. 184. The head and sill will rest on stone templets built in the walls.

QUESTIONS ON CHAPTER IX

(1) Draw a line diagram of the framework for a properly trussed self-supporting partition. The distance from wall to wall to be 11 ft. 6 ins. and the height of the partition 9 ft. 6 ins., with a door opening 20 ins. from one of the walls. Name and give the dimensions of the members. What is the object of the braces?

(2) Draw details of the joints for the above partition including oblique sketches of the pieces apart. Show the metal fastenings you would use.

CHAPTER X

ROOFS

LEAVING out of consideration particular architectural styles, the nature of the roof covering and the general climatic conditions have much to do with the pitch of a roof. In this country it is desirable to pitch the roofs at a sufficient angle to throw off rain and snow.

A slated roof should be pitched not less than 25°, and a rise of $\frac{1}{3}$ ($33\frac{1}{3}$°) may be considered a good average. For tiles the pitch should not be less than 40°, and as tiles are heavier than slates the roof members should be of larger size.

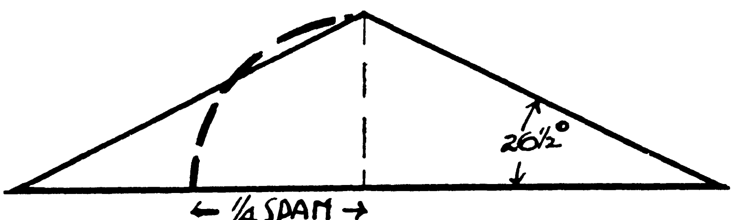


FIG. 185.

Generally, if the roof covering materials are of small size, as tiles and small slates, the pitch should be higher.

A quarter pitched roof is shown (Fig. 185), the height to the ridge being $\frac{1}{4}$ of the span, and the angle of inclination $26\frac{1}{2}$°.

Fig. 186 is $\frac{1}{3}$ pitch, $ab = \frac{1}{3}$ of the span cd.

LEAN-TO ROOF.—The weight of a piece of wood together with its load, as shown in Fig. 187, would rest with a downward pressure on each wall. Suppose, however, the ends of the timber were cut between the walls, as shown in Fig. 188, the downward pressure would tend to throw the walls outwards.

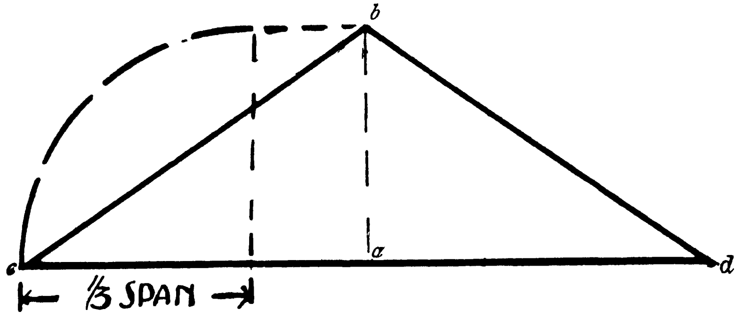


FIG. 186.

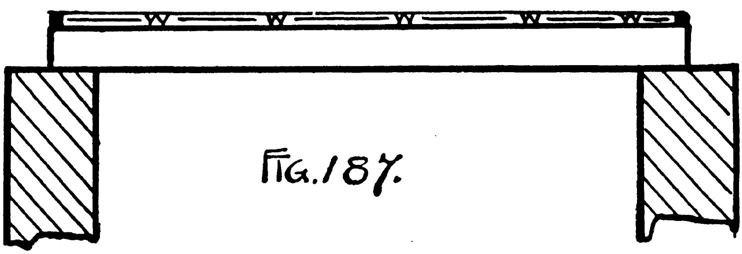


FIG. 187.

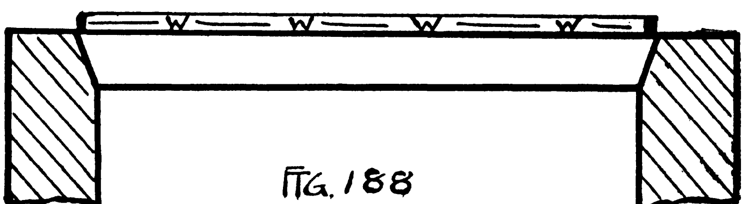


FIG. 188

The same is true where in a lean-to roof the rafters are cut and fixed as in Fig. 189; the tendency to slide down at A

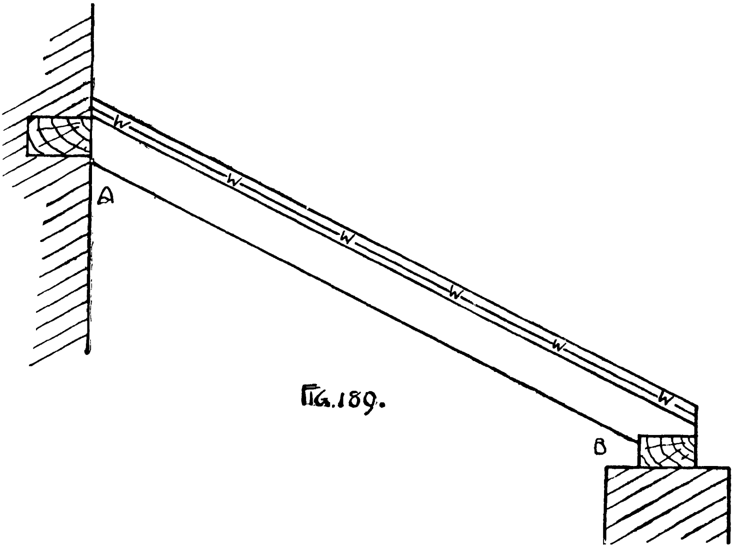


FIG. 189.

would cause an outward thrust on the wall at B. But by making a horizontal bearing for the inclined rafter at both

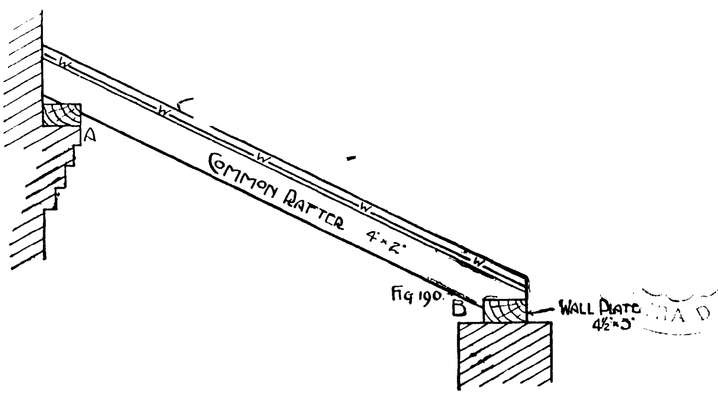


FIG 190.

ends as at A and B, Fig. 190, each wall would carry an equal amount of the downward pressure, and there would be less outward thrust.

This principle should be observed in constructing a lean-to roof. The $4\frac{1}{2}'' \times 3''$ wall plate at A is carried by corbelling out the brickwork. A wall plate is bedded on the wall at B, and to these the common rafters are notched to form a bird's-mouthed joint and then spiked.

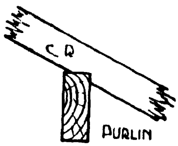


Fig. 191.

If the lean-to roof is used for spans greater than 8 ft., a purlin should be inserted midway between the wall plates, its size depending upon the distance apart of the supporting walls. Fig. 191 shows a purlin with the common rafter.

COUPLE ROOF.—A couple roof (Fig. 192) is used for small out-buildings, and may be used for spans up to 12 ft. Obviously, there is a tendency to push the walls outwards, but this will

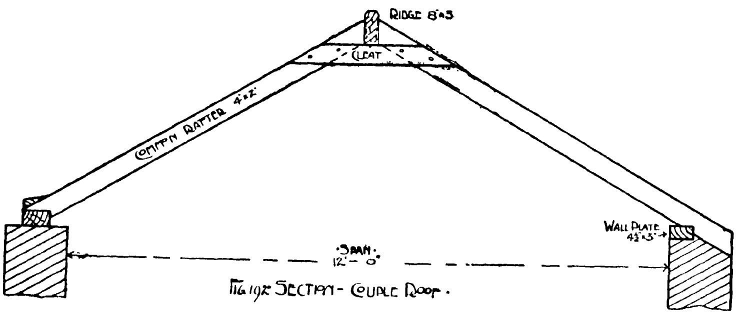


Fig. 192 SECTION - COUPLE ROOF.

depend to a large extent upon the length and stiffness of the ridge piece. By making this member strong enough in itself to carry a major portion of the weight of the roof, the thrust on the walls becomes insignificant. The roof here shown is to span 12 ft., the ridge is $8'' \times 3''$ and its length 10 ft. The

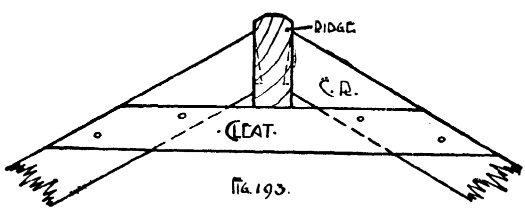


Fig. 193.

$3'' \times 2\frac{1}{2}''$ common rafters are sunk into the ridge (Fig. 193) to prevent sliding, and each pair should be well tied together as shown, or every fourth or fifth pair of spars may be bolted through and held tightly against the ridge.

The *Couple Close Roof* is formed by securing the lower ends or feet of the common rafters together with suitable timbers, which may act as ceiling joists as well as so many ties (Fig. 194).

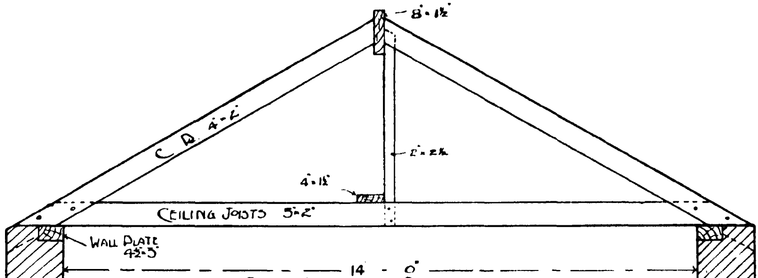


Fig. 194. Couple-Close Roof.

This roof can be used for spans up to 12 or 14 ft. The common rafters are the usual size 4″ × 2″ or 3″ × 2½″, and the ceiling joists for 14 ft. span would be 5″ × 2″, stiffened by nailing a 4″ × 1½″ piece almost beneath the 8″ × 1½″ ridge, from

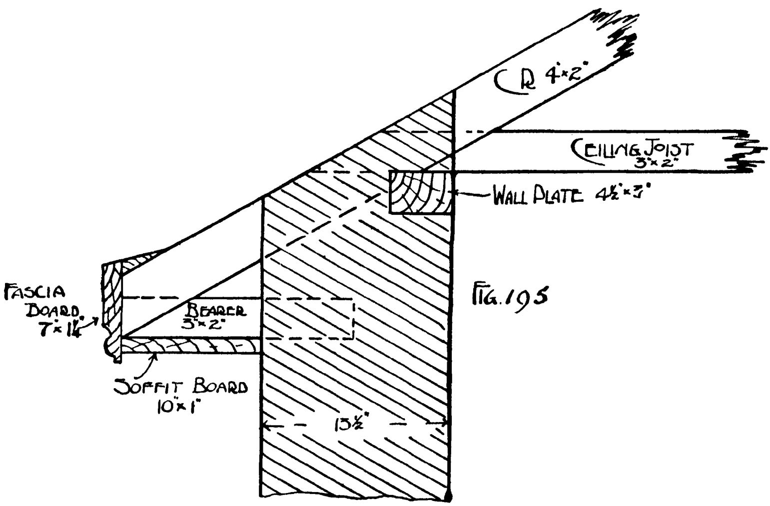


Fig. 195

which 2″ × 2½″ suspenders are arranged and spiked to alternate ceiling joists. Fig. 195 shows overhanging eaves with a soffit board. A modification of this roof is shown in Fig. 196, and is commonly used for dwelling-houses. A partition wall (P) affords an intermediate support for the ceiling joists, which

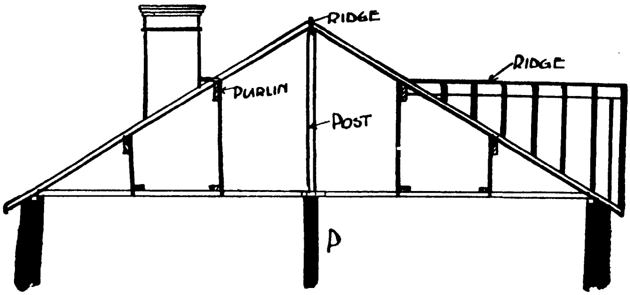


FIG. 196. SECTION

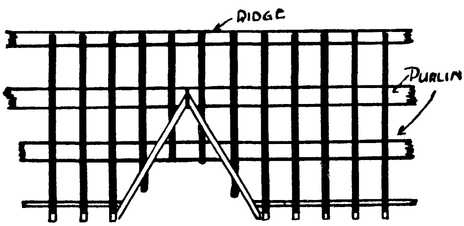


FIG 197. ELEVATION

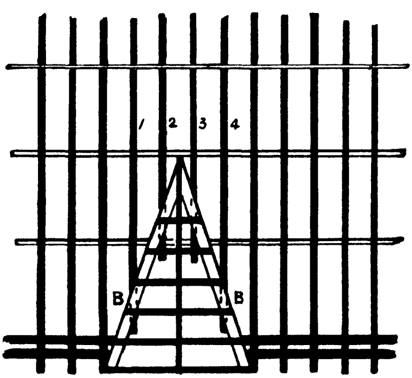


FIG 198. PLAN

are stiffened as before by means of suspenders from the roof-members. The purlins and ridge are supported on party, gable, and partition walls, which in some instances are carried up to the roof; the size of the purlins will vary between 8″ × 3″ and 12″ × 4″. according to the distance between the supporting walls.

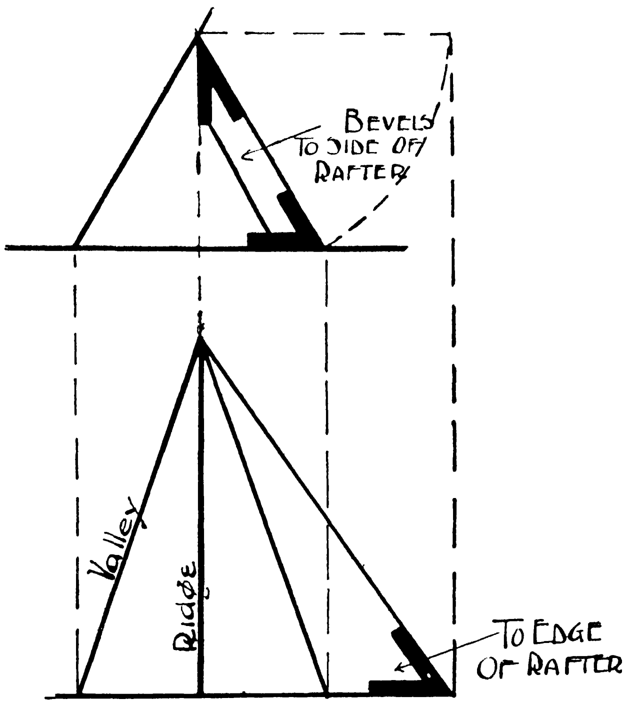


FIG. 199.

On the elevation (Fig. 197) the roof is broken to form a pediment. The ridge for this is resting on the front wall at one end, and fixed to the purlin at the other. The lower purlin is continuous, and helps to support the main rafters 1, 2, 3, and 4, Fig. 198, which are carried far enough to give support for the two boards BB. The lower ends of the pediment rafters are secured to the latter, and the bevels for cutting them are shown, Fig. 199. (The student should make a piece of wood of the shape given, and use paper cut to shape for surface

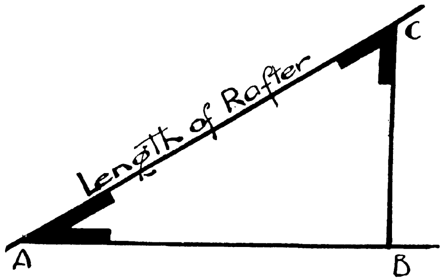


FIG. 200.

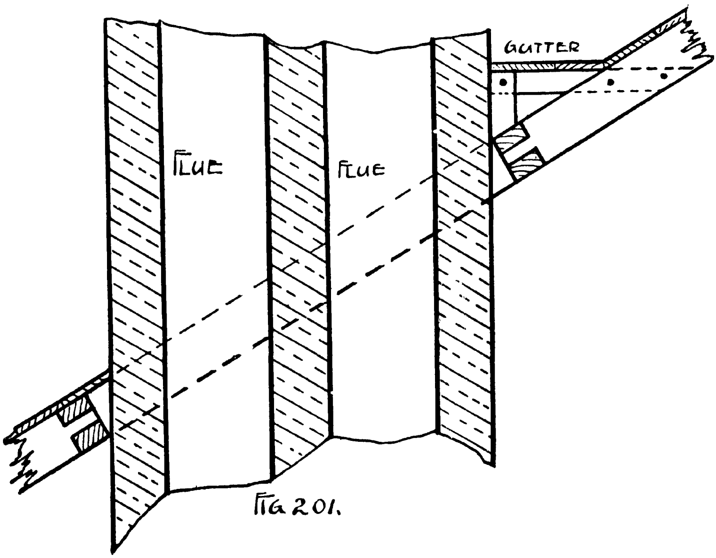


FIG. 201.

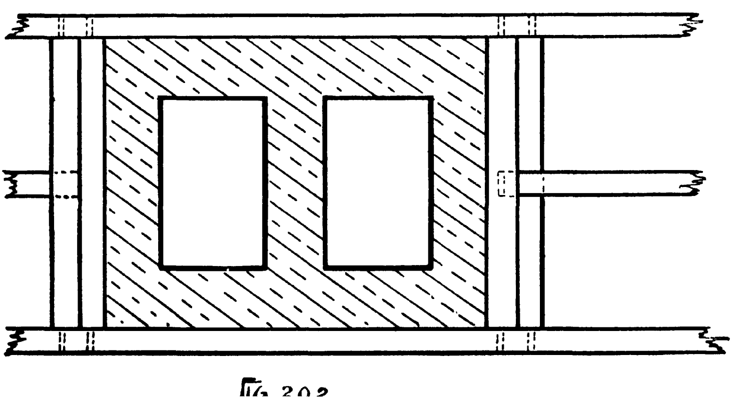


FIG. 202

development.) The bevels for the main roof are shown in Fig. 200.

The boards for supporting the lead to the valley have been omitted for clearness. The framing of the rafters about the chimney is shown in Figs. 201 and 202, but the section only for the gutter behind the chimney is shown.

COLLAR BEAM ROOF.—This roof is arranged by fixing a collar beam to each pair of rafters about ⅓ of the distance

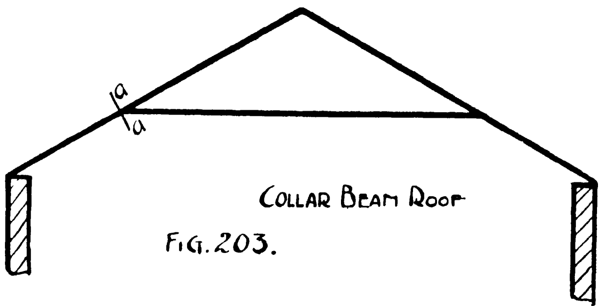


FIG. 203.

up above the eaves. This gives also increased height in the room below by raising the ceiling level. It will be seen that the common rafters are required to resist a bending stress at the point where the collar beam joins with them, *aa*, Fig. 203, especially as the walls are not likely

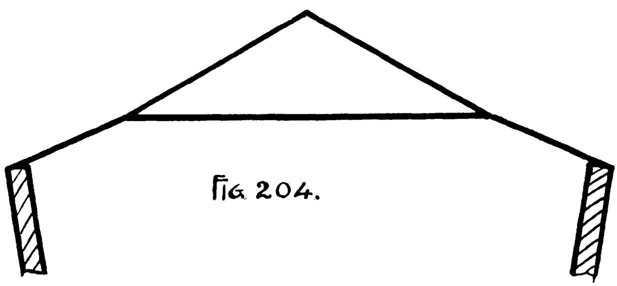


FIG. 204.

to be thick enough to resist an outward thrust from the roof. Fig. 204 is suggestive of this tendency, and as the common rafters are also slightly weakened at *aa* in making the joints, it becomes necessary to make them larger than usual, say, from $4\frac{1}{2}'' \times 2''$ to $6'' \times 2\frac{1}{2}''$ according to the span

The collar beam is bolted to the common rafters; the joint is shown in detail in Fig. 205.

