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ROOFS AND ROOFING



ROOFS AND ROOFING

ALFRED F. COLLINS

A.R.I.B.A.

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NOTE : ILLUSTRATIONS

OWING to the plates being reproduced larger than was originally proposed, the scales given in words were incorrect and they have been eliminated. The ratios for the most important plates which cannot be scaled are given below.

Plates X, XI, XIII, and XIV: $\frac{1}{3}$ rd full size.
,, XVII and XVIII: $\frac{2}{3}$ rds full size.
Plate XX: $\frac{1}{4}$ th full size.

BRITISH STANDARD SPECIFICATIONS

A LIST of these specifications is given where they affect roof coverings. These are probably a little too technical for the ordinary student of Building Construction, but when selecting materials for important work the manufacturers should be asked to give the results of the British Standard Specification tests on their materials. The numbers are those given officially for identification purposes.

680, Welsh Slates.
402, Plain clay roofing tiles.
473, Concrete tiles (plain).
550, ,, ,, (interlocking).
849, Zinc.
747, Roofing felts.
798, Corrugated iron sheets.
690, Asbestos-cement roofing materials.

ACKNOWLEDGMENT

I SHOULD like to thank my friend and former colleague, Mr. F. J. Sawyer, A.R.I.B.A., for the excellent drawings which he has prepared to illustrate this work. It has been difficult to find time to prepare the written part and the rough sketches necessary, and without his help so willingly given it would have been impossible for me to complete it.

A. F. C.

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INTRODUCTION

SLATING, TILING, AND OTHER ROOF COVERINGS

IN all buildings the roof coverings are as important as the walls and foundations. This little book will deal with the various ways in general use by which buildings of all types are protected from the downward penetration of rain and snow, from heat and cold.

At one time countries and even districts depended to a great extent upon local materials, and thus we find in clay areas, tiled roofs; in Wales, slates, usually blue and purple in colour; in the Cotswolds, in Sussex, and near Stamford, the well-known stone slabs for which those districts are famous; and so on. Generally the material found in a district is suitable for local requirements, but the excellent transport arrangements of this country have led to materials being used far from their natural homes.

It is proposed to deal with all types of roofing and to call attention to the artistic as well as the practical properties of each material.

A specification will follow each chapter and the method of measurement will also be explained.

Students should study the effect of roofing materials, climate, and position on the design of the buildings on which they are working. The Builder and Craftsman would also do well to study the use of roofing materials in other districts than their own, also the little points in which the requirements of a first-class Architect differ from the ordinary. If this were done more generally there would not be so many complaints of the rough-and-ready methods of some of our craftsmen in rural districts.

A good roofing material should be easy to fix, damp resisting, durable, of pleasing appearance, comparatively light, and reasonable in price.

CHAPTER I

SLATING

SLATING at one time was the most common form of roof covering, but tiling has gained in popularity at the expense of slating during the last few years.

Slates are cheap near the districts in which they are found, but transport raises the price considerably. They are easy to lay, non-absorptive, neat in appearance, and can be used on a roof of comparative flat pitch.

The ordinary slate used for roofing is an argillaceous or clay rock. It was formed similarly to other sedimentary stones, but has since been subjected to great heat, pressure, and to a shearing action, which renders the slate easy to split along planes known as planes of slaty cleavage. These planes may be at varying angles with the original bed of the slate, or coincident with the bed. In the latter case they are not used for roofing.

Slates are usually divided into two, and sometimes three, classes or qualities and are sold in varying sizes; the Welsh slates generally being known by special names according to size, such as Countess—20" × 10", Duchess 24" × 12", Viscountess 18" × 9"; and sold per 1,000.

A table will be found later which gives the sizes of Welsh slates as used for many years. It should be noted, however that Welsh slates may be obtained as Randoms and Peggies and they may also be obtained of various colours quite unlike the purple and blue generally associated with Welsh slates.

The Delabole slate quarries have been worked since the middle of the sixteenth century and produce excellent slates, which may be obtained in grey, grey-green, and rustic-red colourings. They are very durable and a very pleasing variety in colour may be obtained. It should be noted that the rustic reds are only supplied with a proportion of other slates. Delabole slates may be obtained in regular sizes, but when sold of varying sizes in order to lay in diminishing courses they are described as Randoms (these are large slates) and Peggies (these are smaller than Randoms). They are classified as mediums and seconds.

The Westmorland slates are sold by the ton and should be sorted, so that the larger slates are used at the eaves, each course consisting of similar slates, the courses diminishing towards the ridge.

Westmorland green slates are obtained from the English Lake District and vary from light green to a deep olive green. They are laid in diminishing courses, the thicker and larger at eaves diminishing towards the ridge. These are sold as Randoms and Peggies as with the Delabole slates, but are classified as Bests and Seconds.

Burlington slates from Kirkby-in-Furness, Lancashire, are extremely durable, very hard and tough. It is claimed that these slates resist acid fumes and fire. They have been in use for many years, and are known as Burlington Blue-grey or North Lancashire.

Scottish slates are coarse and thick and often contain iron pyrites, but their weathering properties are not as a rule affected by the pyrites.

Irish slates resemble Welsh, but in some quarries they are thicker and coarser. Killaloe are good, also Valentia, the latter being used very largely as slabs.

The classification of slates as to quality is partly based upon the thinness to which they can be split, the thin slate forming a lighter and neater roof, but the extra weight of the thicker slate is compensated in some respects by the greater strength; and, if equal in weathering properties, its durability. In choosing slates for a building, colour, thickness, weathering qualities, and size should be carefully considered. It is usual to associate Westmorland with green slates, Wales with purple (Bangor) and blue (Portmadoc), and Delabole with a mixture of red, brown, and yellow; but this classification is misleading. It is advisable to obtain samples of slates for good work, especially where appearance is a consideration, as they may be obtained of various colours from practically any slate district, and the quarries near the building site may be able to produce suitable slates at a moderate price.

Tests for Slates.

Absorption. A good slate should not absorb more than $\frac{1}{2}$ per cent., i.e. $\frac{1}{200}$ th, of its weight after 12 hours' soaking.

If stood in water for 12 hours the water should not rise more than about $\frac{1}{8}$ inch.

Toughness. A good slate should be hard and tough and ring well when struck with the knuckles. If soft, the nail holes enlarge and the slate tends to rattle when the wind blows, and to work loose. If too hard it will splinter easily when holed or trimmed.

Colour is not a good test. Where seen the colour should be pleasing to the eye and slates with patches should be avoided. If behind a parapet and not seen from ordinary positions, discoloration does not matter, and should only lead to rejection if it indicates defective composition of the slates (see later note *re* pyrites).

Grain. Should be fine and regular and should run in the direction of the length, so that if the slate splits it will still tend to remain in position. Dark veins are objectionable as the slate is liable to split along the veins.

White Iron Pyrites in slate should lead to rejection, as it decomposes rapidly. Some varieties of iron pyrites, consisting of yellow crystals, will last for many years.

The *feel* of slates should not be soft or greasy.

Breathe on the slates. A strong clayey odour suggests a slate which will not weather well.

The absorption tests are suitable for the ordinary building student to apply and are practically sound. For patches or stains and pyrites, the slates on existing buildings should be examined, because if they have hitherto stood the test in the district the probability is that they will still do so.

In examining old slated roofs, see whether the slates are loose or if any have been replaced (lead or wire clips will indicate this) and test them with the finger-nail, as it is sometimes possible to pick them to pieces owing to decomposition having taken place. If they sag on either side of a party wall, the roof timbers require careful examination.

Method of Fixing. The cheapest method is to fix slating battens to the rafters at the requisite distance apart and nail the nails to the battens (see Figs. 1 and 2). In better work the roof is boarded all over and the slates nailed to the boarding. In order to preserve the boarding, sarking felt is sometimes fixed on top of the boarding and it not only preserves the wood but it acts as an insulating covering and tends to keep the building cool in summer and warm in winter. Battens can be fixed on the top of the felt and for ideal

results counter-battens, so that the air can circulate over the felt and boarding and any moisture driven through the slates can run down the felt (see Figs. 3 and 4). The counter-battens run up and down the roof parallel to the rafters, the battens being nailed at right angles to them. Figs. 1 and 2 show head nailing and Figs. 3 and 4 show centre nailing.