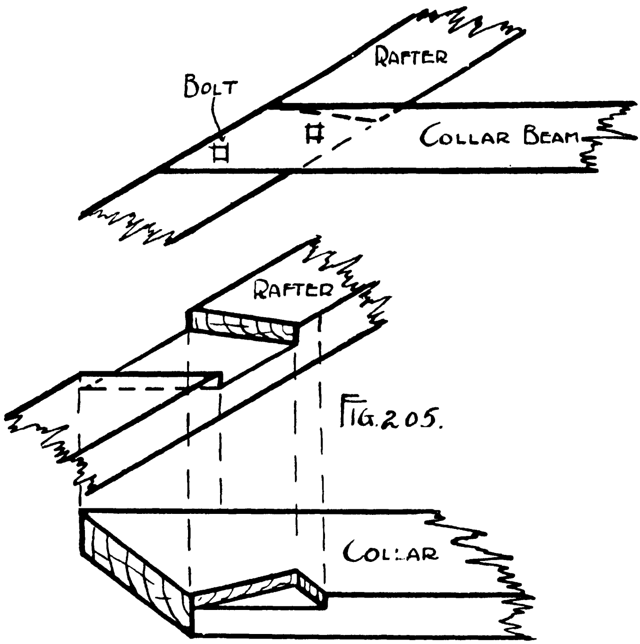


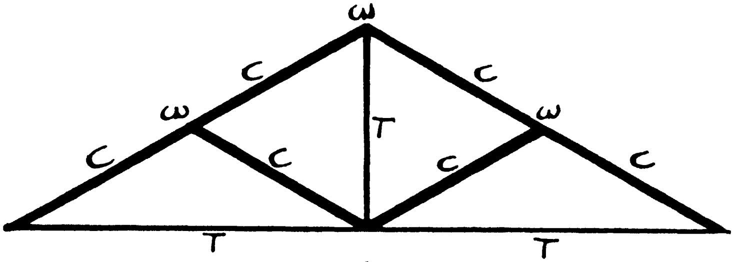
Fig. 205.

THE ROOF TRUSS.—For greater spans than those already dealt with and for buildings where interior walls, if any, are inadequate for the support of the ridge and purlins, the latter, and hence the weight of the roof, must be carried by trusses—that is, rigid frames. The trusses are, in arrangement, triangulated, and are designed to prevent outward thrusts on the walls.

The members of the truss are intended to resist either tensional or compressional stresses only, though cross stresses are occasionally introduced as in the case of tie-beams carrying ceiling joists, and in some instances floor joists where rooms are arranged in the roof.

Fig. 206 is a line diagram of the *King Post* truss, the thick and thin lines indicating members subject to compressional and tensional stresses respectively. The absence of cross strains is obtained by concentrating the weight of the roof at each angular point as shown (*w*). Common rafters should be supported at intervals of not more than 8 ft., so that if the distance between any two of the points of support exceeds this amount, a different form of truss must be used.

Fig. 207 is an elevation of a king post roof truss. This truss is, if well fitted together, an exceedingly strong one, and is suitable for spans from 18 ft. to 30 ft. The tie beam holds together the feet of the principal rafters, which in turn support the king post, and this at its lower end carries the struts and part of the weight of the tie beam.



C - COMPRESSION
FIG. 206. T - TENSION
·KING POST TRUSS·

It is usual to camber the tie beam by cutting the king post short to the extent of $\frac{1}{8}$ in. for every 3 ft. in span. This effectively tightens the whole of the joints in the frame when the tie beam and king post are drawn together, and the tendency to sag, or any appearance of sagging, is avoided.

Generally, the dimensions for the members of trusses are taken from tables deduced from calculations and experience, but figures from tables are not easily remembered, and the author suggests the following rule for determining the scantlings for a king post truss in Baltic fir, with trusses 10 ft. apart, pitch from 25° to 35°, and state covering:—

Span.	Thickness of Truss.
18 to 22 ft.	4 ins.
23 to 26 ft.	5 ins.
27 to 30 ft.	6 ins.

The above fixes one dimension of each member in the truss, the other measurements being in the following proportions:—

Tie beam in depth } = twice thickness + $\frac{1}{2}''$ to $1''$ according to span.
Principal rafters on elevation } = $\frac{4}{5}$ of thickness.
King post = $\frac{3}{4}$ „
Struts = $\frac{1}{2}$ „

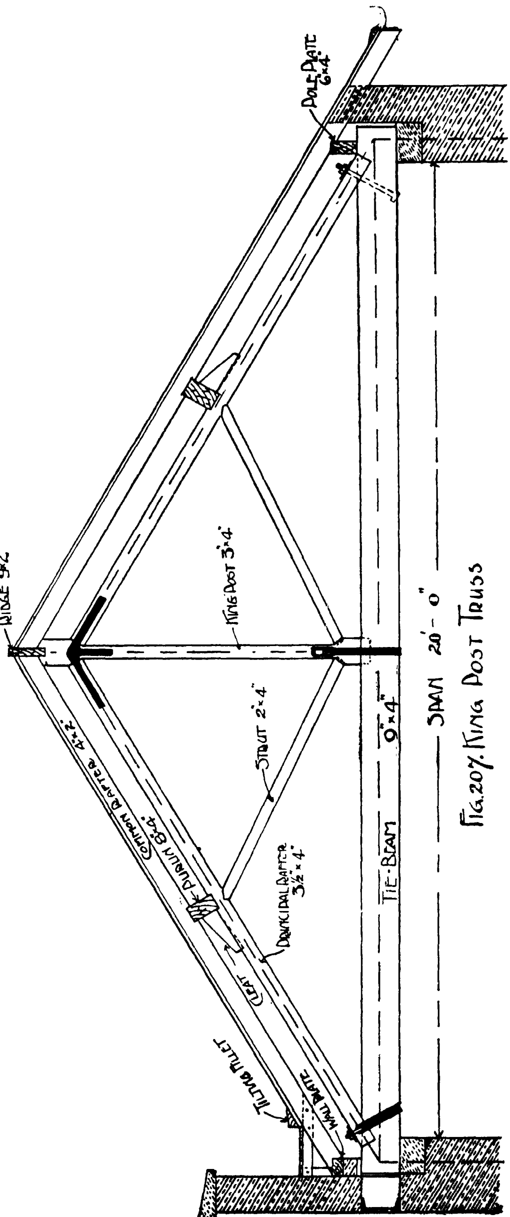


Fig. 207. King Post Truss

Example.—King post truss for 25-ft. span.

Thickness of truss	
Tie beam .	$10\frac{1}{2}''$ or $11'' \times 5''$
Principal rafters	$4'' \times 5''$
King post .	$3\frac{3}{4}'' \times 5''$
Struts .	$2\frac{1}{2}'' \times 5''$

The thickness of the purlins is the same as that of the truss, and their depth 8 or 9 ins. Common rafters vary from $3\frac{1}{2}'' \times 2''$ for 18 or 20 ft. span of roof to $5'' \times 2''$ for 30 ft. span.

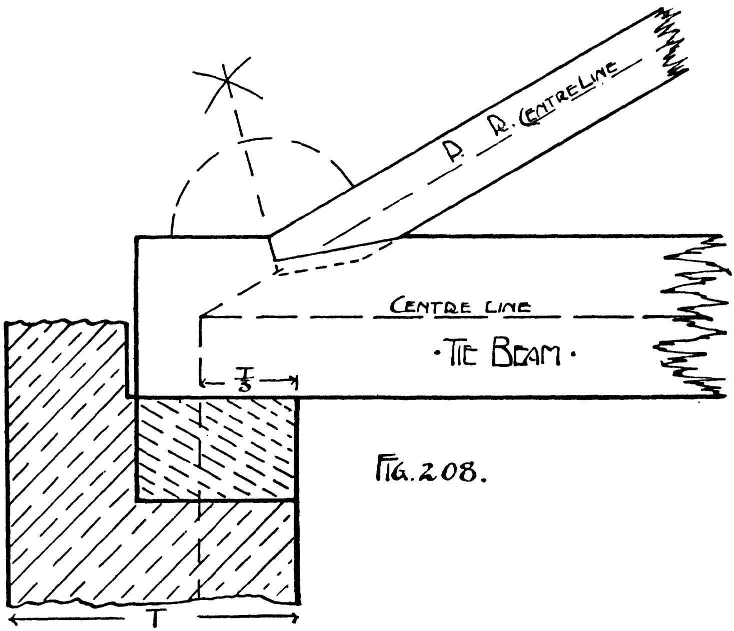


FIG. 208.

Stone templets are provided for the tie beams to rest on. A clear air space should be left about the ends of the latter to give free access for air about the ends of the roof timbers.

In fixing the relative positions of the principal rafters and tie beam, let the centre line of the two meet at a point distanced $\frac{1}{3}$ of the thickness of the wall from the inner face (*see* detail, Fig. 208). In the same figure the method of setting out the joint is given, and an oblique view of the same joint showing the stump tenon in Fig. 209. An alternative method to this is an oblique bridle joint, Fig. 210. The principal rafter is held

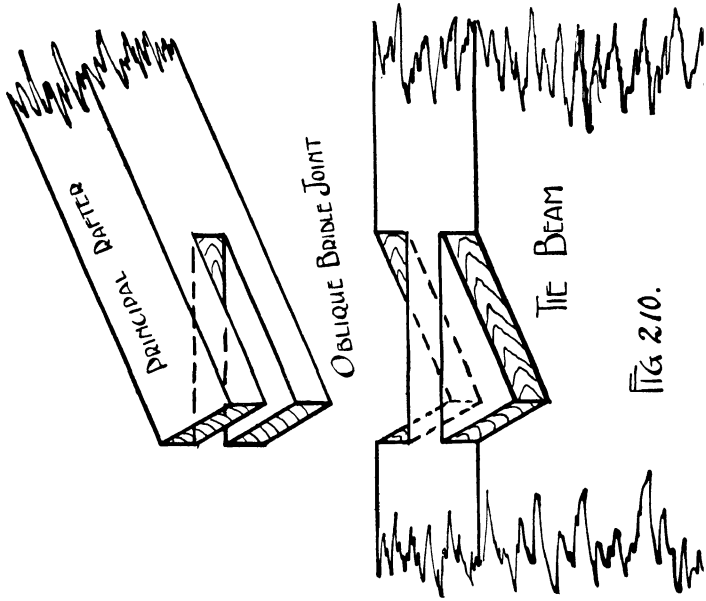


FIG 210.

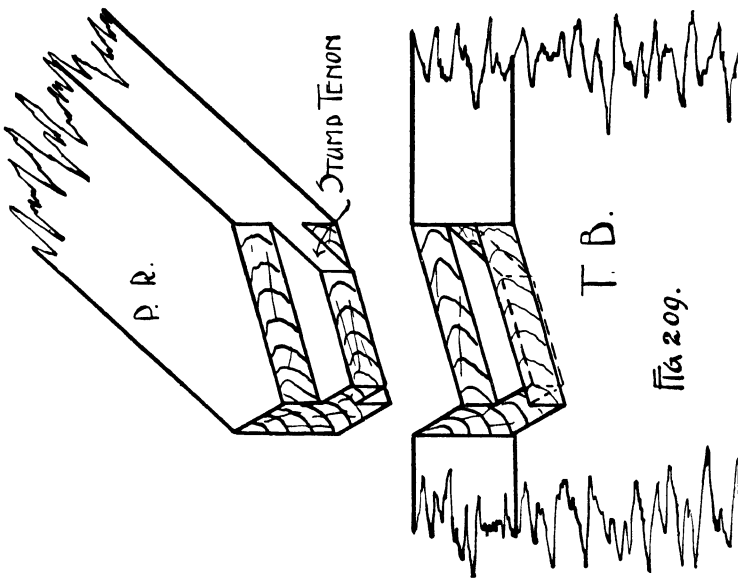


FIG 209.

in place either by a bolt or some form of wrought iron strap, as shown in Fig. 211.

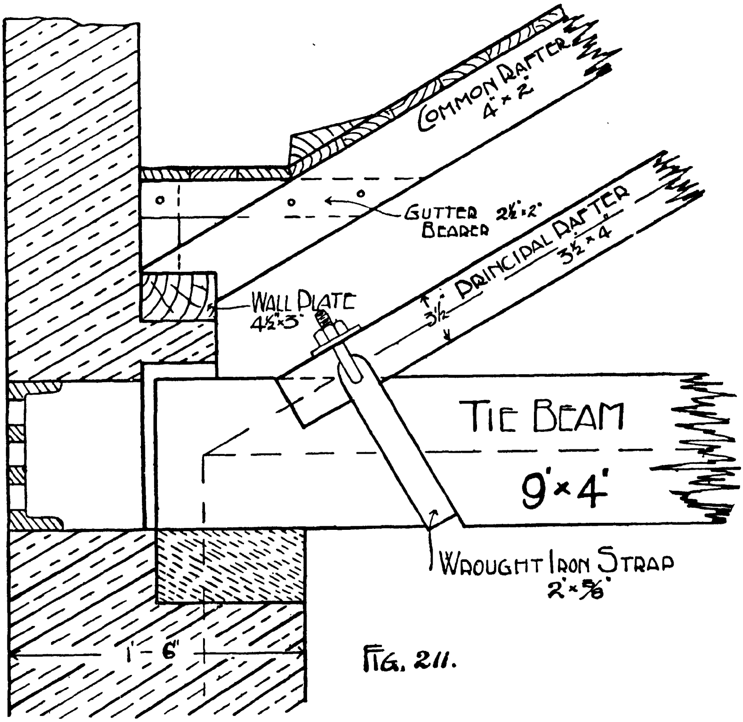


FIG. 211.

Figs. 212 and 213 are details of the joint at the foot of the king post; the struts are stump tenoned into the king post, and the latter is stump tenoned into the tie beam. The tie beam and king post are here shown held together by means of a wrought iron strap or stirrup, which is drawn upwards by means of cotters. These bear on the two gibs, which in turn press on the strap at the top and on the bottom of the mortise hole in the king post, indicated by the arrows.

To enable the strap to move upwards in tightening, the mortise hole must be cut at a point higher in the king post than would be reached by the slot in the strap. This is indicated as clearance in the section, Fig. 213, and in the detail, Fig. 214. Sometimes bolts are used through the strap in place of gibs and cotters, or the joint may be secured with a single bolt to pass upwards through the tie beam into the king post.

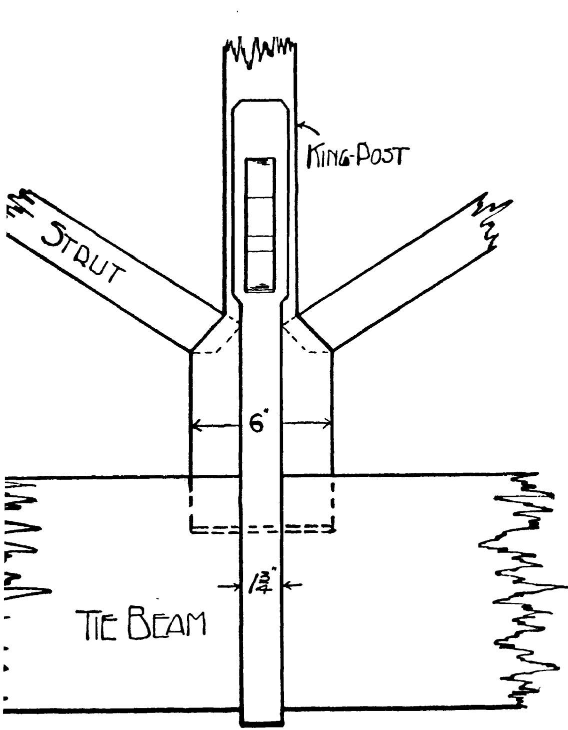


FIG. 212.

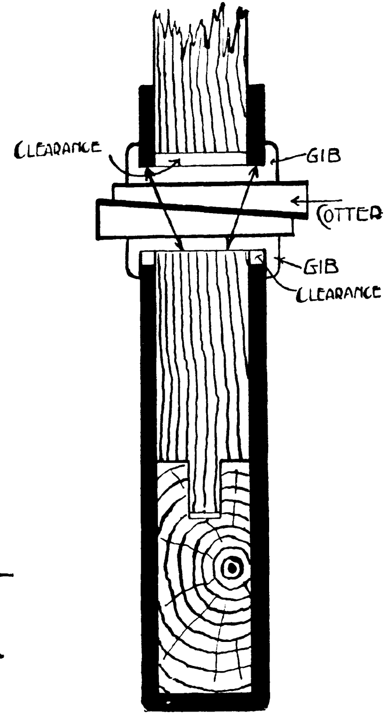


FIG. 213

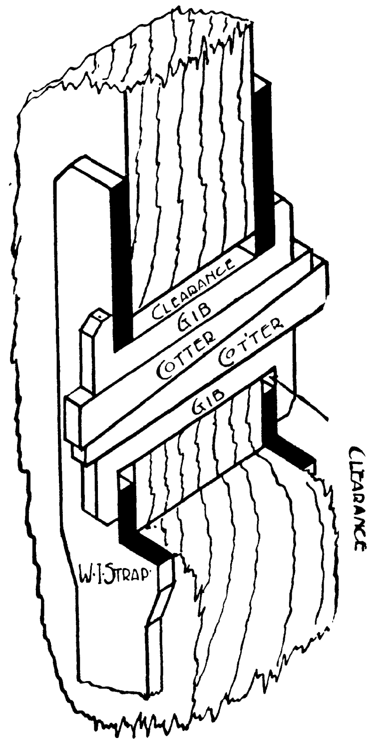


FIG. 214.

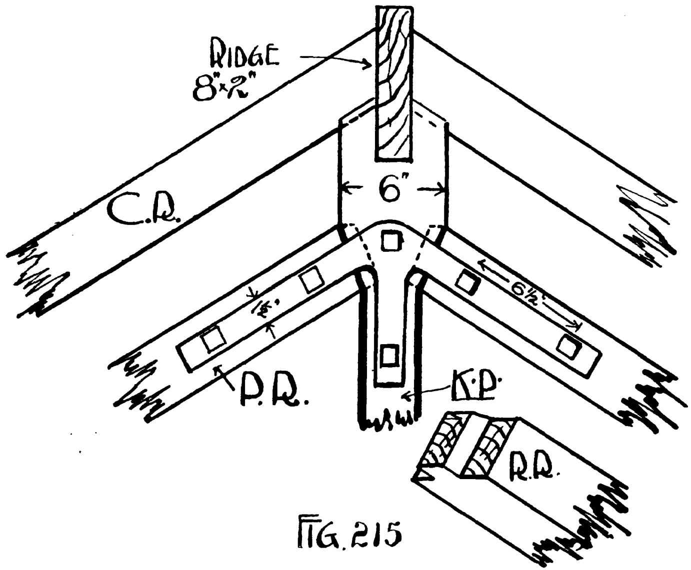


FIG. 215

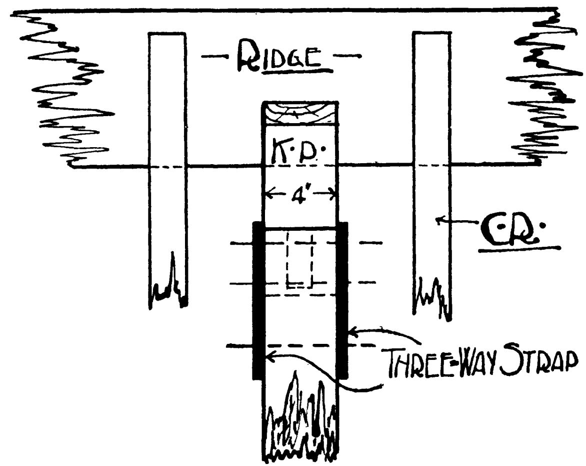


FIG. 216

Figs. 215 and 216 are the front and side views of the joint at the head of the king post. The principal rafter is stump tenoned into the king post, and wrought iron three-way straps, one on each side, are bolted through. The king post is carried up and slotted for the ridge piece as shown.