Nails.

These may be of composition, iron, copper, zinc, or lead. Composition nails, of tin, copper, and zinc, are of the requisite hardness and do not oxidize.

Iron nails if cast are brittle. If of malleable iron they are usually galvanized to prevent oxidation.

Copper nails do not readily oxidize but are soft and expensive.

Zinc nails are soft and not satisfactory.

Lead nails are used for repair and maintenance work and for fixing to tee or angle irons.

Terms.

Head. The upper edge of the slate.

Tail. The lower edge of the slate.

Lap. If centre nailed is the distance by which the tail of one slate overlaps the head of the slate in the next course but one below it (see Fig. 3).

If head nailed it is the distance by which the tail of one slate overlaps the nail hole of the next but one below it (see Fig. 1).

Gauge. The length of the exposed part of each slate, or the distance apart of the nail holes.

Margin. The exposed part of each slate.

Back. The upper face of a slate.

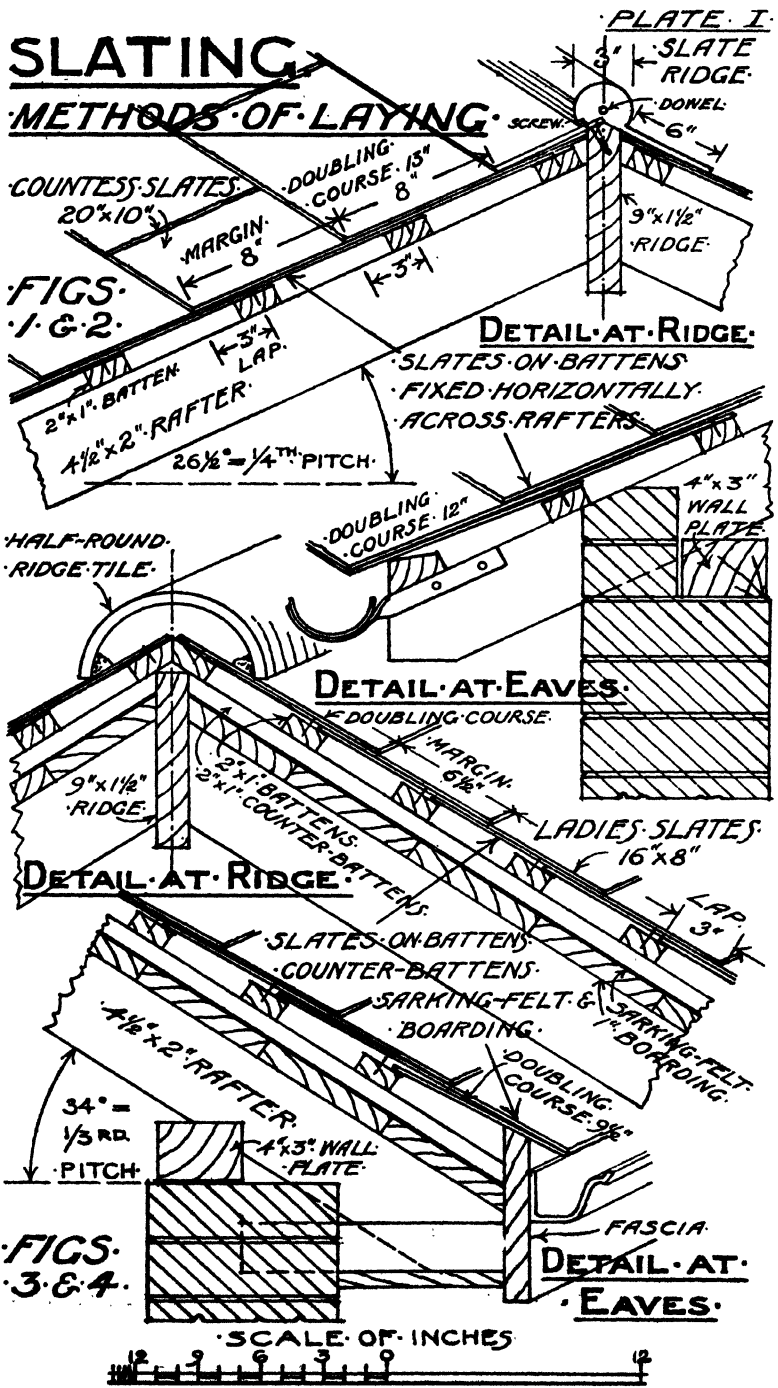
Bed. The under face of a slate.

Two nails are used for each slate and these may be fixed either at the head or near the centre of the side of the slate. In the first case the holes are about 1 inch from the upper edge and in both cases at about 1 inch to 1½ inches from the long edges (see Figs. 5-7). These are elevations of a portion of roof, and the slates are foreshortened.

In the first method each slate covers a smaller area of roof, each nail hole is covered by two slates, but there is a greater leverage upon which the wind can act. With centre nailing a

SLATING

METHODS OF LAYING



little more roof is covered, there is less leverage and the slates are less likely to be torn off by the wind, but there is only one slate over each nail hole. Fig. 6 is an elevation showing Ladies slates nailed near middle or 'centre nailed'.

When battens are used the gauge must be calculated so that they are the correct distance apart, the gauge varying according to the lap, size of slate, and method of nailing. It may be found by the following formulae:

Head Nailed.

$$\text{Gauge} = \frac{\text{Length of slate} - (\text{lap} + 1")}{2}$$

For Countess slating, 3-inch lap.

$$\text{Gauge} = \frac{20" - (3" + 1")}{2} = \frac{20" - 4"}{2} = \frac{16"}{2} = 8"$$

Three inches is a normal lap, but it may vary between $2\frac{1}{2}$ inches and 4 inches: the greater the lap, the more efficient the roof covering. The lap should be at least 3 inches in exposed situations.

Centre Nailed.

$$\text{Gauge} = \frac{\text{Length of slate} - \text{lap}}{2}$$

For Countess slating, 3-inch lap.

$$\text{Gauge} = \frac{20" - 3"}{2} = \frac{17"}{2} = 8\frac{1}{2}"$$

It will be found that each Countess slate, 3-inch lap, will cover $10" \times \frac{1}{2}"$ more roof if centre nailed.

The position of the nail hole for centre-nailed slates may be found thus, working from the bottom of the slate

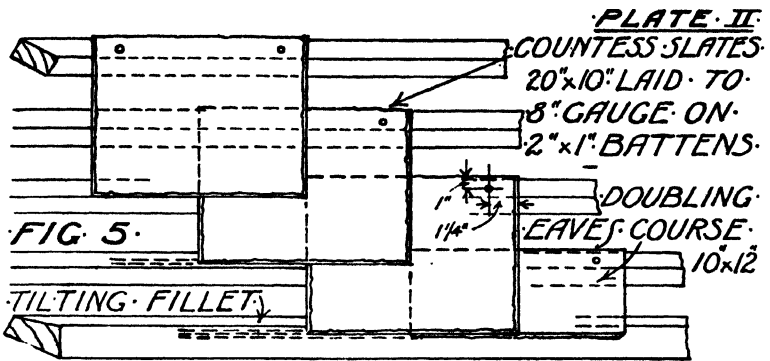
$$\text{Gauge} + \text{lap} + \frac{1}{2}" \text{ clearance}$$

For Countess slating as above,

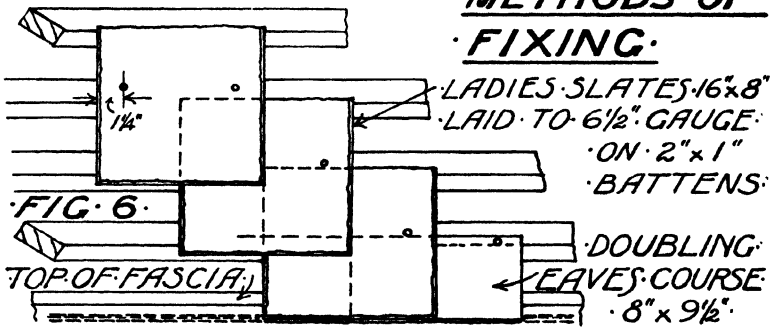
$$8\frac{1}{2}" + 3" + \frac{1}{2}" = 12"$$

Having found the gauge, the battens may be fixed, the gauge determining the distance centre to centre of the battens.

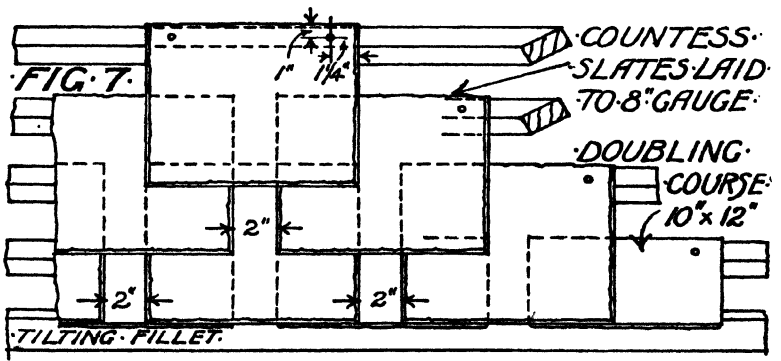
The bottom course of slates is laid upside down, i.e. with



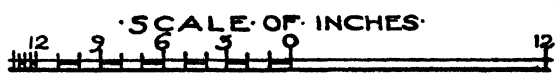
NAILING NEAR THE HEAD. **SLATING.**
METHODS OF FIXING.



NAILING NEAR THE MIDDLE.



OPEN SLATING NAILED NEAR HEAD.



the 'back' downwards, and the slates are made to a special size, namely, gauge + lap + 1".

For Countess = 8" + 3" + 1" = 12 by the width of 10". (See Figs. 2 and 4, which illustrate Countess and Ladies slating at eaves.)

The lowest edges of the slating are known as eaves and are given a tilt either by means of sprocket pieces, a fillet, or the fascia board. This brings the bottom courses of slates together and tends to slow up the rainwater and direct it into the gutter (see Figs. 2 and 4 for tilt by means of fillet or fascia and see Fig. 25 in tiling for a sprocket piece).

The joints between the slates should always be central over the next slate below, and in order to obtain this 'bond' wider slates known as 'slate and a half' are used in alternate courses to the verges of the gables, and next vertical faces, &c.

Valleys are formed by fixing boarding to form a bottom and covering with lead, which is dressed under the slates and over tilting fillets.

The edges of the lead may be formed into beads and the leadwork is fixed with copper nails. The slating is trimmed so that it works out to straight, though raking, lines, the lead showing in between (see Fig. 8). If objection is taken to the exposed lead, the mitre may be made to fit closer and the valley made weathertight with lead soakers.

Valleys may also be swept and this method is often employed when slates of varying sizes or stone slabs are used: it is, however, more laborious and this often makes the cost prohibitive (see Fig. 9).

Hips are often formed by roughly mitreing and covering with half-round tiles bedded in cement. Another method is to fix a wood roll on top of the hip rafter and cover with lead, dressing it down on to the slates. Again the slates may be cut and mitred neatly and soakers fixed. Specially made slate rolls are sometimes used, each length of roll being in two pieces, the roll on one and the other consisting of a flat slab which fits under the roll. The flat piece is nailed to the hip rafter and its upper edge covered by the roll, which is screwed into the ridge and the joints made tight with cement (see Fig. 10).

Ridges may be formed with half-round or other type of tile ridding, which may be red or blue in colour, lead dressed over a wooden roll or a slate ridge all as described to hips.

SLATING.

LEAD COVERED VALLEY.

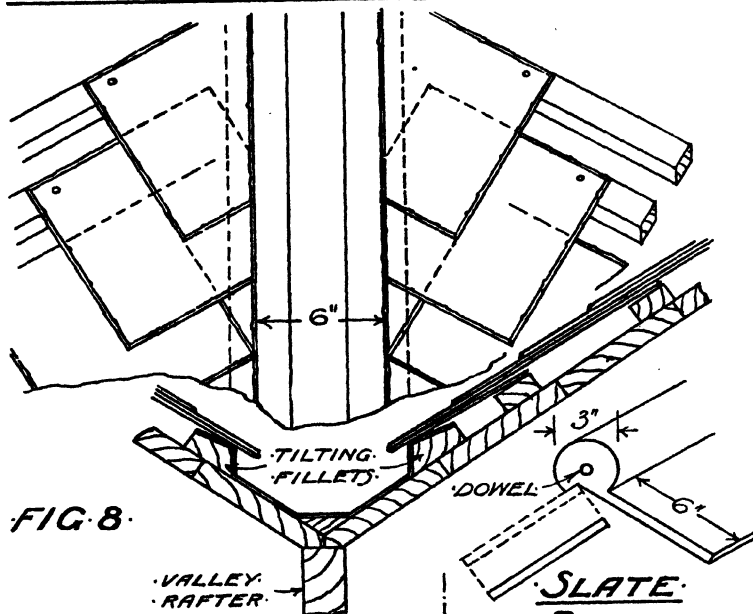


FIG. 8.

"SWEEP" VALLEY.

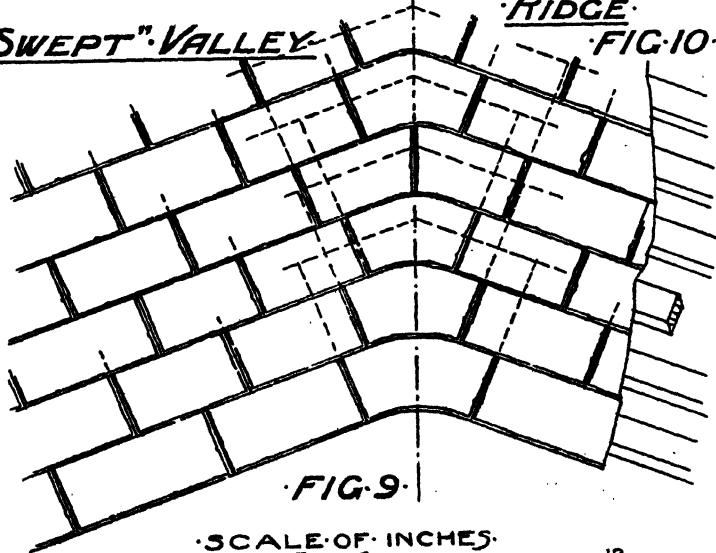
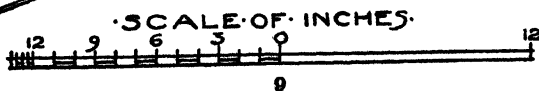


FIG. 9.



Open slating is often used in sheds and unimportant buildings, the long edges of the slates being 2 inches apart. This arrangement leads to a considerable saving in slates and in many cases gives sufficient covering, thus effecting a useful economy (see Fig. 7).

Slaters' Tools.

The tools used by the slater are as follows:

The Square (see Fig. 11).

Cutting iron (see Fig. 12).

Hammer. This may be used to hole the slates, to nail and to extract bent or broken nails (see Fig. 13).

Zax. To cut and hole slates (see Fig. 14).

Ripper. To remove defective slates by cutting the nails (see Fig. 15).

Defective slates are removed by cutting the nails with the ripper, pulling out the old slate, inserting a new slate, and securing it with strips of copper or lead, known as 'tacks', which are hooked over the head of the slate below, two to each slate, and when the new slate is in position the lower end of the tack is turned up over the lower edge of the new slate.