The gutter boards to receive the leadwork are supported by $2\frac{1}{2}'' \times 1\frac{1}{2}''$ gutter bearers, the upright and horizontal pieces being

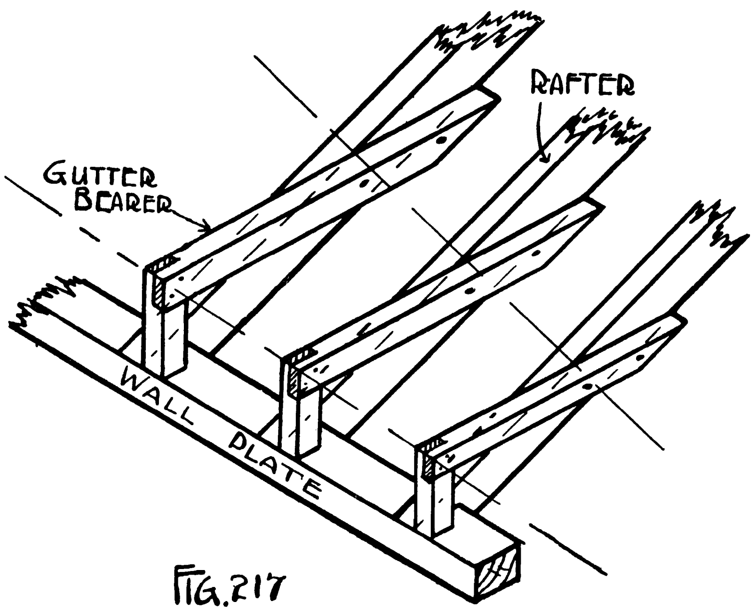


FIG. 217

halved together. They are nailed to the sides of the spars or rafters, and arranged to give fall for the gutter as shown (Fig. 217).

Figs. 218 to 220 are elevation, plan, and section of a roof to cover a square bay. The piece A, $3'' \times 2''$, may be fixed to the wall by nailing to plugs driven into the joints of the brickwork. The plugs are cut with an axe to have a slight twist, giving a parallel plug (Fig. 221).

The rafters are bird's-mouthed to the wall piece and to the $3'' \times 3''$ plates, which are halved or dovetail halved at the angles as shown (Figs. 222 or 223).

The hip pieces are $4\frac{1}{2}'' \times 2\frac{1}{4}''$, and are bevelled off on the top

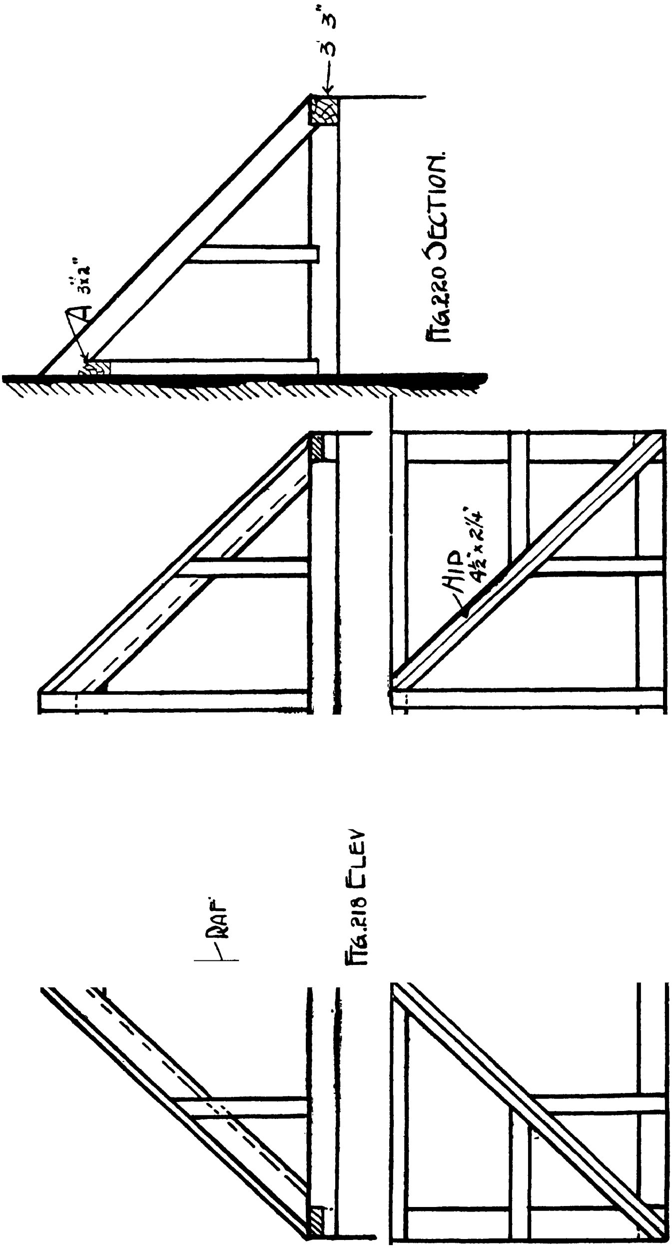
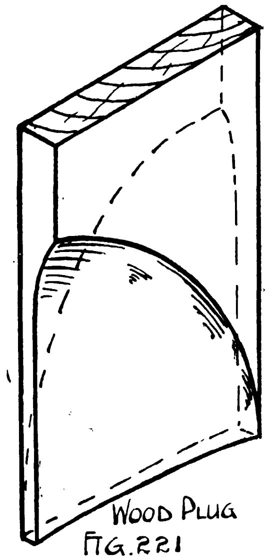


FIG. 220 SECTION

FIG. 218 ELEV

FIG. 219 PLAN

edge (*see* section, Fig. 224). The angle for this bevel is measured in a position at right angles to the hip, or at right



WOOD PLUG
FIG. 221

angles to the intersection line of two inclined surfaces as in a square pyramid, the plan and elevation of which is given

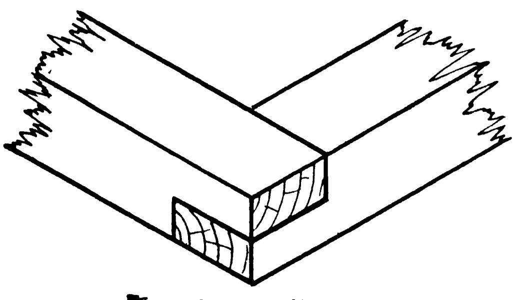


FIG. 222 ANGLE HALVING

in Fig. 225. The part section is taken on AB, so that A′B′ is the true length of the line of intersection of the two faces. Take a line from B″ to C at right angles to A′B′, then B″C is the altitude of a triangle whose base is DE. Make BC″ equal to B″C, and join from C″ to E, and C″ to D. The angle EC″D is the true angle between the two faces of the pyramid, and is known as the dihedral angle. A similar

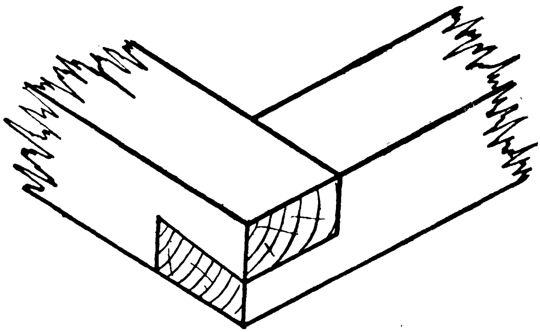


FIG. 223. DOVETAIL HALVED JOINT

operation is necessary in finding the angle for the backing of the hip rafter, and is shown in Fig. 226.

The plan of the hip is shown AB, and its true length is A′B′, B′C being made equal to distance H. The bevel for the plumb cut of the hip is shown at B′, and that for the ordinary rafter at D. The bevel for the backing of the hip is shown at

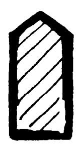


FIG. 224. SECTION OF HIP RAFTER

E, and the construction is similar to that just described. A jack rafter is shown in plan at FGHJ, and one bevel for this is shown at K, F′J′G′H′ being the true shape of the top edge of rafter.

STEEL SQUARE. — The steel square is an American invention, and is gradually coming into more general use in this country.

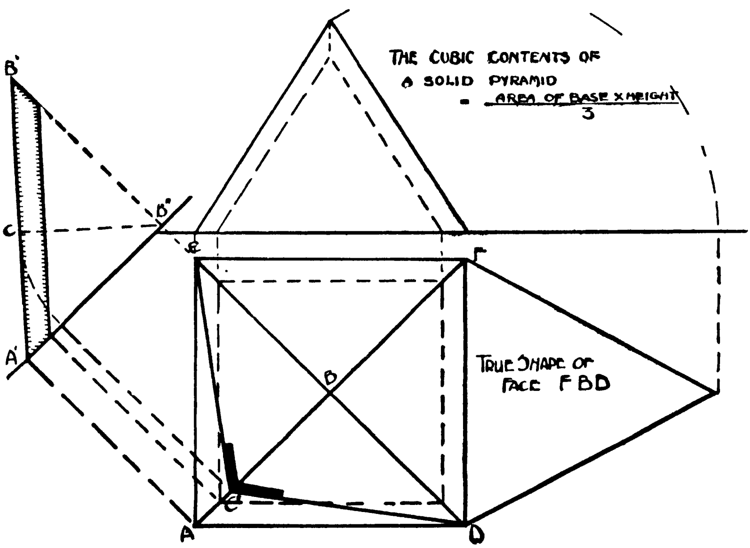


FIG. 225

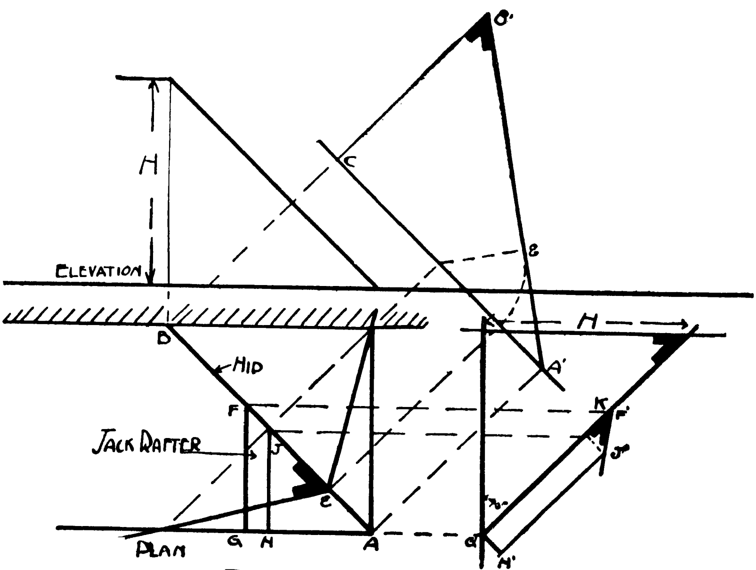


FIG. 226

The square has many uses, some of which will not be dealt with here. The blade is 24 ins. long and 2 ins. wide, and the

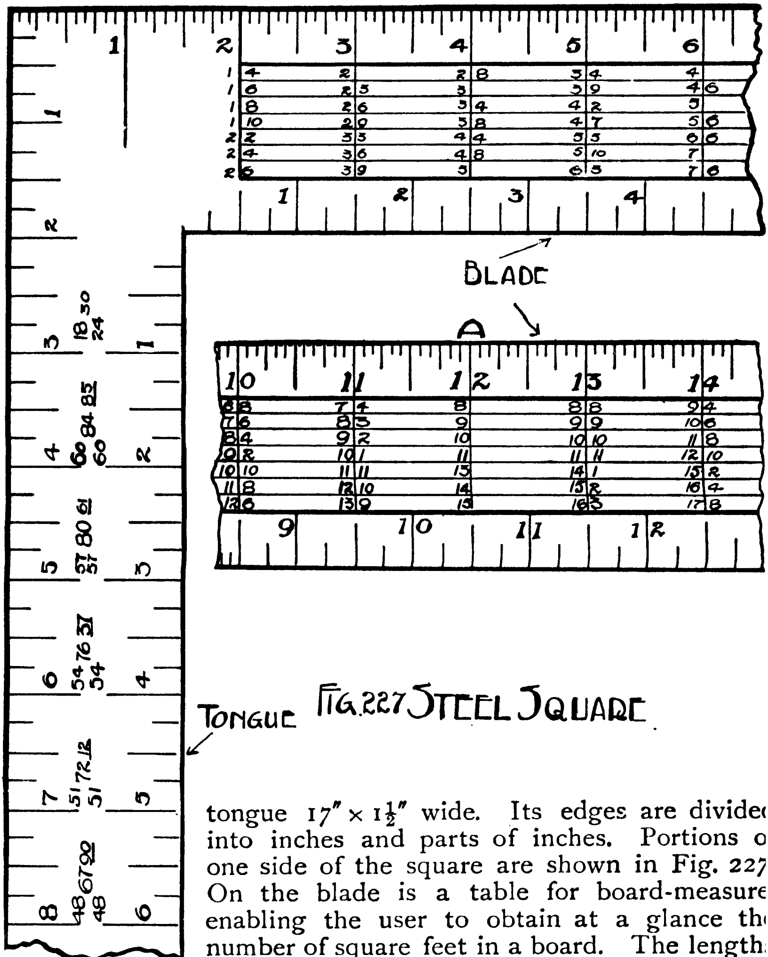


FIG. 227 STEEL SQUARE.

tongue 17" × $1\frac{1}{2}$" wide. Its edges are divide into inches and parts of inches. Portions o one side of the square are shown in Fig. 227 On the blade is a table for board-measure enabling the user to obtain at a glance th number of square feet in a board. The length of the boards in feet are given on line 1 —marked A—at the centre of the blade The outside edge figures are used for the widths of th board.

Example 1.—To find the number of square feet in a boar 9 ft. long 10 ins. wide.

On line 12 (or at A), Fig. 227, the 9 is on the second lin and along this same line under 10 of the outside inch divisions is 7 ft. 6 ins., which represents in feet and inches the number of square feet in the board.

If the board is 9 ft. long and $10\frac{1}{2}$ ins. wide, the number of square feet contained will be found by taking the average of the figures under 10 ins. and 11 ins., thus:—

	Sq. ft.	Sq. in.
	7	6
	8	3
2)	15	9
	7	$10\frac{1}{2}$ sq. ft.

Example 2.—Find the number of square feet in a board 13 ft. long and 14 ins. wide.

On line 12 find 13, and on this line, to the right under 14, is given 15 ft. 2 ins.

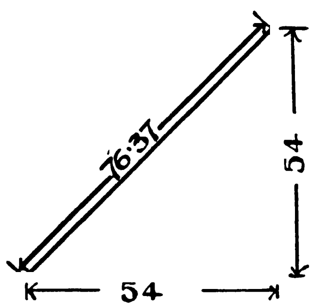


FIG. 228.

In addition to the ordinary divisions of inches on the tongue are some figures representing brace-measure.

Taking the figures under 6 of the outside edge we have $\genfrac{}{}{0pt}{}{54}{54}$ 76 37, which means that two lengths of 54 units at right angles to each other, as Fig. 228, would have a brace 76.37.

The proportions of the sides of a triangle as this are as

$$1 : \sqrt{2}$$

$$\text{or } 1 : 1.414.$$

Therefore the length of the brace is readily obtained by calculation as follows:—

$$54 \times 1.414 = 76.35.$$

Under 7 on the tongue we have $\genfrac{}{}{0pt}{}{51}{51}$ 72 12.

By calculation—$51 \times 1.414 = 72.11$.

The square is used also for obtaining the bevels for cutting rafters. Taking a roof of $\frac{1}{4}$ pitch as diagram, Fig. 229, the

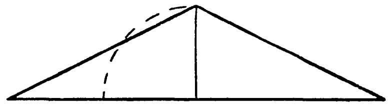


FIG. 229. ¼ PITCH OR RISE OF 6" TO 1 FOOT

rise would be 6 ins. to 1 ft. Fig. 230 shows the square placed on the end of a rafter, to the edge of which the 6" mark on

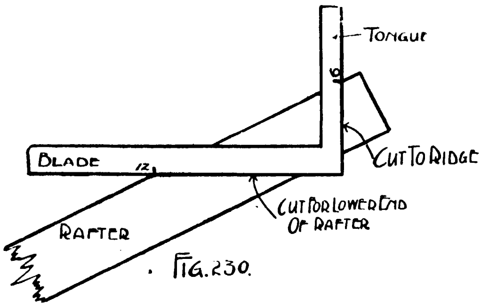


FIG. 230.

the tongue and 12" on the blade are placed, giving two cuts or bevels. A strip of wood cut as shown in Fig. 231 may be used as a fence against the back of the rafter when marking.

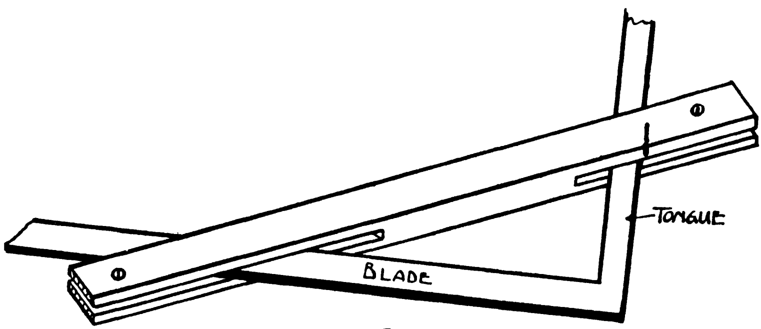


FIG. 231.

Now, assuming half the span of this roof (to the ends of the rafters) to be 10 ft., then the length of the rafter will be ten times the distance from 12 to 6, Fig. 230.

The calculation of length of the hypotenuse of any right-

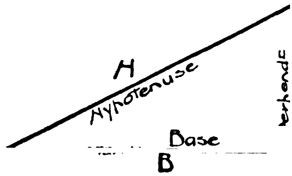


FIG. 232.

angled triangle, as Fig. 232, is based on Euclid I. 47, from which we have:—

$$H^2 = B^2 + P^2$$

$$\therefore H = \sqrt{B^2 + P^2}$$

$$= \sqrt{12^2 + 6^2}$$

$$= \sqrt{144 + 36}$$

$$= \sqrt{180}$$

$$= 13.4 \text{ ins.}$$

Or taking the lengths in the roof, viz., 10 ft. and 5 ft. rise.

$$\text{Then rafter in length} = \sqrt{10^2 + 5^2}$$

$$= \sqrt{100 + 25}$$

$$= \sqrt{125}$$

$$= 11.2 \text{ ft.}$$

QUESTIONS ON CHAPTER X

(1) Show how you would trim round a void in a roof-opening, 3′ × 2′ 4″, common rafters 4″ × 2″.

(2) The walls of a building 12 ft. long, which is to be roofed over, are 10 ft. apart. Is a truss necessary, and if not, why? Make a line diagram, and explain the type of roof you would use. Sketch the details of the most important joints.

(3) What is meant by "trussing"? Draw a line diagram of a king post truss; mark the points where the truss bears the weight of the roof, and explain the nature of the stresses on the members. Give the spans for which the king post truss is suitable.

(4) Show a line diagram of a king post truss; name the members and mark their dimensions for a span of 24 ft. To a scale of 3 ins. to 1 ft. draw an elevation and section of the joint connecting the king post and tie beam, using a wrought-iron stirrup with gibs and cotters. Explain the action of the latter.

(5) Why and how is the tie beam of a king post truss cambered? Draw details showing two methods of connecting the tie beam and principal rafter, and show metal fastenings in each case.
Scale 3 ins. to 1 foot. Make oblique sketches, showing the pieces apart.

(6) To a scale of 4 ins. to 1 ft. draw the joints at the head of the king post, including ridge piece $8'' \times 1\frac{1}{2}''$, ends of common rafters $4'' \times 2''$, and $1\frac{3}{4}'' \times \frac{3}{8}''$ wrought-iron three-way straps bolted through. Also show the section of an $8'' \times 5''$ purlin, supported by a cleat, and resting on the back of the principal rafter over the strut.

(7) Price the king post truss mentioned in Question 4 at 3s. 3d. per cubic foot.

(8) Draw a collar beam roof suitable for a span of 15 ft. Scale $\frac{1}{2}$ in. to 1 ft. Draw details of the joint connecting the collar beam and the rafter.

(9) A roof of the collar beam type shows signs of failure by bending at the joint of the collar and rafter. Why is this? Can you suggest a method for rectifying the fault?

(10) Draw a square pyramid of 4 ins. base and $3\frac{1}{2}$ ins. altitude, and find the following: true shape of an inclined face, true length of the intersecting edge of two inclined faces, the angle of one inclined face to the other.
Find the number of cubic inches in the pyramid where

$$\text{contents} = \frac{\text{area of base} \times \text{height}}{3}$$

(11) The span of a roof to the ends of the rafters is 30 ft., and the pitch $\frac{1}{3}$. Explain and illustrate by sketches, etc., how you would find the bevels and the length of the common rafters, by the use of the steel square. Also find the length of the rafters by calculation.

CHAPTER XI

CENTRES

CENTRES are temporary arrangements to give support for the bricks or stones (voussoirs) of which an arch is composed during its construction.

For segmental or flat arches up to 4 ft. or 6 ft. span, and 4½ ins. on the soffit, a single board from 1 in. to 2½ ins. thick,

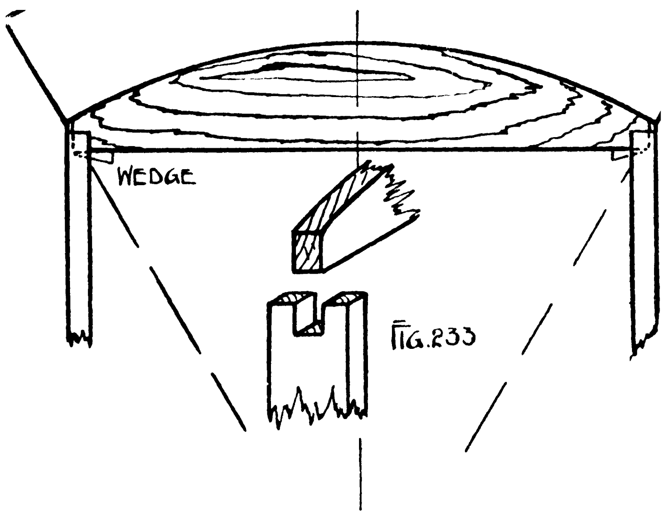
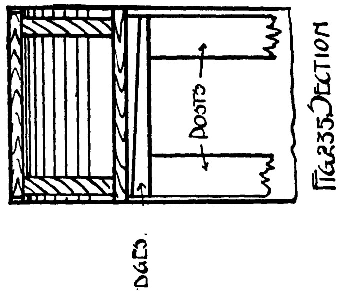


FIG. 233

called a turning piece, is all that is required for the centre. The board is cut to the shape of the arch, as shown in Fig. 233, and two upright pieces are slotted at the top ends to receive and support the centre; and small wedges may be inserted, as shown, to facilitate the easing of the centre. The lowering or easing of the centre should be just sufficient to enable the bricks to take their natural bedding in the mortar when the arch is completed.



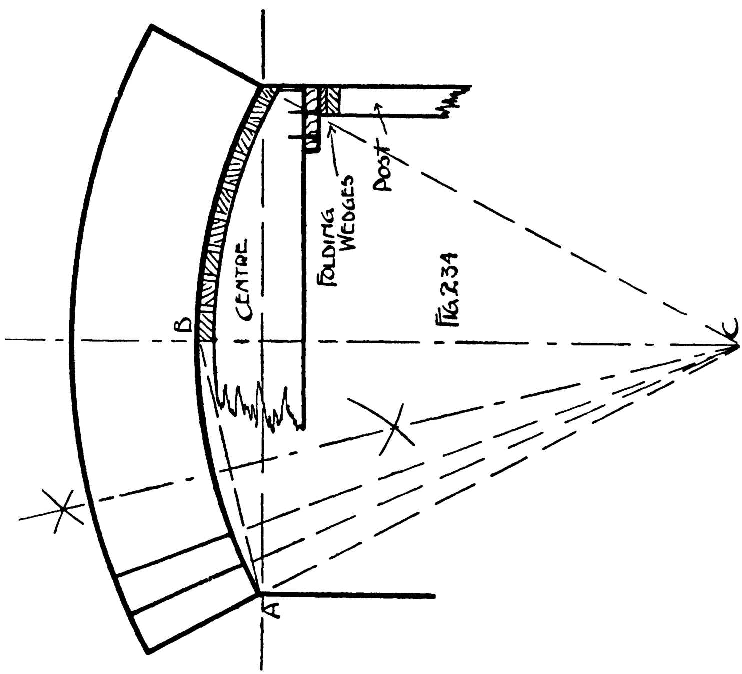


Fig. 234 shows a centre suitable for heavier and deeper arches than the last, and consists of two turning-pieces or ribs with laggings nailed to their top edges as shown. The laggings to this centre are $1\frac{1}{2}'' \times \frac{3}{4}''$, and $\frac{1}{2}$ in. apart, their length being slightly less than the thickness of the arch. Folding wedges, as shown in Fig. 235, are placed between the upright supports and the centre for easing purposes.

The geometrical setting out for segmental arches is shown, Fig. 234. Given the span and rise, the line AB is bisected to

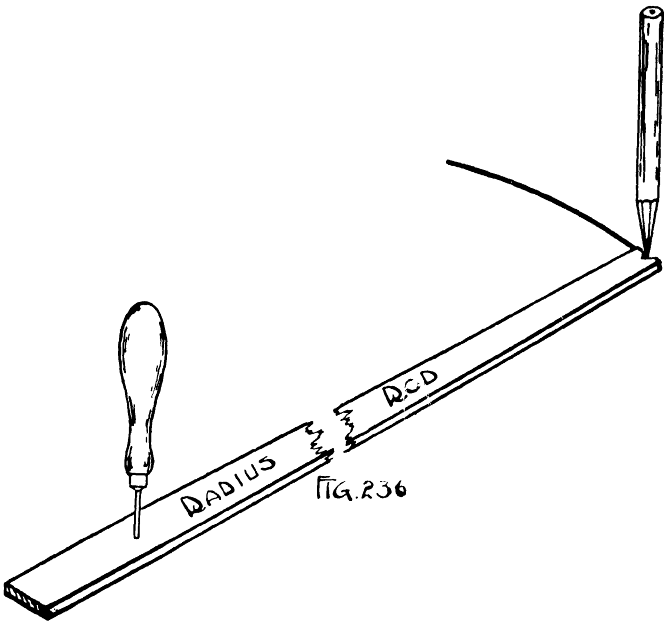


FIG. 236

obtain the centre (C) for the curve, which may be drawn in the workshop either with a radius rod, Fig. 236, or with a piece of string.

The length of the radius for the curve in segmental arches may be found sometimes more conveniently by calculation than by geometry.

The span or opening and the rise are generally given, and the rule is:—square half the span, divide by the rise, to this add the rise and divide by two.

$$\text{Radius} = \frac{\left[\left(\frac{\text{span}}{2}\right)^2 \div \text{rise}\right] + \text{rise}}{2}$$

Taking an opening of 4 ft., rise 6 ins.

$$\text{Then } R = \frac{(\frac{4}{2} \times \frac{4}{2} \times \frac{2}{1}) + \frac{1}{2}}{2}$$

$$= \frac{8 + \frac{1}{2}}{2} = 4 \text{ ft. } 3 \text{ ins.}$$

In other cases where the opening is large and the rise comparatively small, necessitating an unusually lengthy radius rod

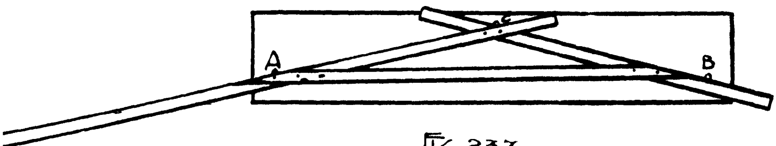


FIG. 237.

for striking the curve, a lightly constructed triangular frame may be used, as shown in Fig. 237.

Nails are driven at ABC—AB is the span and OC the rise. The frame is made to touch these as shown In making the

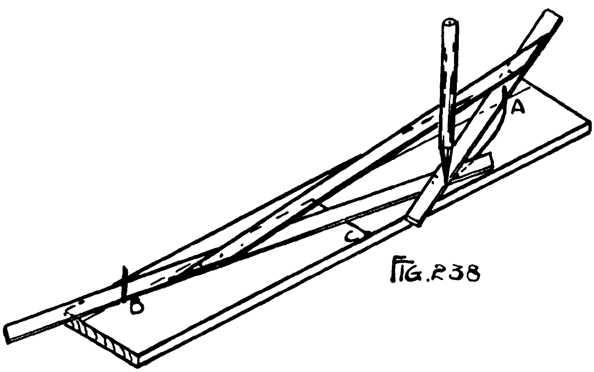


FIG. 238

curve the pencil is held where the laths cross each other at C, and the frame made to slide against nails A and B, as shown in Fig. 238.

Fig. 239 shows a centre for a semi-elliptical arch. The tie and the ribs to which the laggings are nailed consist of 1-in. boards nailed together as shown.

Various methods of obtaining the elliptical curve are given.

In Fig. 240 the lines BC and OC are each divided into the

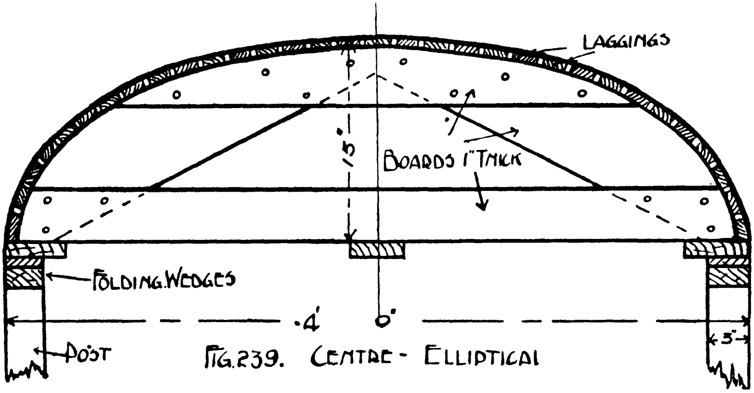


FIG. 239. CENTRE - ELLIPTICAL

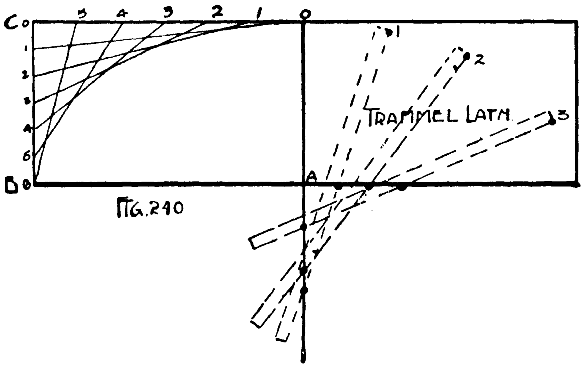


FIG. 240

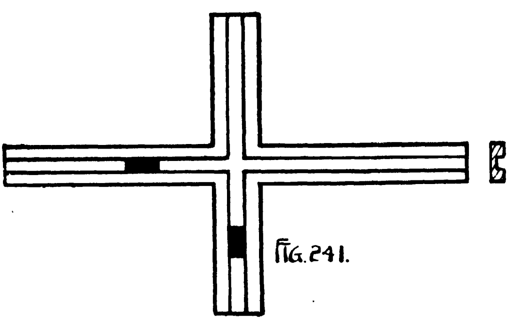


FIG. 241.

same number of parts, and the points joined as shown. The cross lines are tangents to the curve.

The trammel method is that in which grooved pieces of wood are arranged in a cross as shown, Fig. 241. Trammel

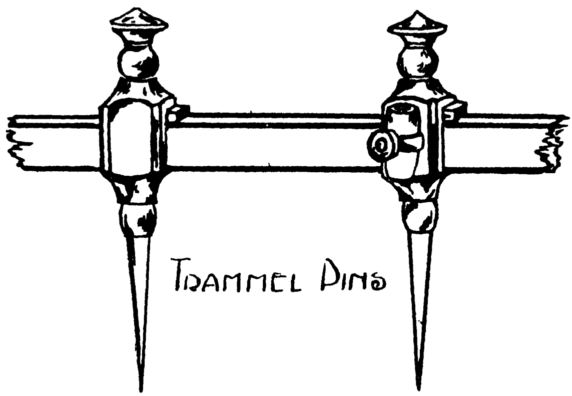


FIG. 242

pins (illustrated, Fig. 242), are adjusted on a loose bar so that AO is equal to half the minor axis and A′B equal to half the

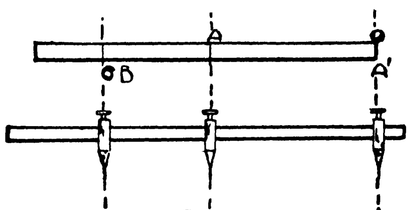


FIG. 243

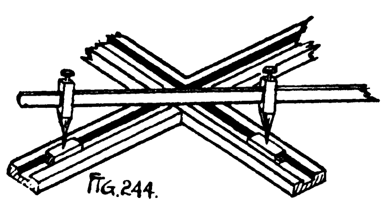
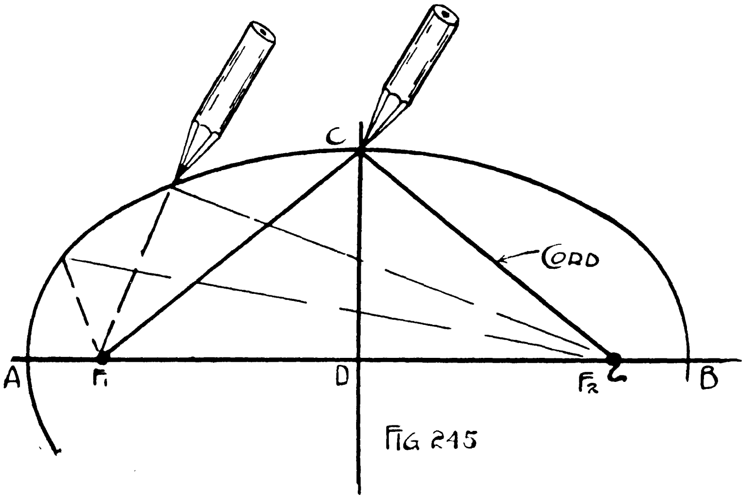


FIG. 244.

major axis (Fig. 243). The pins AB are fixed in small blocks (as shown in Fig. 244) which slide along the grooves, and the curve is marked out by the pin or pencil A′.

A similar method is shown in Fig. 240, where a lath is marked with the distances of half the major and half the minor axes as before indicated, A'B and AO. A number of points in the curve are then marked as 1, 2, 3 by keeping point B on the minor axis and point A on the major axis.



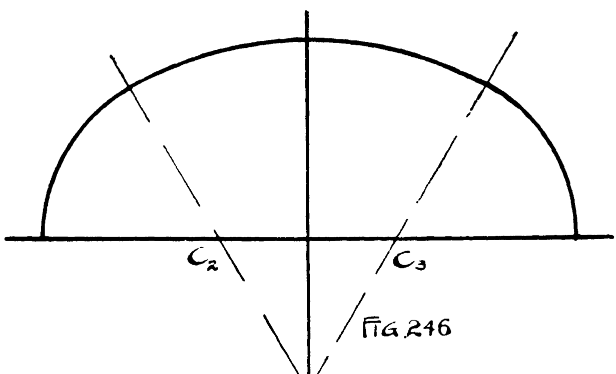


Fig. 245 shows a good workshop method of obtaining the curve. AB is the span and CD the rise. With distance AD mark CF_1 and CF_2 from point C. Drive nails at F_1 F_2, and attach a cord to reach from F_1 to C, and secure at F_2. Mark the curve by sliding the pencil as shown.

For another method see chap. iv. p. 171.

Fig. 246 is a curve struck from three centres; C_2 C_3 are obtained by dividing the span into three equal parts, and through these points lines are drawn at 60° to find C_1.

QUESTIONS ON CHAPTER XI

(1) A centre is required for a small segmental arch of 4-ft. span and 8-in. rise; draw the centre and show clearly the method of striking the curve. Also find the length of the radius by calculation.

(2) Show how you would strike a curve for a centre, segmental in shape, without using its radius length.

(3) Draw an elevation and section of a centre suitable for the support of a semi-circular arch 4 ft. 6 ins. span, and 18 ins. on the soffit. Show clearly the method of easing and striking the same. Give the dimensions and name the parts. What is the area of the soffit of this arch?

(4) Sketch a set of trammel pins, and explain the method of using them in striking a curve for an elliptical centre. Show two other methods of obtaining this curve.

CHAPTER XII

THE SCREW

Fig. 247 is an end view of a woodworker's bench showing a vice, and Fig. 248 is a front view of the latter. A piece of wood is shown held firmly in the vice by pressure due to the tightening of the screw.

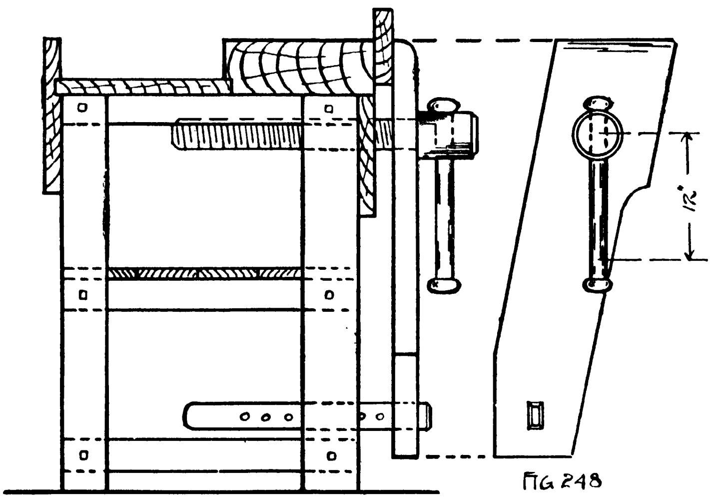


FIG 248

FIG 247

In construction a screw consists of a cylinder with a projection of uniform section forming a kind of inclined plane of spiral form.

Fig. 249 is the plan and elevation of a cylinder. In plan the circumference is divided into six equal parts, 0, 1, 2, 3, 4, 5, and from these points projectors are taken into the elevation. In the triangle ABC, Fig. 250, AB is an assumed distance, and

AC is made equal to the distance round the cylinder, which may be obtained by one of three methods—

(*a*) Geometrically—by points, 1, 2, 3, 4, 5 (Fig. 250) from the distances in plan, Fig. 249.

(*b*) Diameter multiplied by 3.1416, usually written $d\pi$.

(*c*) The distance DE, obtained as shown in plan, Fig. 249, equals half the circumference (approximately).