Rendering is the term used for bedding slates in hair mortar. The mortar supports the slates and enables the slate to stand up better to traffic over the roof.

Torching consists of pointing the inside of slating with hair mortar to keep out driving rain and draughts.

Shouldering is forming a 2-inch seal of hair mortar so that the tails of the slates are kept down and rain cannot penetrate.

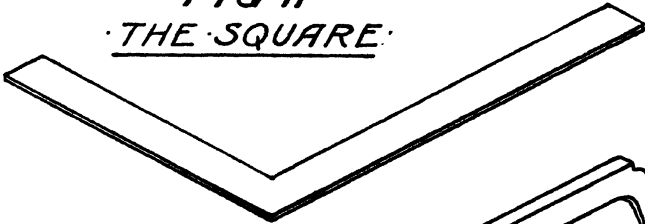
These methods of improving the weather-resisting properties of slated roofs should be avoided if the timber is likely to be affected or the mortar may induce decay, and if the roof is sealed up entirely it is not good for the timber, tending with the presence of moisture to cause dry rot.

The names and sizes of the Welsh slates are given below. The Countess 20" × 10" for ordinary roofs, Duchess 24" × 12" for large roofs, and Ladies 16" × 8" for small roofs, are those most generally used, but the builder should study cost and labour in every important case in which he can choose his materials, as he may find that a slightly different size of slate will serve as well at a lower cost.

SLATER'S TOOLS.

SKETCHES NOT DRAWN TO SCALE.

FIG. 11.
THE SQUARE.



SLATER'S LABOURER'S

CUTTING IRON.

(FIXED TO "BLOCK"
BY MEANS OF THE
SPIKED ENDS).

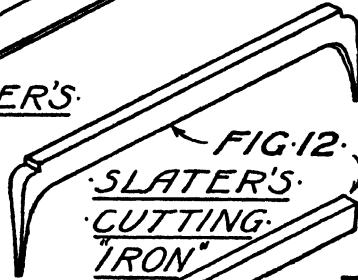
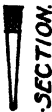


FIG. 12.

SLATER'S
CUTTING
IRON

FOR CUTTING-OUT
OLD NAILS

FIXING
SPIKE



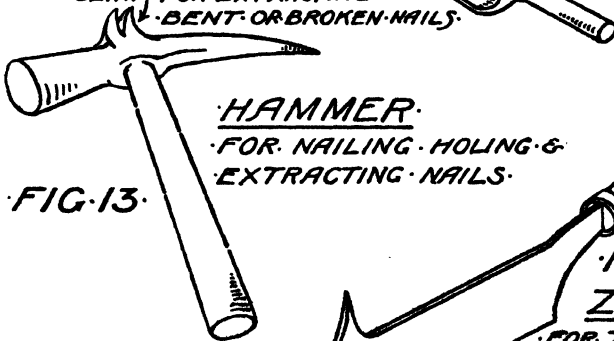
FIG. 15

RIPPER.

REMOVING

(30" LONG) USED FOR
BROKEN SLATES.

CLAW FOR EXTRACTING
BENT OR BROKEN NAILS



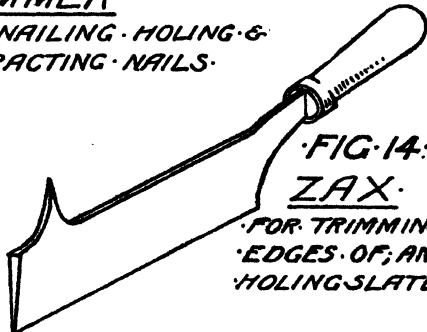
HAMMER.

FOR NAILING, HOLING &
EXTRACTING NAILS.

FIG. 13.

FIG. 14.
ZAX.

FOR TRIMMING
EDGES OF, AND
HOLING SLATES.



Slate Names and Sizes.

Empresses	26" × 16"	Long Ladies	16½" × 8½"
Small Empresses	26" × 15"	Ladies	16" × 8"
Princesses	24" × 14"	Wide Headers	14" × 12"
Duchesses	24" × 12"	Headers	14" × 10"
Small Duchesses	22" × 12"	Small Headers	18" × 10"
Marchionesses	22" × 11"	Small Ladies	14" × 8"
Countesses	20" × 10"	Narrow Ladies	14" × 7"
Wide Viscountesses	18" × 10"	Doubles	18" × 7"
Viscountesses	18" × 9"	Wide Doubles	12" × 8"
Wide Ladies	16" × 10"	Small Doubles	12" × 6"
Broad Ladies	16" × 9"	Singles	10" × 8"

The above are sold per 1,000.

Queens	24"-34" long and various widths
Rags	average size 36" × 24"
Imperials	30" × 24"

also Randoms and Peggies.

The above are sold by weight.

Stone Slates.

In some districts such as Colley Weston near Stamford, and the Cotswolds, thin slabs of stone are used as 'slates'. They are not true slates, but limestones which readily split along the planes on which they were formed. They were also formerly greatly used in and around Horsham in Sussex, and in Oxfordshire. Where appearance is the first consideration, and they are suitable, architects often use these slabs, which have a very picturesque appearance, especially when covered with moss or lichen and finished with half-round red ridge and hip tiles. They are heavy, especially after rain, as they are thick and absorptive; but, being poor conductors of heat, tend to keep buildings cool in summer and warm in winter. Their weight, and the extra strong roof timbers necessary to support them, prevent these roofing slabs being so extensively used as would otherwise be possible.

The slates are sorted; the largest are used at the eaves, the courses diminishing up to the ridge. Battens are fixed to the rafters, laths are fixed in between and covered with lime mortar which is brought up flush with the battens. The slabs are fixed in position with galvanized iron nails, one in the centre of the top of each slab; the head of the lower slate being covered with mortar sufficient to bed the upper slate, and finally they are pointed.

The slates may be cut and mitred at hips and with lead gutters underneath or covered with stone sawn to shape, or with tiles.

Valleys may be of lead, or swept as with 'peggies'.

Ridges may be covered similarly to hips.

The method of splitting the slabs is of interest. They are stacked with the bed vertical and left for the frost to split during the winter. If necessary they are watered to ensure that the splitting takes place.

CHAPTER II

TILING

THE tiles used for roofing are thin slabs of burnt clay. The clay is prepared in the same way as for bricks but it must be more carefully done. In brief the processes are:

1. Digging the clay.
2. Removing the stones.
3. Weathering, e.g. exposing in heaps to the frost or grinding to crush the lumps, especially of lime, which might split the tile into pieces.
4. Tempering. Formerly this was done by turning the tile over and beating it with shovels, &c., but the modern method is to pass the clay through a pug mill which cuts and kneads the clay and prepares it quickly for the moulder.

5. Moulding.

6. Burning.

The tiles used as roof coverings may be roughly divided into three classes:

- (i) Plain tiles.
- (ii) Pan tiles.
- (iii) Patent tiles of various makes, many being of very ingenious design.

Plain Tiles.

There are many makes of plain tile in general use, but they are all thin rectangular slabs of burnt clay about $10\frac{1}{2}'' \times 6\frac{1}{2}'' \times \frac{1}{2}''$ with two nail holes to each tile. Most modern tiles have two projecting nibs which may be used to hang the tiles, the nibs projecting downwards over the battens and preventing the tile from dropping or sliding down the roof (see Figs. 16 and 23-6). It is, however, usual to nail every fourth, fifth, or sixth, course.

All plain tiles should be curved in the direction of their length, so that the lower ends of each tile fit tightly on the next tile below (see Fig. 16). Special tile and half, and half-tiles, are used at gables in order to give the bond, they are also used against vertical faces of all kinds.

Tiles may be hand or machine made, the hand made being

TILING

PLAIN TILES ETC.

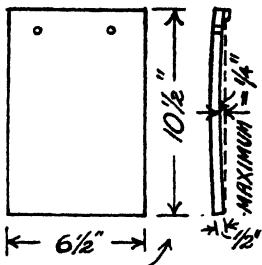
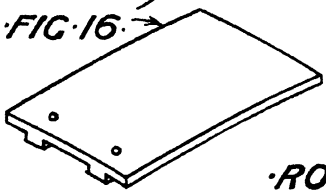


FIG. 16.

- TILE AND A HALF = $9\frac{3}{4} \times 10\frac{1}{2}$
- HALF TILE = $3\frac{3}{4} \times 10\frac{1}{2}$
- UNDER-EAVES TILE = $6\frac{1}{2} \times 7$
- UNDER-RIDGE TILE = $6\frac{1}{2} \times 9$



ISOMETRIC SKETCH

ROUND VALLEY TILE

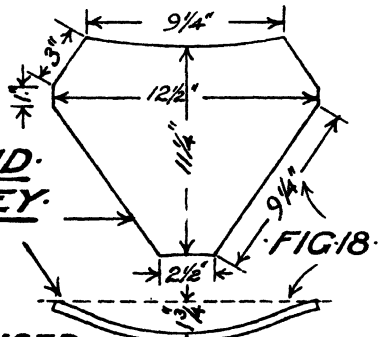


FIG. 18.

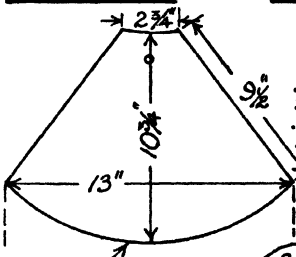


FIG. 17.

ARRISED VALLEY TILE

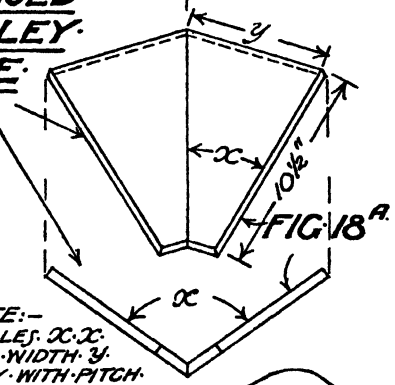
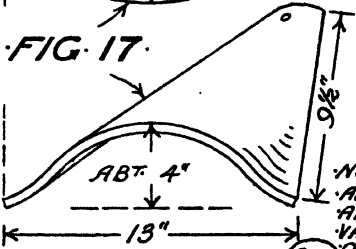


FIG. 18 A.



BONNET HIP TILE

NOTE:—
 ANGLES X.X.
 AND WIDTH Y
 VARY WITH PITCH
 OF ROOF.
 (EXAMPLE =
 FOR PITCH
 OF 45°).

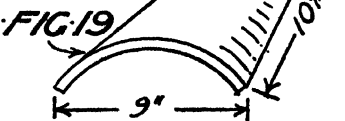


FIG. 19

CONE HIP TILE

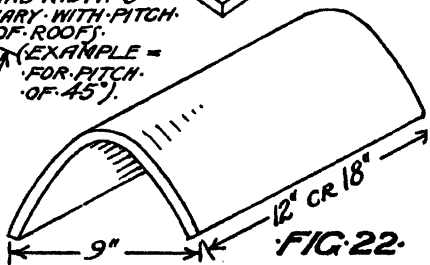
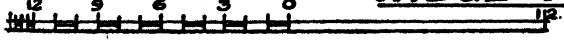


FIG. 22.

HOG'S BACK RIDGE TILE

SCALE OF INCHES



the better tile, although rougher in texture, more absorptive, and irregular in shape. The machine-made tile has a smoother face and is more compact, but with a tendency to laminate.

The colour of tiles varies very considerably according to the clay used and the burning, which should be very thorough, and the tile should, when fractured, show the same colour throughout.

There are many varieties of plain tile, and it is impossible to mention more than a very small percentage. In every case in which the choice of tile is to be made, the local tile should be compared with well-known tiles of approved quality. Before a final choice is made, examples of tiles of the selected type should be examined in position and their appearance considered in the light of their length of service. In this connection it may be noted that old tiles are very much sought after by architects for use on new buildings or extensions to existing buildings.

Among the plain tiles which may be obtained all over the country the following are well-known makes, or districts which produce a distinctive type of tile. Generally the tiles may be obtained in a range of colour from orange to dark red or purple.

Broseley tiles from various makers in this well-known district of Shropshire have been used all over the country and form a thoroughly reliable roof covering, the clay is very carefully prepared and the tiles well burnt so that they are very regular in shape and texture, giving an exceptionally neat appearance.

Messrs. Thomas Lawrence & Sons of Bracknell make tiles which have the qualities of the old tiles which charm us by the beautiful colouring. By a careful choice the beauty of an old roof may be obtained on a new house.

Messrs. S. & E. Collier of Reading is another firm which specializes in tiles of good quality and beautiful colour and texture.

The following districts are well known for beds of clay which are suitable for roofing tiles and from which excellent tiles are produced:

Maidenhead; Silverdale, North Staffordshire; Hartshill, Stoke-on-Trent; Burgess Hill and Ditchling, Sussex; Loughborough; Cranleigh, Surrey; Cheltenham.

There are many small yards producing good tiles, but generally one should be very careful in selecting from small

works unless examples can be seen which have stood the test of time.

It should be noted that machine-made hand-finished tiles are often sold as hand made. They are denser than hand made and if well prepared and burnt are no doubt better than many hand made. Prices should be very carefully compared.

Lap is the lap of a tile over the next but one below it (see Fig. 24).

Gauge is the length of tile exposed (see Fig. 24).

The usual *Lap* for a plain tile is $2\frac{1}{2}$ inches, this gives a 4-inch gauge and the pitch should be 45 degrees or more. Many villas and cottages have been built with a roof pitch of 40 degrees, but there is always a tendency for rain and snow to blow underneath the tiles if the pitch is less than 45 degrees. Tiles are more absorptive than slates and a steeper slope throws off the water so much quicker that the tiles have a better chance of a long life.

Tests. The tests for tiles are: Ring when struck by knuckle.

The fracture should be clean and the same colour throughout, but the best test is to inspect similar tiles which have been in use for some years, the longer the better. If the clay is similar and the tile equally well burnt, its life should be about the same, subject to the conditions of exposure being equal in effect.

Typical sections through the eaves of tiled roofs are given in Figs. 23-6. The first illustrates an ordinary tiled roof with tile laths and tilting fillet, soakers, and stepped cover flashing.

Fig. 24 is a section showing feather-edged and rebated boarding instead of battens. This gives some of the advantages of a close-boarded roof and is a very popular method of construction.

Fig. 25 shows a sprocket piece spiked to rafter, a boarded roof with laths on the boarding.

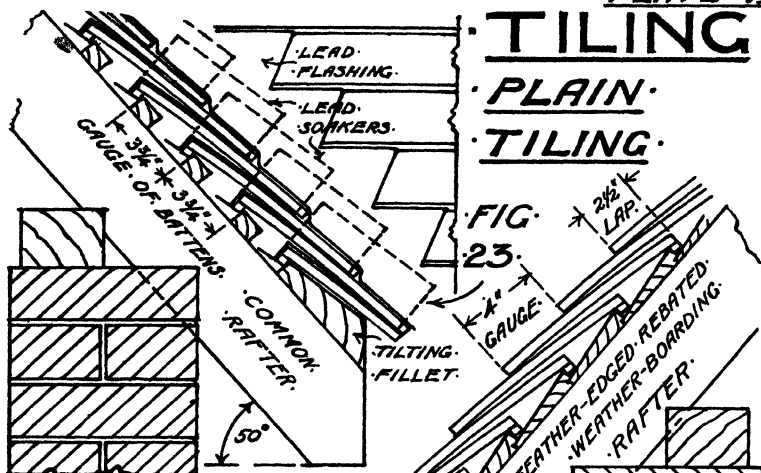
Fig. 26 illustrates a soaker in Isometric projection.