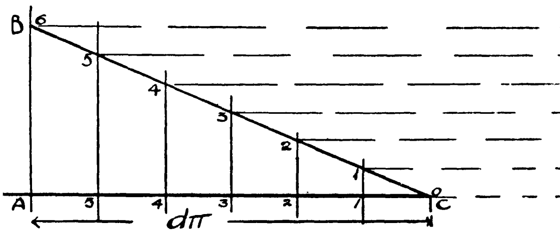


FIG. 250.

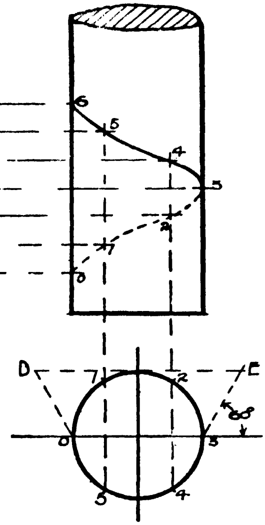


FIG. 249

Transfer the points from the hypotenuse BC of the triangle to the elevation, and intersect as shown; then the helical curve, of which the elevation is found by drawing through the points, is the same as would be obtained by wrapping the triangular piece of paper cut as ABC in Fig. 250 round the cylinder.

One form of thread is shown in Fig. 251. An object moving on the surface of the thread from A downwards would travel round the screw once on reaching B, and the perpendicular distance moved from A to B is termed the pitch of the thread.

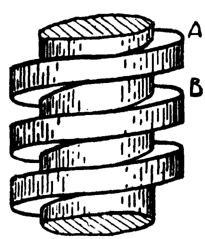
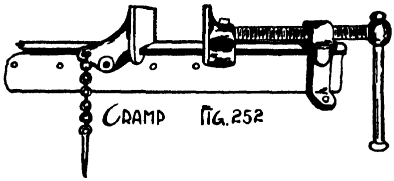


FIG. 251

Similarly, the screw on making one revolution in a fixed nut moves bodily in the direction of its axis the distance AB.

It is the same in the case of the screw in the vice, Fig. 247 or the cramp, Fig. 252.



CRAMP FIG. 252

The thread for the vice screw is shown in Fig. 253, and this screw on making one revolution would move the distance of the pitch of the thread AC.

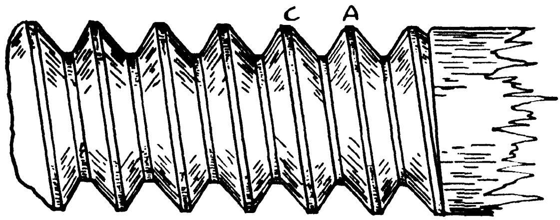


FIG. 255

In the triangle ABC, Fig. 254, let BC represent the circumference of the thread and AC the pitch. Now in raising

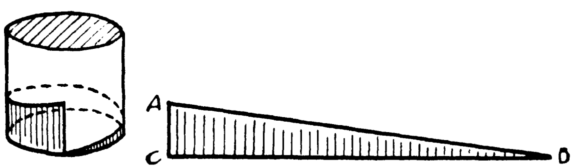


FIG. 254

a weight (W) from C to A by rotating the screw, the work done will be equal to

$$W \times AC$$

and if the power (P) were applied upon the circumference of the thread, then the work done by the power (P) is

$$P \times \text{circumference or } P \times BC$$

Hence we get the equation

$$P \times BC = W \times AC$$

But in most cases in practice the power is not applied upon the circumference of the thread or screw, but along the circumference of a circle described by a lever, such as the handle of a vice or cramp, the power being applied close to the end.

Suppose the effective length of the power arm in the vice handle to be 12 ins., then the circumference described by P is:—

$$d\pi \text{ or } 2\pi r = 24 \times 3.1416$$
$$= 85.47, \text{ say } 85\tfrac{1}{2} \text{ ins.}$$

Taking the pitch AC at $\frac{3}{4}$ in. and the power or turning force applied to the handle as 60 lbs. we have—

$$P = 60 \text{ lbs.}$$
$$\text{circumference} = 85\tfrac{1}{2} \text{ ins.}$$
$$\text{Pitch} = \tfrac{3}{4}''$$
$$\text{Then } P \times \text{circumference} = W \times \text{pitch}$$
$$60 \times 85\tfrac{1}{2} = W \times \tfrac{3}{4}''$$
$$5130 = W \times \tfrac{3}{4}''$$
$$W = \frac{5130 \times 4}{3}$$
$$= 6840 \text{ lbs.}$$

No allowance has been made for friction, which, of course, may be reduced by the use of blacklead on the thread, but in any case the resistance to the turning force (P) by friction is very great, reducing the efficiency of the screw to about 30%. Therefore $\frac{30}{100} \times \frac{6840}{1} = 1952$ lbs. only is the approximate amount of force applied against the vice by the screw.

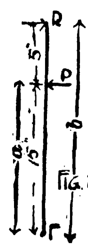


FIG. 255

Fig. 255 is a diagrammatic representation of the vice, and from the distances given the pressure on the piece of wood in the vice offering resistance R can be found.

Taking moments about F we get—

$$P \times a = R \times b$$
$$\therefore R = \frac{P \times a}{b}$$
$$= \frac{1952 \times 15}{20}$$
$$= 1464 \text{ lbs.}$$

Bolts used in securing straps at the joints in roof trusses, or in bolting together the parts of a flitched beam, are other instances where pressure is applied by tightening with a screw thread.

Example.—A nut on a 1 in. bolt is tightened by means of a wrench or key. The turning force or power (P) is 30 lbs., and the distance from the centre of the bolt to the point at which the power (P) is applied is 10 ins. The pitch (p) of the thread of the bolt is $\frac{1}{8}$ in. Find the pressure (w), the efficiency being .25.

We have per revolution—

$$P \times 2\pi r = wp$$

If E = efficiency

$$\text{then } P \times 2\pi r \times E = wp$$

$$\text{and } w = P \times 2\pi r \times E \div p$$

$$= \frac{30}{1} \times \frac{2}{1} \times \frac{22}{7} \times \frac{10}{1} \times \frac{25}{100} \times \frac{8}{1}$$

$$= 3771 \text{ lbs.}$$

to the nearest lb., which is quite sufficient accuracy, as the efficiency is not known exactly.

Again, each end of the tie-rod of the trussed beam, Fig. 120, is threaded, and the rod is tightened by nuts bearing on the plates; so that the rod will be subject to a low tensional stress—quite apart from that produced by the loading of the beam—due to the tightening of the nut at one end.

Example.—In tightening a nut at the end of a tie-rod, P, 10 lbs. is applied to a wrench at a point 9 ins. from the centre of the nut — the pitch being $\frac{1}{7}$ in. Find the tension in the rod. Efficiency = .25.

We have per revolution of nut—

$$P \times 2\pi r \times E = wp$$

$$\therefore \text{ tension in rod } (w) = P \times 2\pi r \times E \div p$$

$$= \frac{10}{1} \times \frac{2}{1} \times \frac{22}{7} \times \frac{9}{1} \times \frac{25}{100} \times \frac{7}{1}$$

$$= 871 \text{ lbs. to the nearest lb.}$$

The efficiency of screw threads depends upon the amount of friction, and the friction varies very considerably according to conditions. The shape and roughness of the threads are determining factors; the square thread, for instance, is more efficient than the V-thread, although the V-thread is the stronger. Also, the roughness or otherwise of the surfaces in contact, such as those of the nut and the washer or plate, will affect the efficiency.

WOOD SCREWS.—The efficiency of wood screws is very low on account of the excessive friction, which, however, may be reduced by boring a hole into the timber so that the shank of the screw will fit easily. The thread of the screw will cut its own way into the fibres, excepting in very hard wood, in which case the hole for the shank should be continued, but of a much smaller diameter.

QUESTIONS ON CHAPTER XII

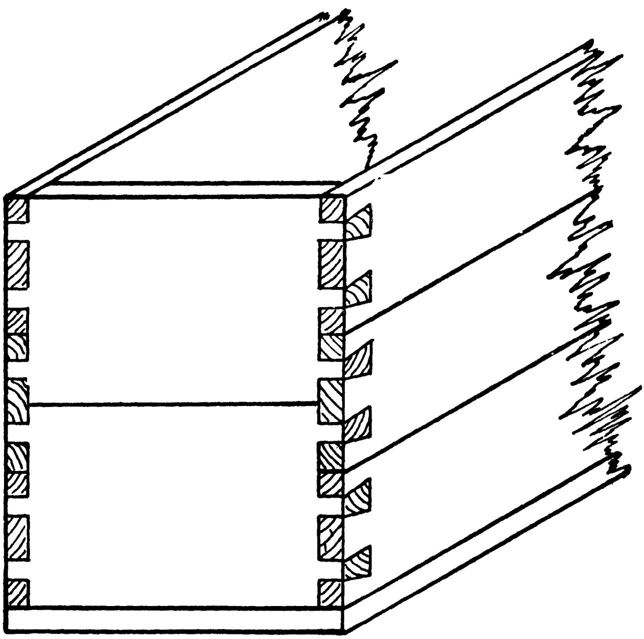
(1) A frame is screwed up by means of a cramp, the pitch of the screw thread being $\frac{1}{4}$ in. The radius of the arm by which the screw is turned is 10 ins., and the force applied at the end is 30 lbs. What pressure will be exerted upon the frame, allowing a 40% efficiency?

(2) In a screw jack the handle is 18 ins., the screw being actuated from the centre. The power applied to the handle (P)=20 lbs. Find the pressure exerted per revolution when the pitch of the screw thread is $\frac{3}{4}$ in., efficiency ·35.

CHAPTER XIII

CISTERN AND JOINTS

FIG. 256 shows a portion of a wooden cistern, the sides of which are made of three 1-in. boards, and the ends of two 1-in. boards. The sides and ends are dovetailed together, and



PORTION OF WOODEN CISTERN FIG. 256

it will be seen that the pins and dovetails are cut so as to lock the separate pieces together. The capacity of the cistern is to be 8 cu. ft., and for convenience in fixing it must be 2 ft. 6 ins. long and 18 ins. wide (inside measurements).

The depth, therefore, will be—

$$\text{Depth} = \frac{8}{2\frac{1}{2} \times 1\frac{1}{2}} = \frac{8}{1} \times \frac{2}{5} \times \frac{2}{3} = 2\tfrac{2}{15}, \text{ say 2 ft. 2 ins.}$$

The cistern will require the following timber:—

2 Sides 2′ 8″ × 2′ 2″ × 1″ =

$$\begin{array}{lll} 2 & 8 & \\ 2 & 2 & \\ \hline 5 & 4 & \\ & 5 & 4 \\ \hline 5 & 9 & 4 \end{array} \times 2 = 11' \ 6'' \ 8'''$$

2 Ends 1′ 8″ × 2′ 2″ × 1″ =

$$\begin{array}{lll} 1 & 8 & \\ 2 & 2 & \\ \hline 3 & 4 & \\ & 3 & 4 \\ \hline 3 & 7 & 4 \end{array} \times 2 = 7' \ 2'' \ 8'''$$

1 Bottom piece 2′ 8″ × 1′ 8″ × 1″ =

$$\begin{array}{lll} 2 & 8 & \\ 1 & 8 & \\ \hline 2 & 8 & \\ 1 & 9 & 4 \\ \hline 4 & 5 & 4 \end{array} = 4' \ 5'' \ 4'''$$

$$23' \ 2'' \ 8'''$$

Say $23\frac{1}{4}$ sq. ft.

1 in. yellow pine is about 4d. per square foot.

The capacity of this cistern is 50 gallons since 1 cu. ft. is 6.25 gallons. The weight of a cubic foot of water is 62.5 lbs., or of a gallon 10 lbs. Therefore the total weight =

$$50 \times 10 = 500 \text{ lbs.}$$
$$\text{or } 62.5 \times 8 = 500 \text{ lbs.}$$

If the cistern is to be fixed against a wall, it may be supported on two wooden brackets constructed as shown, Fig. 257. The joint at A is a common dovetail joint, shown, Fig. 258.

The line diagram, Fig. 259, is taken from the centre lines of the members as BC DC, Fig. 257. Assuming that of the total weight of the cistern and water 170 lbs. is to be supported by

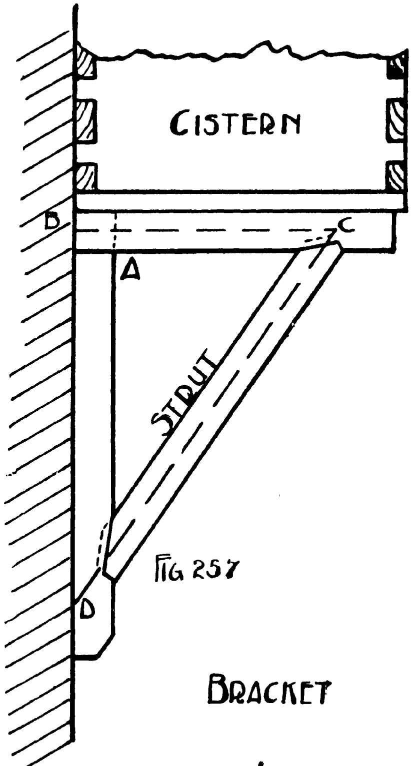
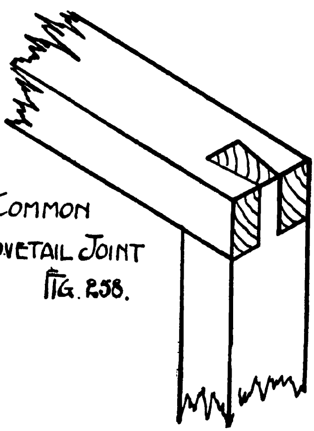


FIG 257

BRACKET



COMMON DOVETAIL JOINT

FIG. 258.

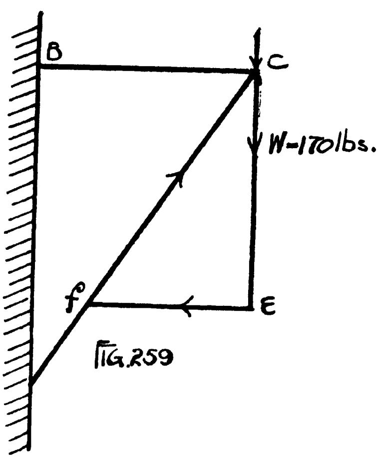
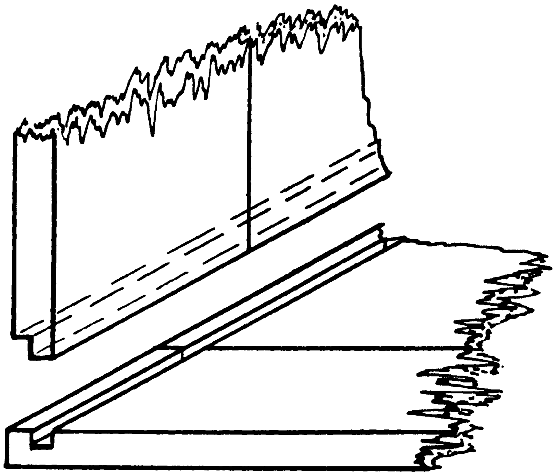


FIG. 259



CROSS-GROOVING FIG. 260

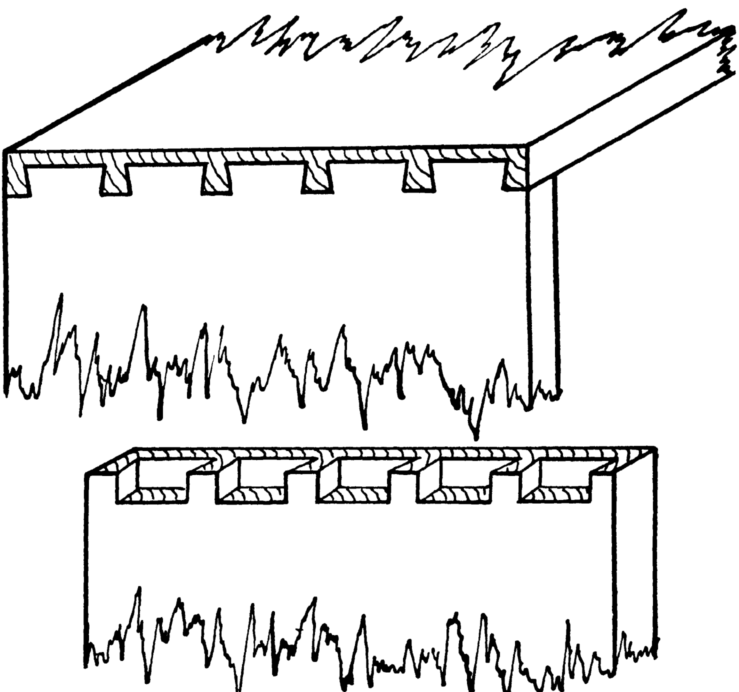


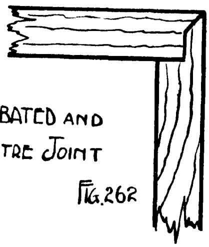
FIG. 261. LAPPED DOVETAIL

the bracket at C. Scale C*e* equal to 170 lbs. and join from *e* to *f* parallel to BC. Then *ef* measured to the scale represents the tension in BC, and *f*C gives the compression in the strut DC.

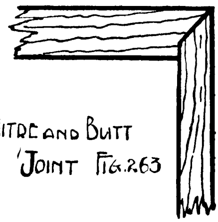
Sometimes cross-grooving is resorted to for the end joints in cisterns and for similar work, as shown, Fig. 260, but this is not so strong as the dovetail joint.

A lap dovetailed joint is shown, Fig. 261. This form of joint is not so strong as the one used in the cistern, but is useful in cases where the dovetail is required to be out of sight as in drawer fronts.

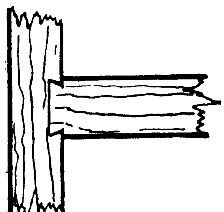
MISCELLANEOUS JOINTS.—Figs. 262 to 265 are heading joints



REBATED AND MITRE JOINT FIG. 262

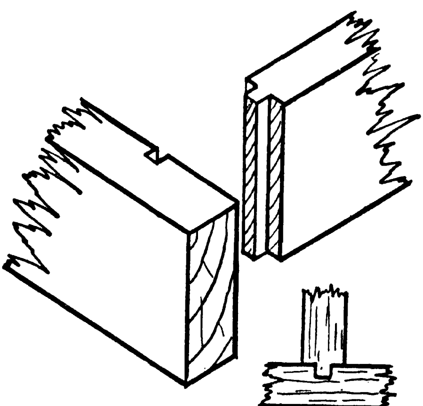


MITRE AND BUTT JOINT FIG. 263



DOVETAILED HOUSING. FIG. 264

used where the ends of timber are to be joined. A fox-tail tenon is formed by making saw kerfs in the stump tenon,



TONGUED HOUSING FIG. 265

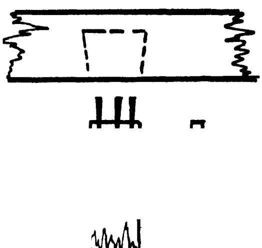
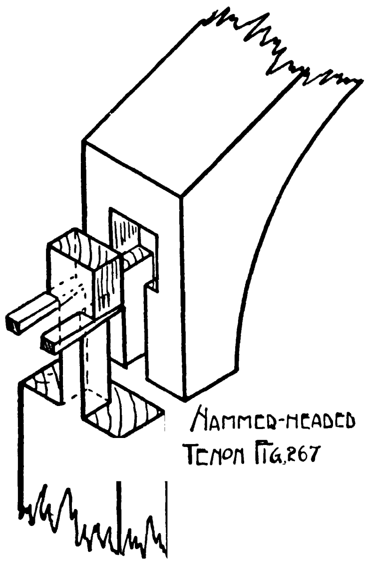


FIG. 266. FOX-TAIL TENON

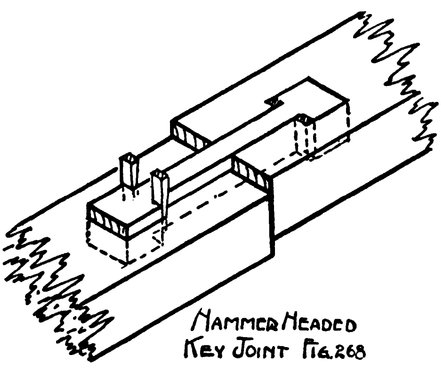
Fig. 266, and inserting wedges. The tenon is opened by the wedges on being driven home. A hammer-headed tenon used for connecting a door frame jamb with a curved head is



HAMMER-HEADED TENON FIG. 267

shown in Fig. 267, and a hammer-headed key joint is shown in Fig. 268.