Special tiles are made for hips and valleys. Those for hips may be bonnet hips (see Fig. 17). Half-round hips similar to the half-round ridge tiles are sometimes used but have a rather clumsy appearance. Arris hips are very neat and on small roofs look well (see Fig. 18). This illustrates a Valley tile but the hip is similar though reversed with the nail hole in the narrow end.

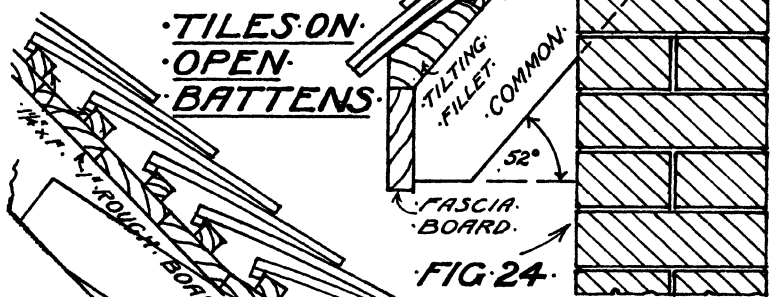
The bonnet hips have a very picturesque appearance and

TILING

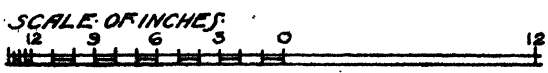
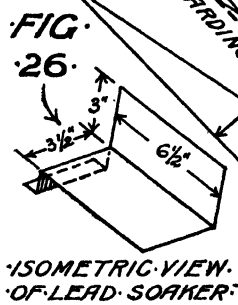
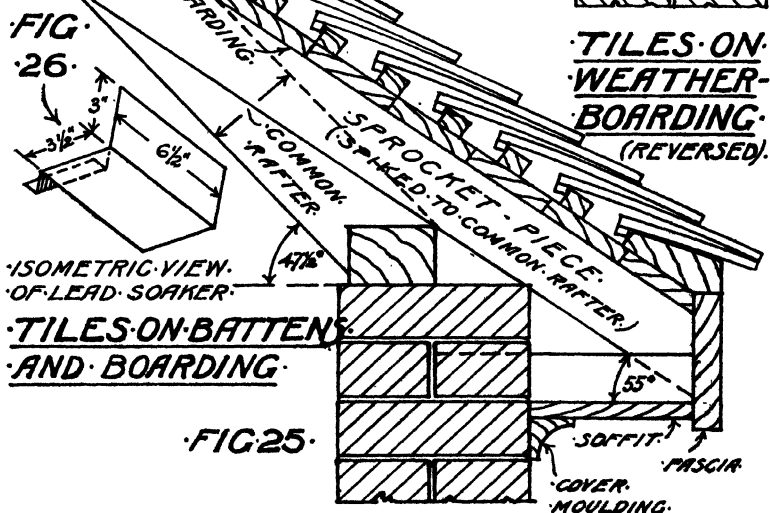
PLAIN TILING



TILES ON OPEN BATTENS



TILES ON WEATHER-BOARDING (REVERSED)

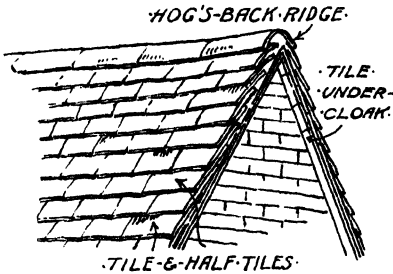


give quite a distinctive quality to a roof. Fig. 19 illustrates a cone hip tile.

Valley tiles are similar to the arris hips and make a sound job, avoiding the necessity for lead gutters or soakers (see Fig. 18 and another type in Fig. 18A).

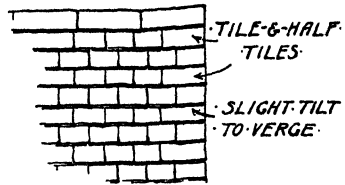
Valleys may be laced and this is a good method where valley tiles are not available (see Fig. 9 in the chapter on Slating, the lacing for slates and stone slabs being similar in arrangement).

In order to obtain the bond, 'tile and a half' tiles should be used to valleys and hips. These in alternate courses bring the joints of the tiles in one course central with those in the course above and the course below.



SKETCH OF
GABLE-END

FIG. 20.



ELEV'TN. OF
GABLE-END

FIG. 21.

Verges are formed as in Fig. 20, tiles being bedded on the slope of the gable so as to form a projecting course; on this mortar is bedded, and the roofing tiles carried over with a slight turn upwards at the extreme edge of the verge. This tends to throw the water on to the roof and prevent it running down the gable, besides giving a picturesque appearance to the roof (see Figs. 20 and 21). Half-tiles or tile and a half may be used to verges, and abutments at right angles to the courses of tiles, in order to make the bond.

Various types of ridge tile may be obtained and may be selected from the manufacturers' lists, but the most serviceable ridge is the half-round type already referred to.

Fig. 22 illustrates the Hog's back ridge tile which is very

similar to the half-round ridge tile and appropriate with very steep pitches.

Pantiles form an old-fashioned type of roof covering (see Figs. 27 and 28). They should not be used in exposed situations or in roofs where there is much cutting. This rule regarding cutting also applies to most of the patent roof tiles, which are usually of large size and special shape.

A form of patent tile which was very popular at one time is **Taylor's** patent, later known as the **Broomhall** tile. These tiles were laid on a ridge-and-valley system, one row of tiles from eaves to ridge being laid as channel tiles and the courses on either side as ridge tiles, each tile being reversible (see Fig. 29). These tiles are only made in small quantities now and are expensive, but it is sometimes necessary to obtain them for repairs.

The tiles made by the well-known firms of Bridgwater, in Somerset, are excellent of their type and useful on large plain roofs with little cutting. There are many types, but Single and Double Roman, Angular and Grecian pattern are all effective and of neat appearance. These tiles, like nearly all the patent types, are laid with a single lap. In some of them driving rain and snow are prevented from penetrating into the roof by means of little ridges formed on the upper surface of the tile (see Fig. 30 for Double Roman). Each tile has two rolls and an upturned edge which is covered by the roll of the next tile.

These tiles form a light covering weighing 6 cwts. to the square against nearly 11 cwts. with plain tiles. They do not require pointing, nailing or torching. A length of only 80 feet lineal of batten is required instead of 300 feet for plain tiles; and only 75 tiles are required to the square as against 300 plain tiles; they are interlocking and can be laid to a flat pitch like slates, and have been used all over the country for housing schemes, and for large plain roofs.

Board's patent weather block and weather lock plain tiles are of ingenious design, having a ridge at the top edge, a slight set off in the centre of its length and the lower edge is curved. They appear very like ordinary plain tiles when laid.

There are several types of Belgian tile very much used in this country. A very popular type is the **Sterreberg** interlocking pantile which may be obtained in a great variety of pleasing colours, plain or glazed. The interlocking device is effective.