A dovetail key is shown, Fig. 269. A key of this form



HAMMER HEADED KEY JOINT FIG. 268

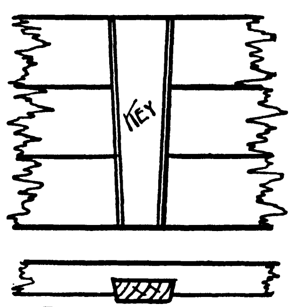


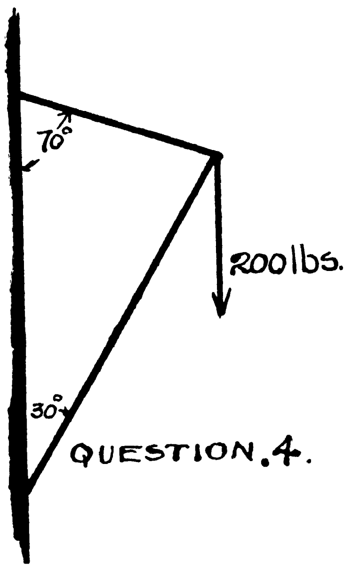
FIG. 269. DOVETAILED KEY

may be used to hold together any number of boards which are allowed to expand and contract freely.

QUESTIONS ON CHAPTER XIII

(1) Draw the plan, elevation, and section of a wooden cistern 4 ft. 6 ins. long and 1 ft. 10 ins. deep (outside measurements), and having a capacity of 16 cu. ft. State the number of square feet of 1-in. boards required to make it. Scale 1 in. to 1 ft.

(2) Draw a detail of the dovetail joint suitable for the above cistern, the sides and ends of which are made up of boards of different widths.



QUESTION.4.

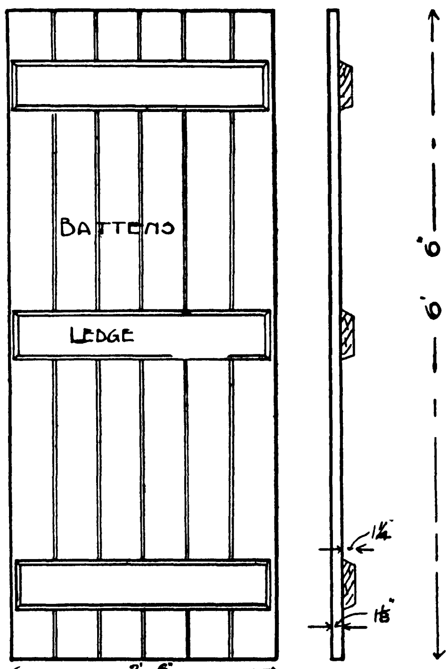
(3) Draw oblique and isometric views of the following joints: lapped dovetail, common dovetail, cross grooving.

(4) Find the amount and nature of the stresses on the members of a triangular frame fixed against a wall and loaded as shown.

CHAPTER XIV

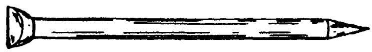
DOORS—DOOR FRAMES AND JAMB LININGS

FIG. 270 shows a ledged door consisting of $5'' \times 1\frac{1}{8}''$ battens secured by nailing to $6'' \times 1\frac{1}{4}''$ ledges. Oval wire nails are used



·LEDGED DOOR· FIG. 270

(Fig. 271) driven through the battens and ledges and thei clenched. These nails can be obtained up to 6 ins. long, anc are very largely used for general work. All the battens o boards and ledges should be taken out of winding in preparation, so that the door will not twist when made.



OVAL WIRE NAIL
FIG. 271.

Fig. 272 shows the use of winding strips. The strips are two parallel pieces of wood; one is placed at each end of the

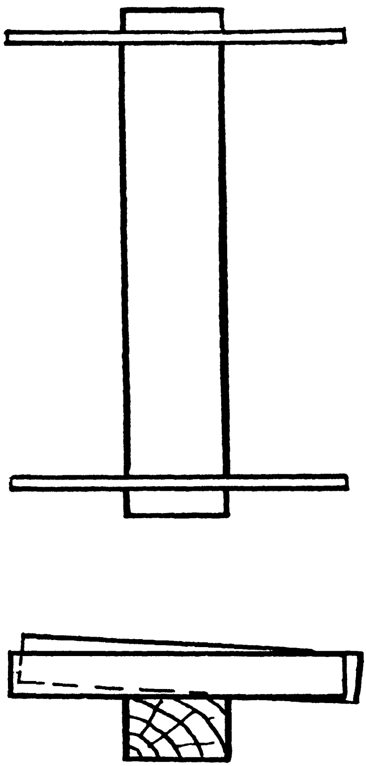


FIG. 272

board, and the top edges of these should coincide with each other when the surface of the board does not twist.

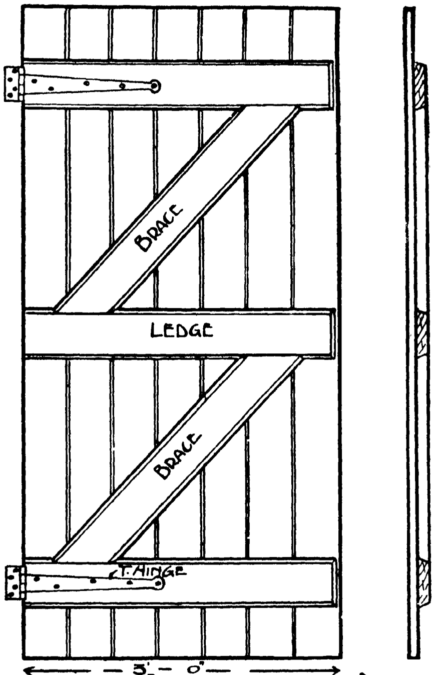


FIG. 273. FIG. 273 LEDGED & BRACED DOOR.

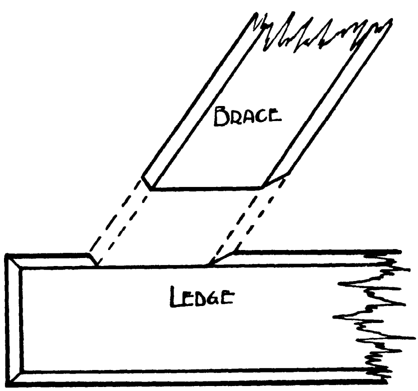


FIG. 274

Fig. 273 shows elevation and side view of a ledged and braced door. The braces are to prevent the door dropping at the free edge, and are inclined upwards from the edge which is hinged to the frame. The braces may be used on doors 2 ft. 6 ins. wide, though many are made without; but for doors of greater width the additional support they afford is very necessary. They are jointed to the ledges as shown, Fig. 274.

All the boards and ledges should be well seasoned; and,

T.G. & V Jointed Fig. 275

Ploughed & Tongued V. Jointed Fig. 276

before being put together, the edges of the boards and the adjacent surfaces of the latter and the ledges should be well painted, particularly where the doors are for external use. The edges of the boards may be tongued and grooved, and

T.G & Beaded Fig. 277

Rebated & V. Jointed Fig. 279

either V-jointed or beaded as Figs. 275 and 277. Fig. 276 is ploughed and tongued and V-jointed, and Fig. 279 is rebated and V-jointed.

The edges of the ledges are splayed as shown to throw off

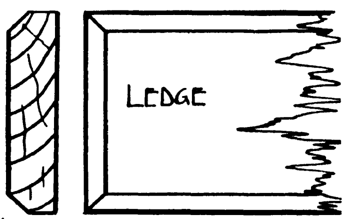


Fig. 280

water readily if exposed to the weather, otherwise they may be chamfered as section and part elevation, Fig. 280.

Door Frame.—A beaded and rebated solid door frame is shown in elevation and section, Fig. 281. It consists of two upright jambs tenoned into a head. The tenoned end of the

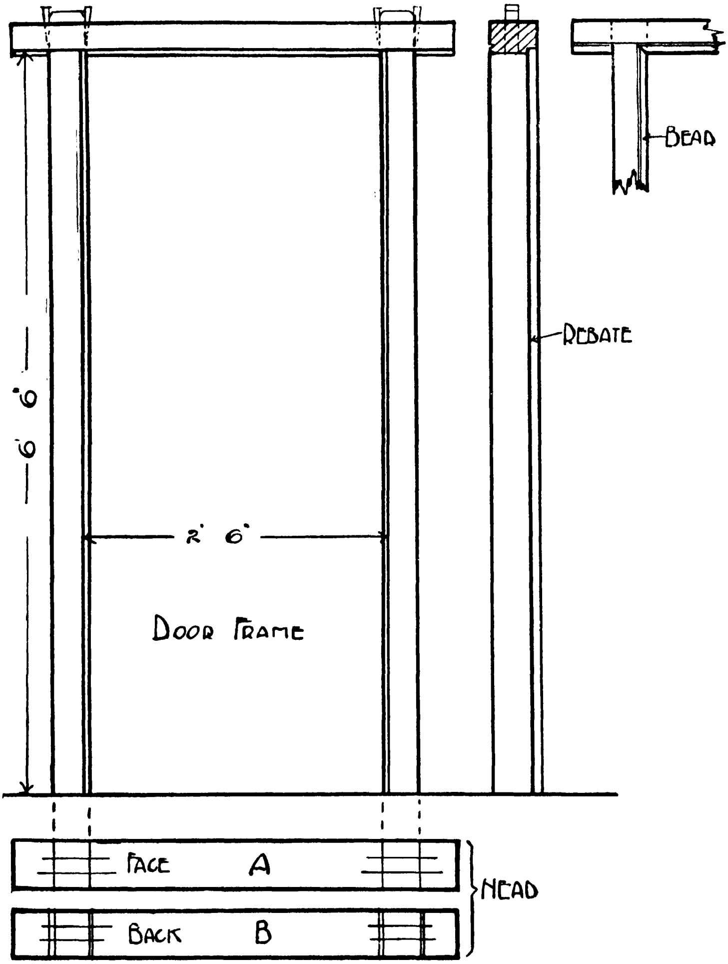


FIG 281

jamb is shown in detail, Fig. 282, and a portion of the bead, Fig. 283. The beads of the above are mitred together; Fig. 284 shows a mitre block used for this purpose. In Fig. 281

(A) is the face of the head marked for mortise holes and the same on the back (B) with wedge room marks. White lead

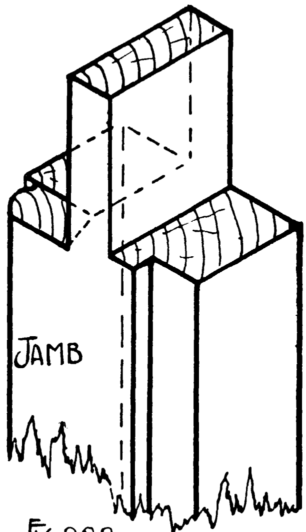


FIG. 282

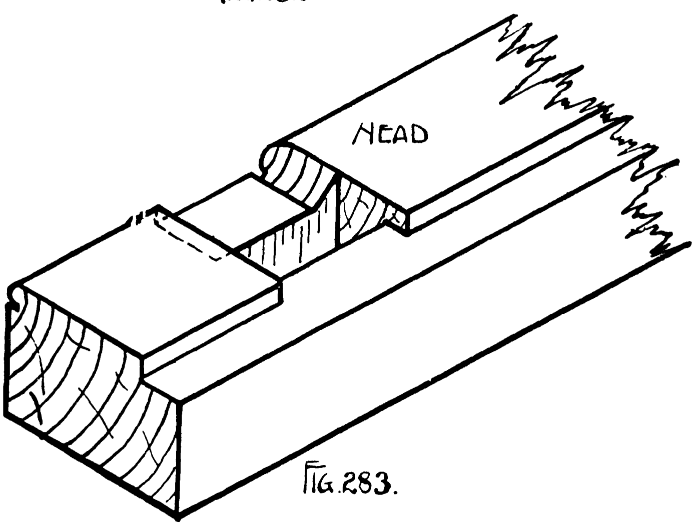
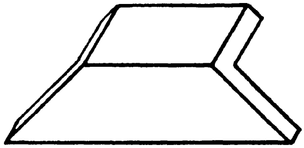


FIG. 283.

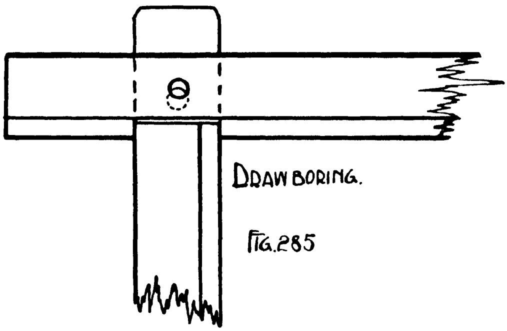
should be applied to the tenons when putting the frame together.

The tenons are secured by wedges, or the joint may be draw-bored and pinned as Fig. 285. The hole in the tenon is bored slightly lower or nearer the abutting surfaces than those in the head.



MITRE TEMPLATE FIG. 284

If there is a stone step, holes are cut for the insertion of iron dowels which are fixed in the bottom ends of the frame (Fig. 286).



DRAW BORING.

FIG. 285

Solid frames are often built in with the brickwork, and the projections of the ends of the head called "horns" are bonded

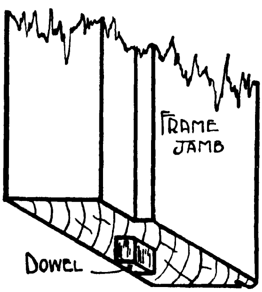
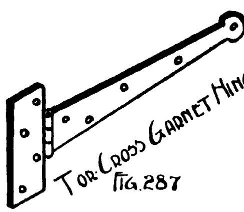


FIG. 286



T OR CROSS GARNET HINGE
FIG. 287

in with the brickwork. If the frames are fixed in the brick recesses afterwards, they will be nailed to wooden bricks or slips which are built in with the brickwork or to wood plugs.

The braced door is hung with T or cross-garnet hinges shown in detail, Fig. 287.

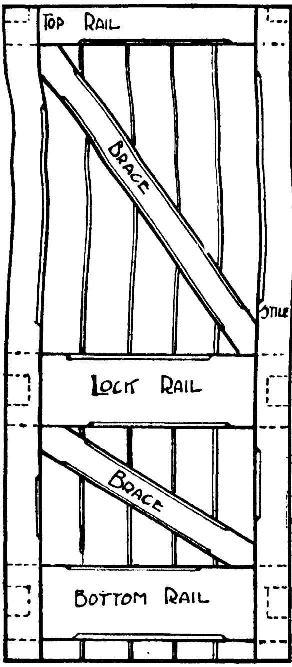


FIG. 288

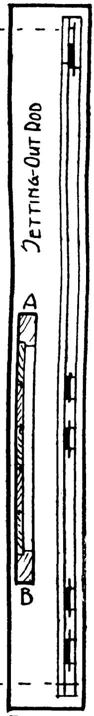


FIG. 290

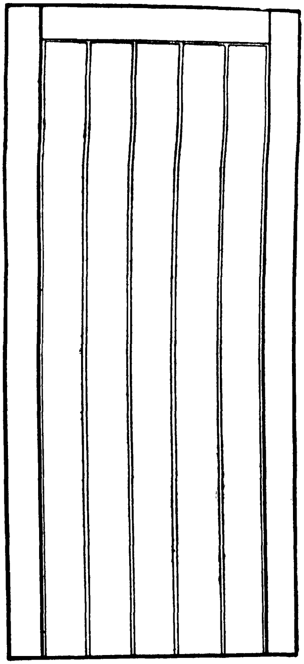


FIG. 289. FRAMED BRACED & BATTENED

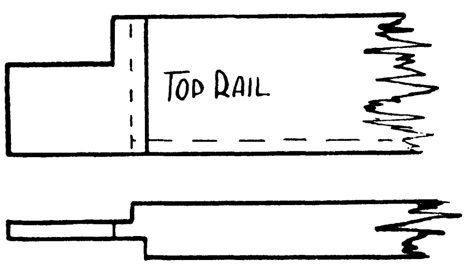


FIG. 291

Figs. 288 and 289 are inside and outside elevations of a 2-in. framed, braced, and battened door. This type of door is strong and very suitable for use in external walls.

The stiles and head are of one thickness — the thickness of the door—whilst the remaining members of the frame are the same less the thickness of the battens.

The horizontal section is shown at AB on the setting-out rod, Fig. 290, and it will be seen that the stiles are rebated for the battens; the head is dealt with similarly. The shoulders of the head will differ in length by the amount of the depth of the rebate, Fig. 291, and a haunch is necessary, as seen in Fig. 292.

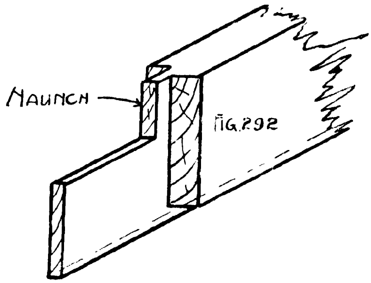


FIG. 292

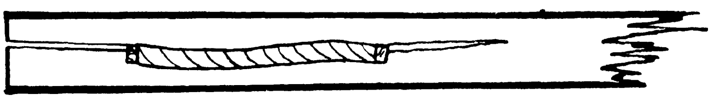


FIG. 293

The thickness of tenons should be one-third the thickness of the material, and to avoid buckling and the possibility of splitting the stile (Fig. 293), their width should not be more than five or six times their thickness.

To keep the mortise holes as near the centre of the stiles as possible, it is necessary to work the tenons on one side of the lock and bottom rails; these are known as bare-faced tenons, Fig. 294. The marking of the edge of the stile is shown on the setting-out rod, Fig. 290, and it will be seen that the bottom rail is kept up $1\frac{1}{2}$ ins. so as to be clear of the damp.

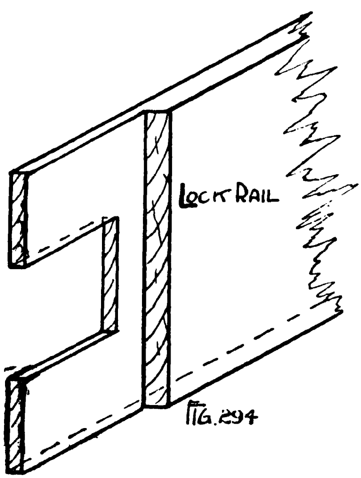


FIG. 294

DOOR FRAME.—The door frame for this door will be made as before described, excepting that the rebate is deeper.

Butt hinges—either cast-iron or steel—Fig. 295, will be used and secured with flat-headed steel screws as shown, Fig. 296.