TILING PAN-TILES

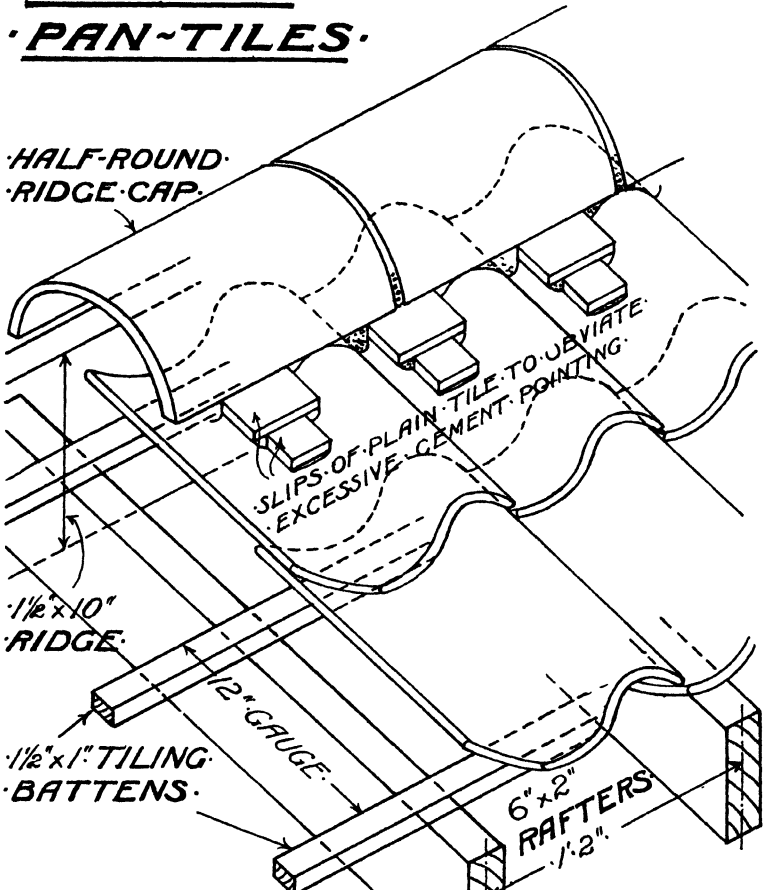


FIG. 27

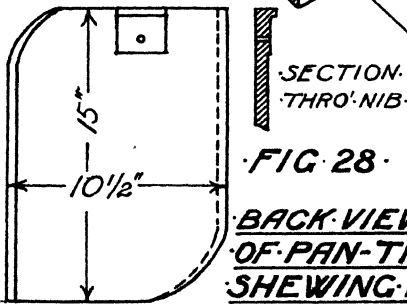
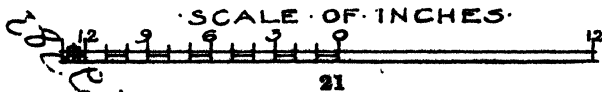


FIG. 28
BACK VIEW
OF PAN-TILE
SHEWING NIB

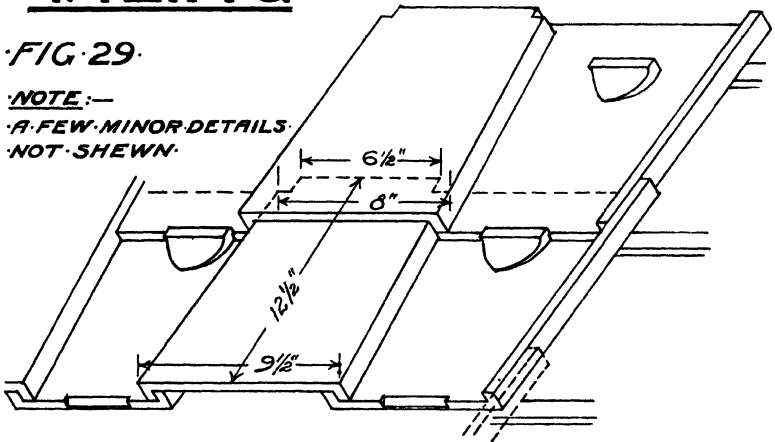
SIZES VARY FROM 13 1/2"
 14" OR 15" IN LENGTH &
 9" TO 11" IN WIDTH
 HORIZONTAL LAP - 3"
 SIDE LAP - 1 1/2" OR 2"



·TILING·

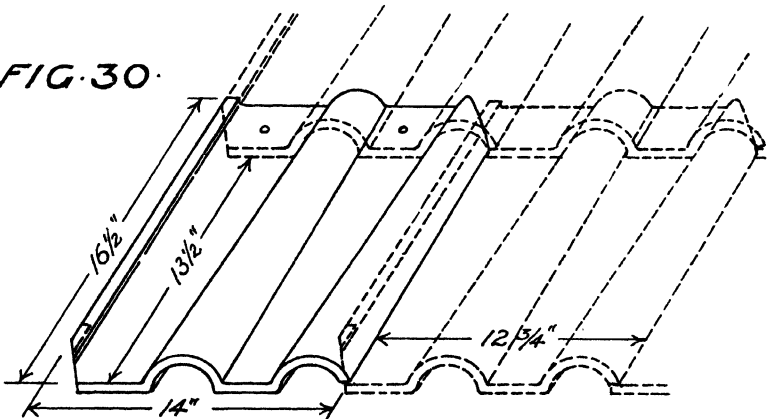
·FIG·29·

·NOTE·—
·A·FEW·MINOR·DETAILS·
·NOT·SHEWN·

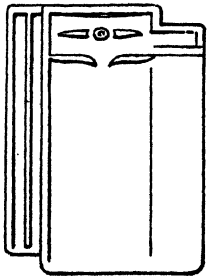


·TAYLOR'S·PATENT·"BROOMHALL"·TILES·

·FIG·30·



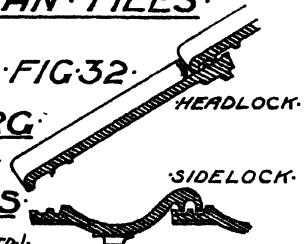
·DOUBLE·ROMAN·TILES·



·FIG·31·

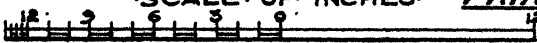
·STERREBERG·
·INTERLOCK-
·ING·PANTILES·
(LANGLEY·LONDON·LTD)·

·FIG·32·



·INTERLOCKING·
·PRINCIPLE·

·SCALE·OF·INCHES·



See Figs. 31 and 32 for sections of these tiles and for sketch showing valley treatment and secret gutter and eaves treatment. Special tiles are made to give a finish to verges and the junction of the two slopes of a Mansard roof. Saddleback ridge and hip tiles are made, also glass tiles.

Other types are Langley's C.D.N., D. and G. Brand and Cloister roofing tiles. The particulars of the Belgian tiles are taken from the brochures of Messrs. Langley of Borough High Street, London, S.E.1.

The glazed tiles form a pleasing variation from the ordinary tile finish and in combination with walls finished in white they have a particularly charming appearance.

With all patent tiles it is advisable to have a few spare tiles in hand on each building or estate, in case the special type of tile is not manufactured in the future, and this is an objection to their use. Another strong objection to the elaborate tiles of this type is that cutting to dormers, hips, splayed gables and chimney-stacks is difficult to carry out successfully. In blocks of cottages with long plain roofs and chimney-stacks at regular intervals, the stacks may be so spaced and shaped that excessive cutting is avoided.

Concrete tiles, similar in shape to ordinary plain tiles may also be obtained, coloured so that they appear very similar to plain tiles. They are cheaper and so far as can be judged will stand up to the work satisfactorily, but are difficult to cut.

CHAPTER III
SPECIFICATION
FOR A SLATED ROOF OF MODERATE
DIMENSIONS

SLATER

Slates. The whole of the slates to be of the best quality, free from cracks and spots, and true in form, the whole to be cut closely to ridges, hips and vertical faces and with proper doubling courses at eaves.

Bays and Small Entrance Hall Roof. The slating to all the small additions in front and side of the house to be of Portmadoc best quality Ladies 16" × 8" laid to a 2½-inch lap, each slate secured with two 1½-inch composition nails, centre nailed.

Main Roof. Cover the Main Roof with similar quality Portmadoc slates, Countess 20" × 10" laid to a 2½-inch lap, each slate secured with two 1½-inch composition nails, centre nailed.

Verges. The Verge to be laid double and bedded in cement. Bond to be obtained by using slate and a half to alternate courses.

Ridges. The Ridges to be formed with half-round red ridge tiles set and pointed in gauged mortar with three-way ridge tiles where the hips occur.

Hips. Form Hips to main roof with similar half-round tiles as to ridges. Provide and fix hip hooks to all Hips.

The Hips to Bays and small additions to be cut and mitred neatly and lead soakers to be laid in between the slates.