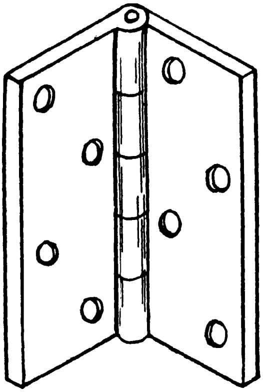


FIG. 295 BUTT HINGE

FIG. 296

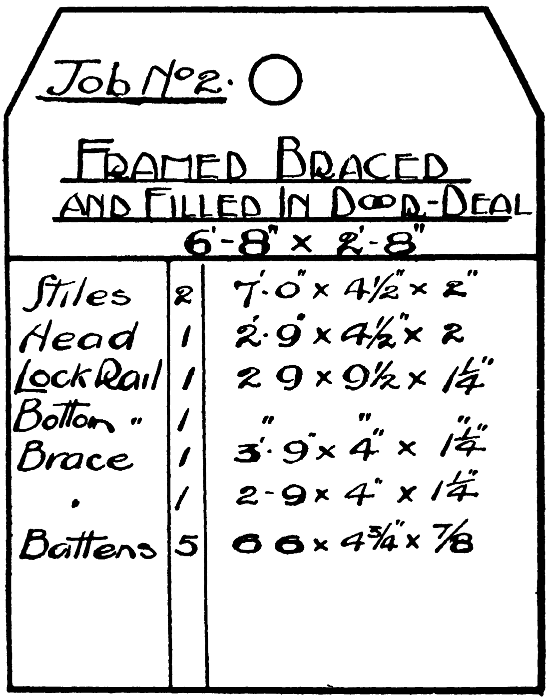


FIG. 297

In general use screws are ten or twelve times more powerful than nails in holding together.

Fig. 297 is a typical quantity board with a statement of the materials required for the door just described.

PANELLED DOOR.—Fig. 298 is the elevation with horizontal section at AA, of a four-panelled door, with a setting-out rod shown along side. The dotted lines in the elevation indicate the grooves for the panels, and the size and shape of the

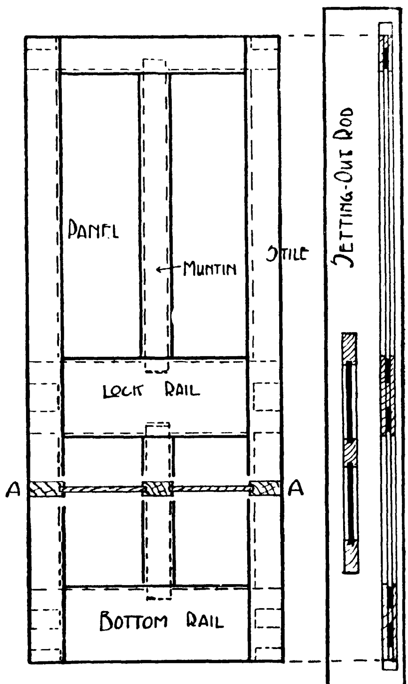


FIG. 298

tenons used in framing. The panels are about one-third the thickness of the door, and correspond with the thickness of the tenons. Stump tenons are used on the muntins, and it will be noticed that where rails and muntins are grooved for panels, the width of the tenons is reduced thereby, and due allowance is made in the mortise holes. In making the door by hand, the tenons would be sawn down (but not shouldered) and the mortise holes made before ploughing the grooves.

A haunch is necessary to both the top and bottom rails, the ends of which are shown at A, B, and C, Fig. 299. Fig. 300 is an oblique view of the end of the top rail.

A convenient height to the door knob from the floor is usually taken as 2 ft. 9 ins., and this will be the distance from the bottom of the door to the centre of the lock rail.

A door without moulds is known as square and flat. A single moulded door is moulded on one side only.

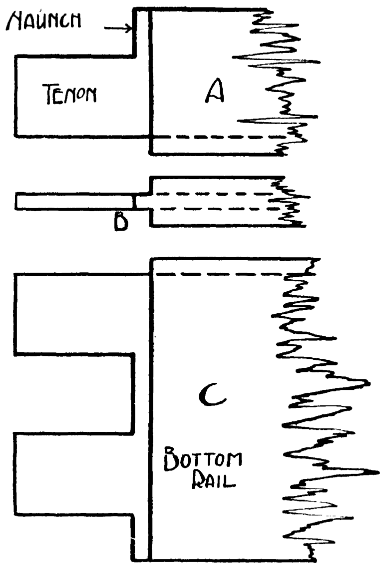


FIG. 299.

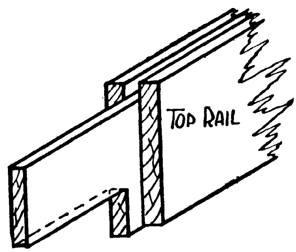
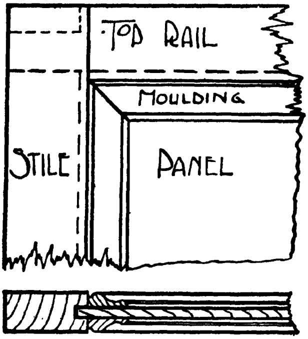


FIG. 300.

Figs. 301 and 302 show horizontal sections and part elevations of double moulded doors; in one case a simple ogee mould is given, and in the other a bolection mould.

Section, Fig. 303, is given to show the position of the nail when driven home. Care should be taken to drive the nails into the solid portion of the frame, and not into the panel, as Fig. 304. The latter would fix the panel, and thereby prevent free expansion and contraction, which, for pieces of the width of panels, is necessary in order to avoid splitting.

For external walls, panelled doors of the type dealt with are rather objectionable, as the ledges of the frame or the mouldings would catch and retain moisture. To obviate this, the panels may be made two-thirds the thickness of the frame, and flush



SECTION FIG. 301

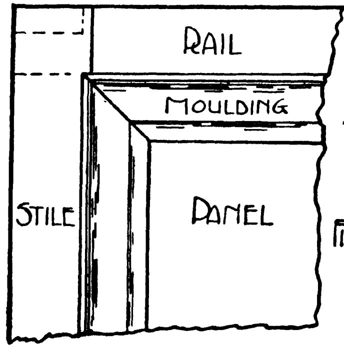
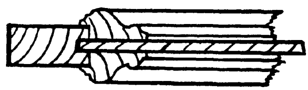


FIG. 302



SECTION

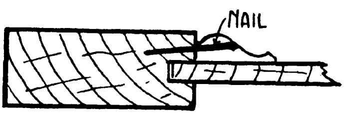


FIG. 303

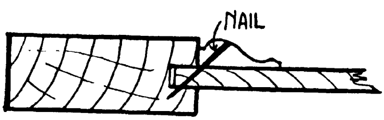


FIG. 304

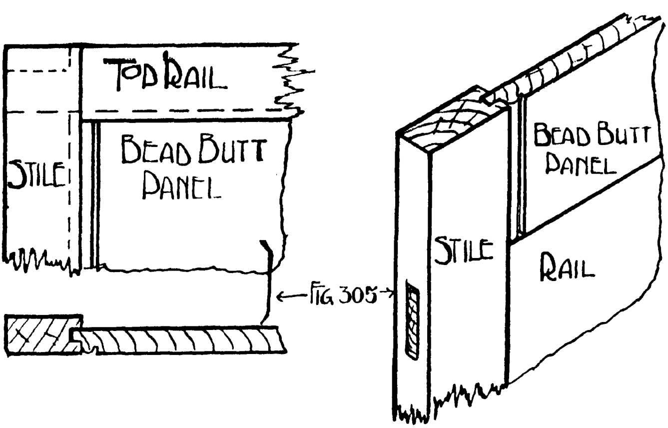


FIG. 305

on the outer side. Fig. 305 shows a bead butt panel, the vertical edges of the panels being beaded. Fig. 306 shows a

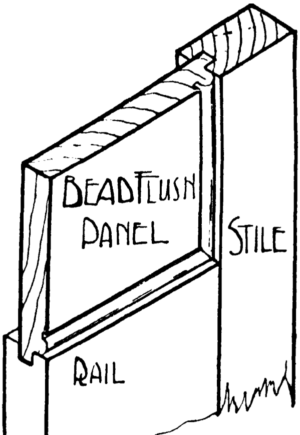


FIG. 306

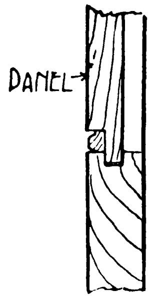


FIG. 307

bead flush panel, the bead being continued all round the panel, which will necessitate working the bead across the grain or

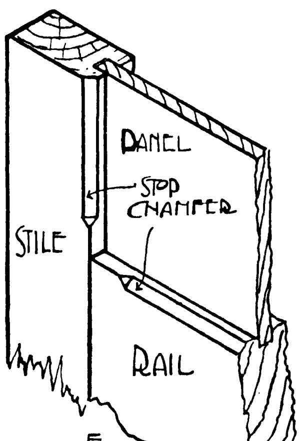


FIG. 308.

planting in a separate piece, as section, Fig. 307, but there are objections to the latter method. Fig. 308 shows part of a door, the framework of which is stop-chamfered.

Fig. 309 is a bolection moulding, and Fig. 310 and 311 planting or panel mouldings. The curves for these and for

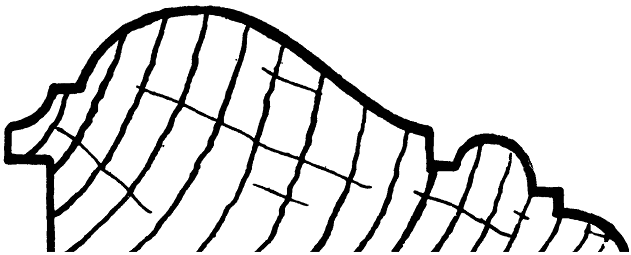


FIG. 309 BOLECTION MOULD

most other forms of mouldings are evolved from the Grecian and Roman mouldings, shown in Figs. 312 to 319. The Roman

FIG. 310 PLANTING OR PANEL MOULD

mouldings are chiefly formed from circular curves, whilst the Grecian are built up of elliptical and parabolic curves.

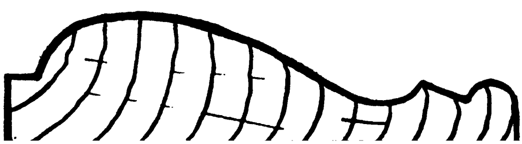


FIG. 311. PLANTING. MOULD

A true ellipse is the curve given by cutting a right circular cylinder by an inclined plane.

Fig. 320 shows the plan and elevation of a cylinder with an inclined plane, AB, cutting the latter at an angle of 45° to the horizontal. The section of the cylinder on this plane is shown projected, giving a true ellipse, of which o-o is the major axis, and 3-3 the minor axis. This is another method of producing an elliptical curve. (*See also* chapter on Centres).

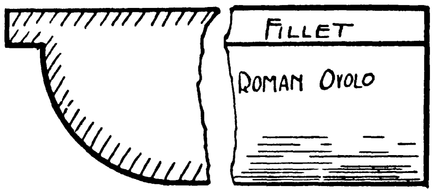


FIG. 312

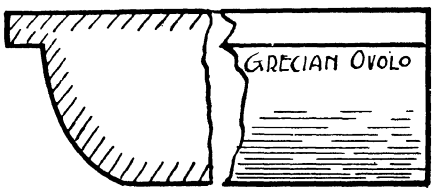
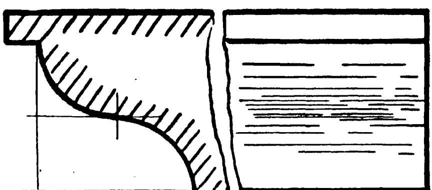
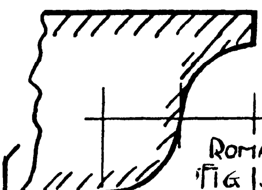


FIG. 313

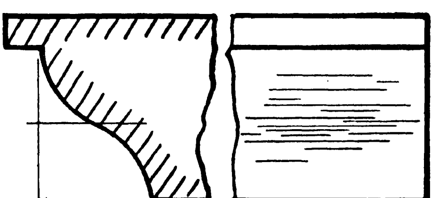


CYMA REVERSA (ROMAN) FIG. 314

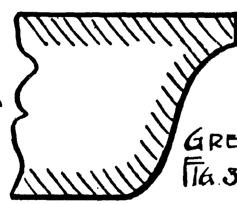


ROMAN FIG. 316

CYMA RECTA OR OGEE.



GRECIAN FIG. 315



GRECIAN. FIG. 317

A parabolic curve mentioned in connection with the foregoing mouldings is obtained by taking a section through a cone

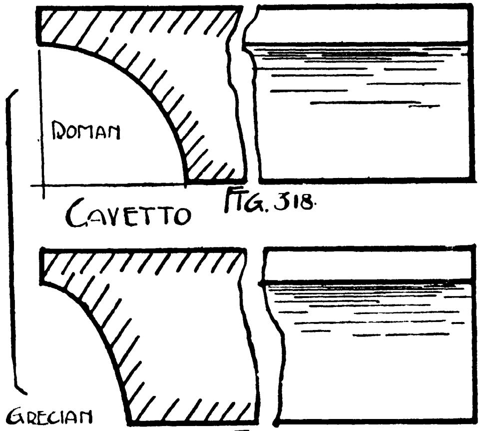


FIG. 318.

FIG. 319

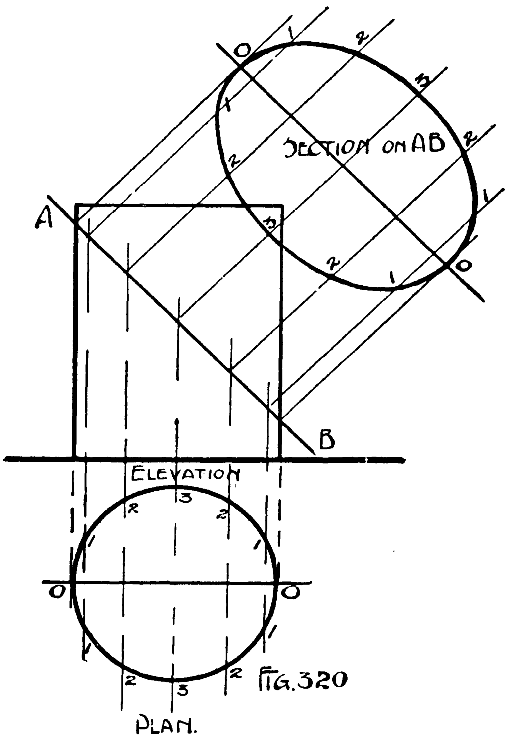


FIG. 320

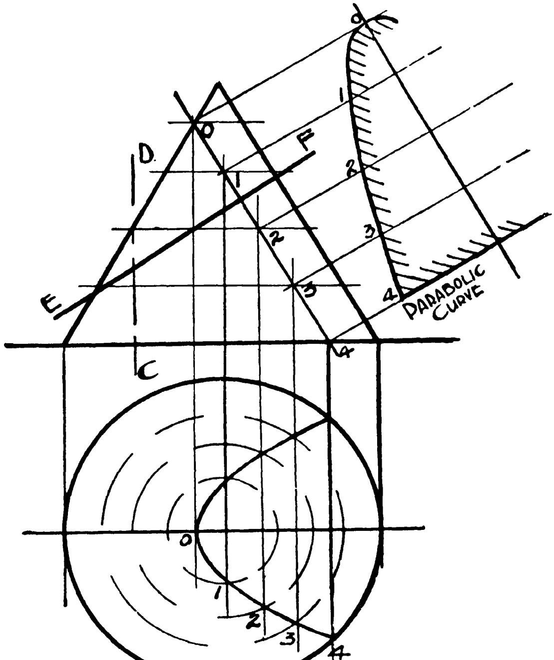


FIG. 321

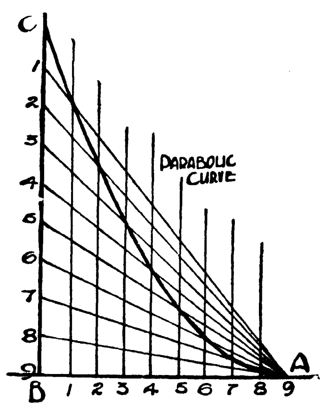


FIG. 322

parallel to its inclined face (Fig. 321). AB is a plane cutting the cone as described, and the part section giving a parabolic curve is shown projected.

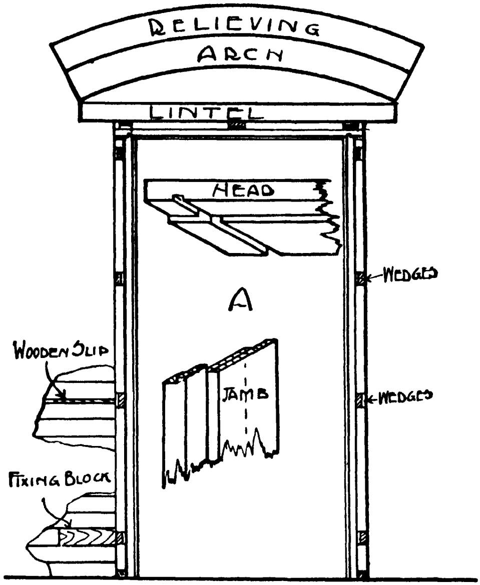


FIG. 323

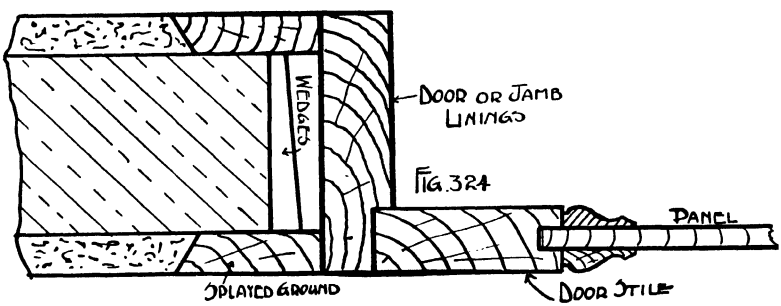


FIG. 324

(A curve known as a hyperbola would be obtained by taking a section on line CD, and an ellipse would again be obtained by taking a section on the line EF).

Another method of drawing a parabolic curve is shown in Fig 322, where the two lines, AB, BC, are divided into the

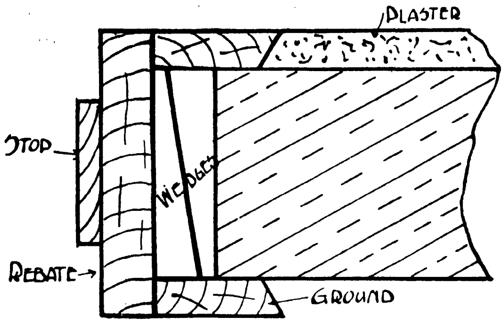


FIG. 325

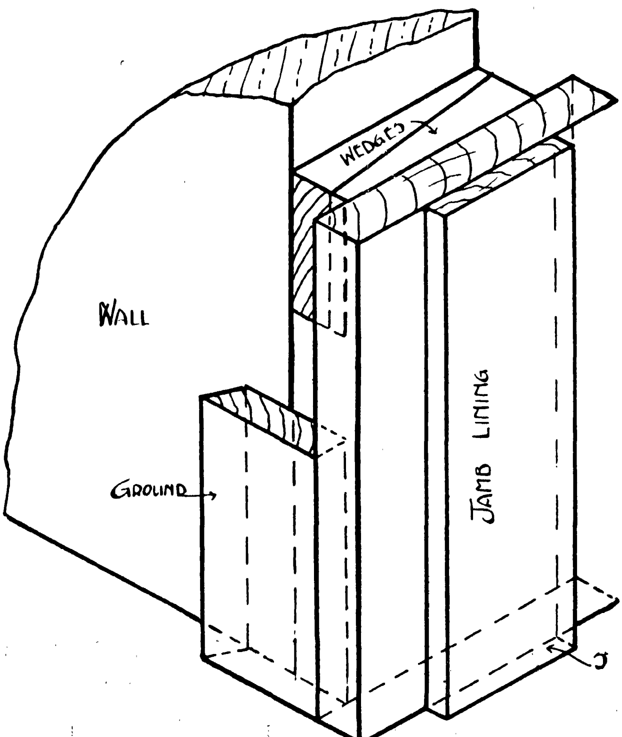


FIG. 326

same number of equal parts. The curve is drawn through the points where the lines 1-1, 2-2, 3-3, etc., intersect.

JAMB LININGS.—Jamb linings to which the doors are hung, are from 1½ ins. to 2 ins. thick, and consist of two stiles and a head fixed in the door openings of interior walls.

Fig. 323 shows 1½-in. linings to a 4½-in. brick partition wall, rebated one side for a 1½-in. door. The width of the lining is 6 ins. or 6¼ ins., allowing ¾ in. or ⅞ in. for the thickness of plaster on each side of the wall.

The lining is plumbed true by the aid of folding wedges driven between the fixing blocks and the stiles, and then nailed through. Grounds are fixed to the wall on each side along the stiles and head to form a base for the fixing of architraves; they are generally splayed back, as shown, Fig. 324, to form a key for plaster.

Another form of lining is shown, Figs. 325 and 326. A piece forming a stop is nailed to the lining, leaving a rebate on each side of equal size. In both cases the stiles are tongued into the heads, as shown at A in Fig. 323.

QUESTIONS ON CHAPTER XIV

(1) Draw to a scale of 1 in. to 1 ft. the back elevation of a ledged and braced door, 6′ 8″ × 2′ 9″, the battens to be tongued and grooved and V-jointed. Make a sectional detail of this joint full size. Place in the correct positions cross garnet hinges.

(2) Make the necessary drawings on a setting-out rod for a 6′ 8″ × 2′ 8″ × 2″ framed, braced, and battened door, the right hand stile to swing into the room. Draw isometric views of the ends of all the rails showing bare-faced tenons.

(3) Draw a back elevation to a scale of 1½ ins. to 1 ft. of the above door, hung to a 5″ × 3″ rebated and beaded frame, and show the position of the hinges. Make an enlarged view of the kind of hinge you would use. Draw an oblique view of the top end of one of the jambs.

(4) To a scale of 2 ins. to 1 ft. draw a vertical section through the lock rail, and a part elevation for a 2-in. panelled door, double-moulded, with bolection moulds on one side and an ogee planting mould on the other.

(5) Draw a horizontal section (scale 2 ins. to 1 ft.) through one of the jamb linings for a 2-in. panelled door in a 9-in. wall. Show all grounds and backings. Describe the fixing, and sketch the joint between the head and jamb lining.

(6) Draw an elevation and horizontal section of a pair of 1½-in. folding panelled doors, hung to a 4′ × 1½″ frame with brass butts, for a fixed wardrobe cupboard. The doors to be stop chamfered on the front, and square and flat at the back, the meeting stiles rebated and beaded. The opening in the frame to be 5 ft. 6 ins. high, and 3 ft. wide, and each door to have two panels. Scale 1½ ins. to 1 ft.

(7) Show by sketches the meaning of the following: Bead butt panel, bead flush panel, bolection mould, ogee or cyma recta. What advantage can be claimed for using panels flush with the frame of the door?

(8) Making drawings of the following curves:—parabolic, elliptical, and hyperbolic. Sketch a moulding suitable for an architrave, embodying the following: cavetto, quirked ogee, bead, and ovolo.

CHAPTER XV

WINDOWS

FIGS. 327 represent the front elevation, horizontal and vertical sections of a simple casement window. The frame is made of $4\frac{1}{2}'' \times 3''$ red deal, rebated for a 2-in. casement, and beaded

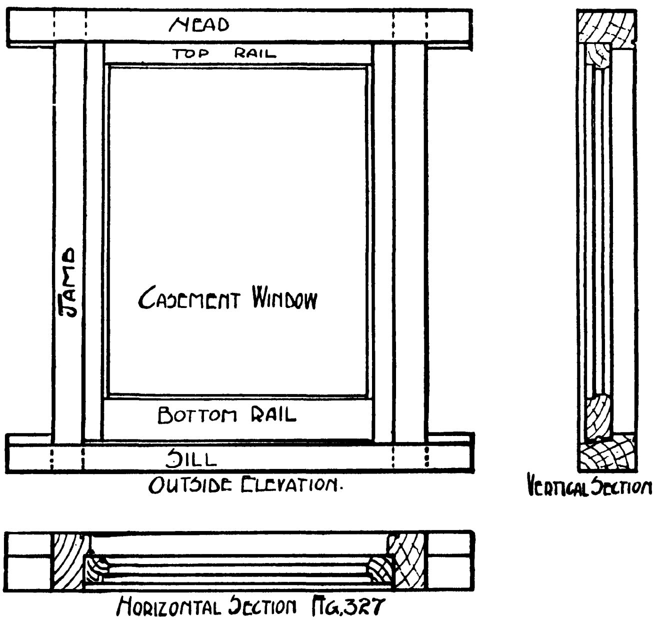


FIG. 327

on the inside edge. The rebate to the sill is inclined or splayed to form a weathering. The stiles are tenoned into the head and sill, the beads being mitred as described for the door frame, Fig. 282. The lower end of the stile is shown in Fig. 328, one shoulder being splayed to fit the weathering of the sill. A portion of the sill is shown in Fig. 329, marked for the mortise hole and sunk weathering. Fig. 330 shows joints used in

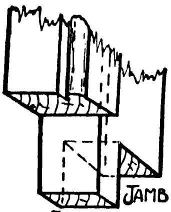


FIG. 328

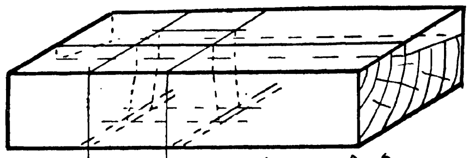


FIG 329 PORTION OF SILL

making the casement, which is rebated for glass and chamfered, the shoulders of the rails being cut to fit the latter. The joints

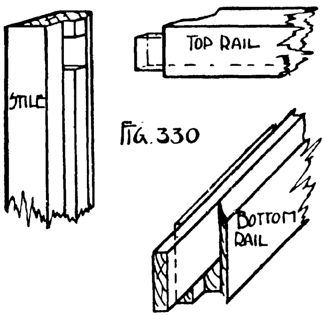
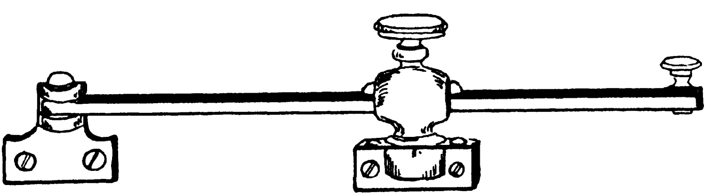


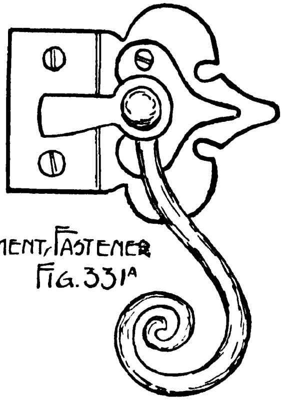
FIG. 330

of the casement would be glued, wedged, and pinned; and the joints of the frame would be coated with white lead and wedged.



CASEMENT STAY FIG 331

The casement, the bottom rail of which is grooved to prevent capillary attraction, should be hung with $2\frac{1}{2}$-in. or 3-in. brass butt hinges, and secured with casement stay and fastener (Figs. 331 and 331*a*).



CASEMENT FASTENER
FIG. 331A

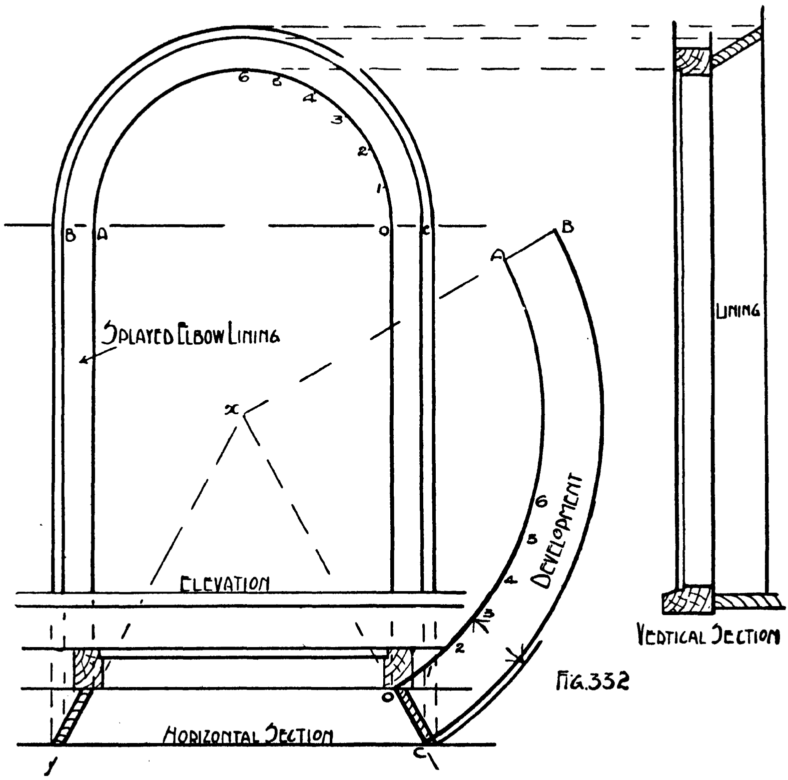


FIG. 332

WINDOW FRAME—SEMI-CIRCULAR HEAD AND SPLAYED LINING.—Fig. 332 is an inside elevation, with horizontal and vertical sections of a solid window frame, with a circular head. (The construction of the frame is left for a more advanced work.) On the inside is a splayed lining, and the development of the circular head is shown at ABCo. In the elevation set off equal parts from o to 6 as shown, this distance repre-

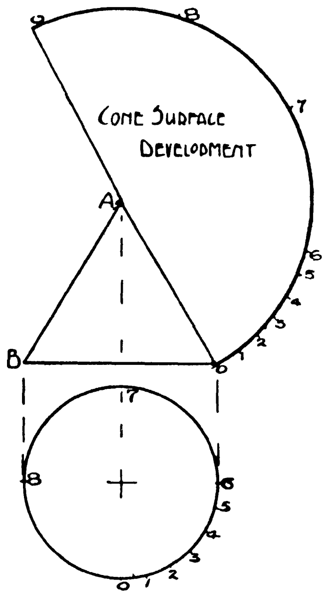


FIG. 333

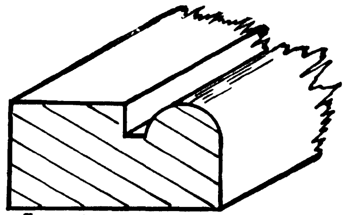


FIG. 334 QUIRKED BEAD

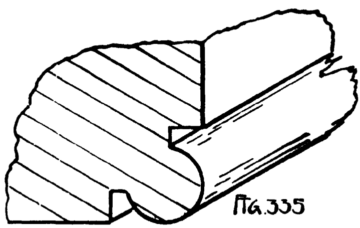


FIG. 335

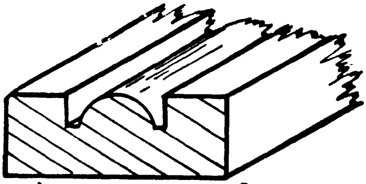
DOUBLE QUIRKED BEAD
OR STAFF BEAD

senting one-half of the curve on the inner edge of the lining. With centre X—obtained by producing the sides of the linings as Co—and radius Xo describe the curve oA, and from the same centre describe the curve CB. On the line oA set off the distances o, 1, 2, . . . 6, and again the distance o6 to 6A. Then ABCo represents the complete surface developed.

The above is derived from the geometrical method of developing the surface of a cone, which is shown in Fig. 333. ABo is the elevation of the cone; with point A as centre a curve is struck with radius Ao, and the length of this curve is made exactly equal to the circumference of the base of the cone, o, 6, 7, 8, etc.

Figs. 334 to 336 are beads very commonly used in joinery.

Fig. 334 is a single quirked bead, and Figs. 335 and 336 are double quirked beads.



Double Quirked Flush Bead
Fig. 336

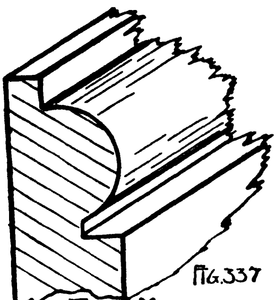


Fig. 337
Torus Moulding

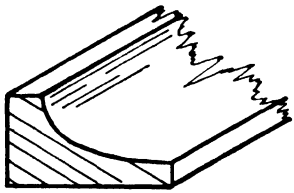


Fig. 338 Scotia Moulding

Fig. 337 is a torus mould very often used on skirting boards, and Fig. 338 is a scotia moulding.

QUESTIONS ON CHAPTER XV

(1) Draw the outside elevation, horizontal and vertical sections of $4\frac{1}{2}'' \times 3''$ rebated and chamfered casement window frames, with two 2-in. sashes, one hung with brass butts, and one fixed. The oak sill is to be double sunk. Size of opening 2 ft. 9 ins. wide, and 2 ft. 6 ins. high. Scale $1\frac{1}{2}$ in. to 1 ft. Give oblique sketches of the joints for the casement sashes.

(2) Sketch the following: Quirked bead, staff bead, double quirked flush bead, cocked bead, torus moulding, and scotia moulding.

(3) Sketch a casement stay and a casement fastener.

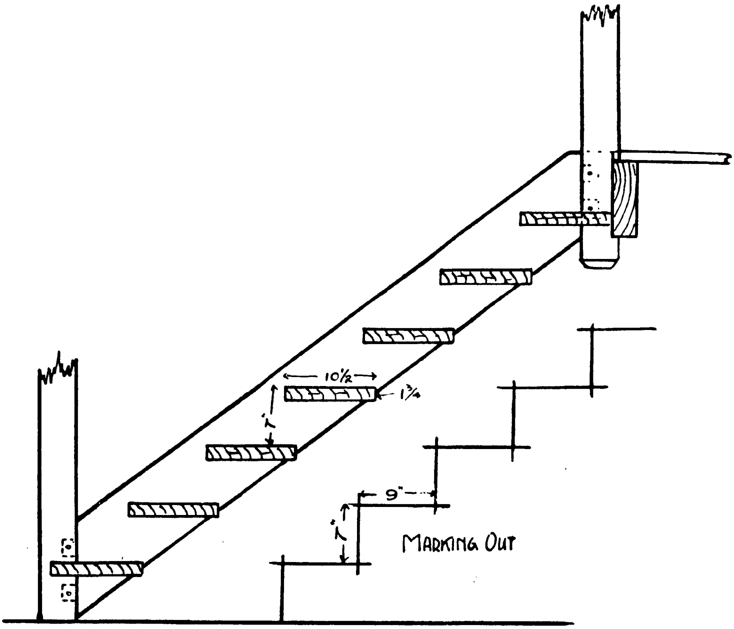
(4) Draw to a scale of 1 in. to 1 ft. a plan and elevation of a cone, the diameter of its base being 4 ft., and its height 5 ft. 6 ins. Develop its inclined face. Find its cubic contents where

$$\frac{\text{area of base} \times \text{height}}{3} = \text{cubic feet.}$$

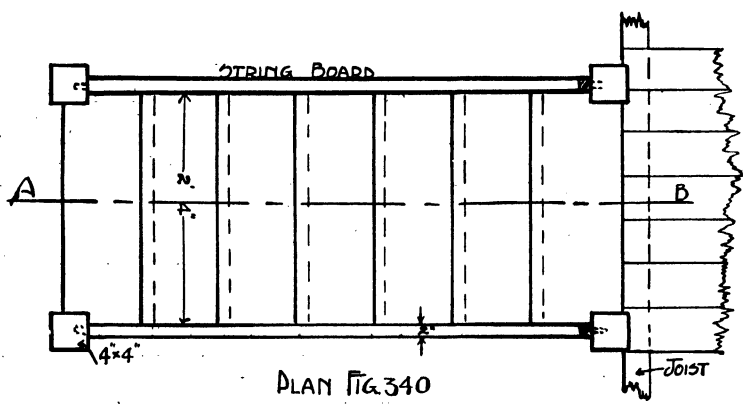
CHAPTER XVI

A SIMPLE STAIR

FIGS. 339 to 341 represent a small flight of stairs of a type generally used in workshops and warehouses. Most forms of



·SECTION ON·A·B· FIG.339



PLAN FIG.340

stairs are built of treads and risers, as Fig. 342, but in this case the treads are without the support of risers, and must therefore be thicker in proportion. The lines shown below the section indicate the method of marking out the amount

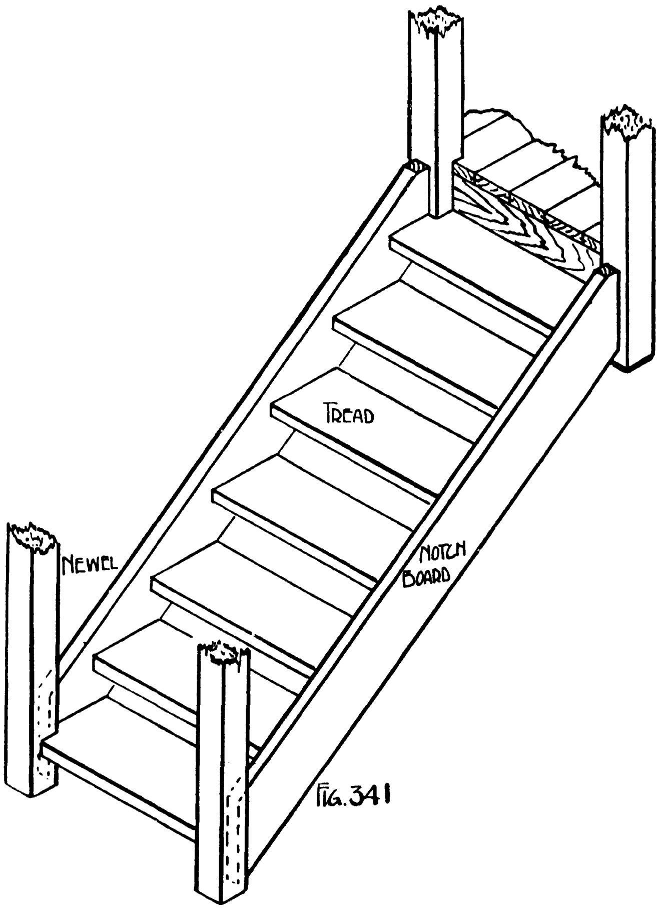


FIG. 341

of tread and rise of each step. Although each tread measures 10½ ins., part of this width (1½ ins.) passes beneath the tread immediately above, therefore the effective "going" of each step is only 9 ins.

The treads are 1¾ ins. thick and housed into the string or notch boards. The latter are stump tenoned into the newel posts at each end, as shown in Fig. 343.

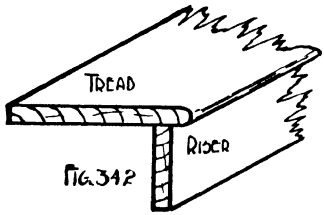


FIG. 342

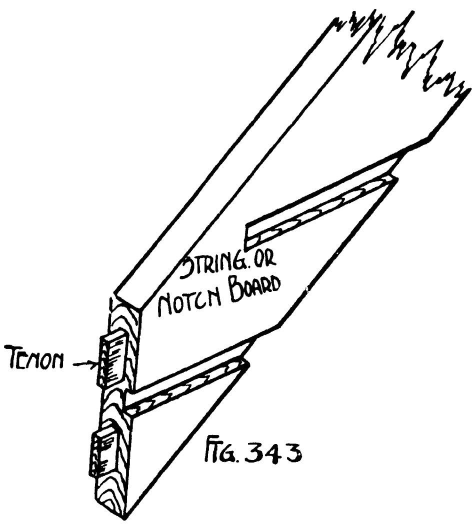


FIG. 343

STAIRCASE IN DEAL

7/	2 6 10½	15 3	1¾ ins. wrot treads.
2/	7 0	14 0	9″ × 2″ wrot strings.
2/	7	14	Housings to ditto.
2/	2	4	Strings tenoned and pinned to newels.

Printed in Great Britain by T. and A. CONSTABLE LTD.
at the University Press, Edinburgh