Flashings to Chimney Stacks. Provide and fix lead soakers to the sloping sides of Chimney Stacks and next walls; cover the soakers where upstanding with 5 lbs. lead stepped flashing neatly cut and turned at top edge into the joints of the brickwork, wedge with lead wedges and point.

Form lead gutters at back of stacks in 6 lbs. lead turned up 6 inches against brickwork of stack and carried up under slates and over tilting fillet to a vertical height

of 6 inches. Form roll in centre with 2 inches wood roll, the lead being properly dressed over so that the overcloak finishes about 1 inch above the gutter.

Flash the upturned edge of lead to gutter with 5 lbs. cover flashing.

Flash on other side of Chimney Stack with 5 lbs. lead apron upper edge turned into joint of brick as to stepped flashing and lower edge dressed down on to slates and secured with lead tingles.

Leave all roofs clean and perfect.

MEASUREMENT OF SLATING AND TILING

General Slating. Slating or Tiling and battening of all kinds are measured by the square of 100 feet superficial. Openings up to 4 feet superficial are not deducted and the slating saved may thus be set off against the cutting. In pricing the builder should note if there are a number of small openings and price accordingly. If over 4 feet superficial in area the openings should be deducted and cutting measured and described. A full description must be given of the battens, slates, lap, &c. Special slating must be kept separate and the extra labour described.

The following labours are described at per foot run to enable the builder to price at the appropriate rates.

Eaves. Measure the Eaves by the foot run, describing the work as 'extra to double course at eaves'.

Verges. Per foot run, describing as 'extra to Verges, using slates of slate and a half width'. Any other requirements should be described, also if on the skew.

Top Edges. Per foot run as 'extra to cutting and waste to top edge of slating'. This labour occurs under ridges, the sills of dormers, skylights, and against the lower edges of chimney-stacks.

Abutments. 'Cutting and waste to square, or raking, Abutments, as the case may be.'

Circular Cutting. 'Circular Cutting and Waste.'

Cutting to Valleys and Hips. 'Cutting and waste to Valleys (both sides measured).' 'Cutting and waste to Hips (both sides measured).'

The Valley tiles or Hip tiles and ridges are measured

by the foot run and described. The mitres intersections, &c., and Hip irons or hooks numbered and described.
Soakers. Lead Soakers are given in dozens.
Glass Slates. Are numbered.

The foregoing notes are only intended as a guide to the ordinary student, and if he studies construction they should prove sufficient for rough estimates.

If the student wishes to take up quantities thoroughly he should work from a good text-book and the Standard Method of Measurement published by the Surveyors' Institution, which has been agreed between the Surveyors' Institution and the Builders' Federation and Institute of Builders.

For rough estimates the items can be lumped together. For instance, one dimension may be made to suffice for Hip Tiles and the cutting and tile and half on both sides of the Hip.

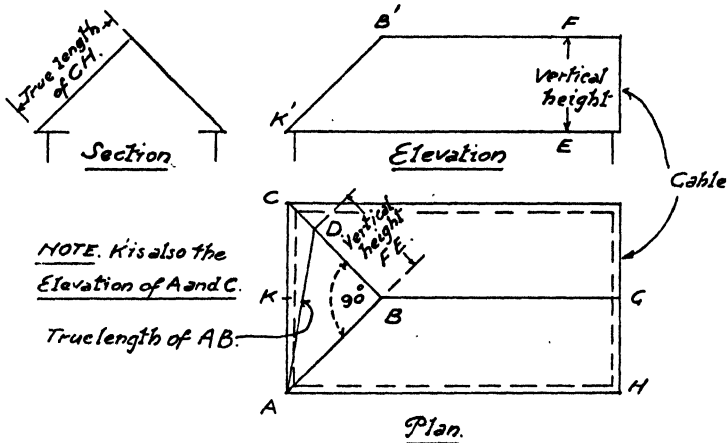
If taking off complete quantities for a house, the extra to eaves, fascia and paint (4) to fascia and the eaves gutter and (4) to gutter may be worked out as one item. The Quantity Surveyor takes such items together as far as he can and abstracts into trades and similar items, but the builder need not abstract all his items on small jobs. He may find it is better to take each trade at one time, and to slightly mix the items as suggested for eaves, fascia, and painting.

(4) is the sign usually adopted for painting 4 coats of oil colour; it is very generally used.

MEASUREMENT OF HIPS AND VALLEYS FOR THE TILES, CUTTINGS, &c.

To obtain the true length of the hip tile AB , set up BD at right angles to AB , make $BD =$ the vertical height FE on elevation, then AD is the true length of AB , measured of course to the same scale. ABD is an outline section on the line AB , the section plane cutting the hip vertically. Valleys may be found in the same way. The student should note that if he wishes to find the true length of the hip rafter he must be careful to allow for the depth of the timber, and this will be quite easy if he draws the rafter complete.

To measure the surface $AKGH$ when the slopes are inclined at the same angle with the horizontal plane, take the length



NOTE. K is also the Elevation of A and C.

True length of AB.

AH and multiply by the true length of GH obtained from the section. The area *AKB* is the same as if the roof were in one plain face. The student should test this and he will find that *KA* if placed in line with *BG* occupies a length *KB* in plan. *BA* remains the same length as before but lettering reversed and *KB* being the full length of the slope as shown in elevation at *K'B'* gives a line equal to *GH* in plan and true length. Twice the area *AKGH* found in this way gives the whole of the tiling to the roof illustrated. The same method is adopted where valleys occur.

If the end slope *ABC* makes a different angle with the horizontal, the lengths *BG* and *AH* should be added and divided by 2 when the average length found multiplied by the true length of *GH* will give area *BGHA*. Twice this will give the area of the two main slopes and for the end take length *AC* and multiply by true length *KB* and divide by 2.

**SPECIFICATION
FOR A TILED ROOF OF MODERATE
DIMENSIONS**

TILER

Tiles. Cover the roofs with best-quality local hand-made sand-faced tiles, each tile with two nibs and nail holes; laid to a 4-inch gauge, and secured by the nibs to feather-

edged boarding; every fourth course nailed with two $1\frac{1}{4}$ -inch composition nails to each tile.

Eaves. All eaves to be formed with proper under-eaves tiles to give double course and bedded in lime mortar.

Verges. Form undercloak with plain tiles bedded on gable, carry tiling over to same projection as undercloak, using tile and half to give bond, bedding in lime and hair mortar and pointing in gauged mortar.

Hips and Valleys. Put to all Hips proper bonnet Hip Tiles to course and bond with the plain tiling, and to Valleys proper Valley tiles bonded to plain tiling. Provide and use all necessary tile-and-half tiles and do all requisite cuttings.

Ridges. Finish the ridges with local ridge tiles of roll type, bedded in lime and hair and pointed in cement.

Soakers. To all vertical faces put light lead soakers and cover the upturned edges with 5 lbs. stepped cover flashings.

Clean out all gutters and leave all roofs clean and perfect and weatherproof at completion.

The leadwork described in 'Slater' will suffice for a simple tiled roof and may be inserted after soakers, but it is usually described in the 'Plumber' and carried out by him, whereas the Soakers must be fixed between the tiles as they are laid.

The student should write a Specification taking each item and endeavouring to vary according to the type of building, situation, &c.

The Imperative Mood should be used and the language should be simple and clear.

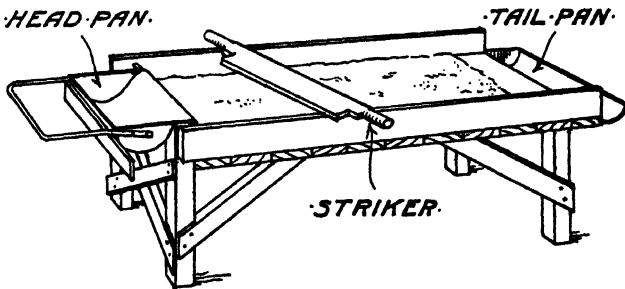
CHAPTER IV

LEAD FLATS

LEAD is not found as a pure metal, but is obtained from a sulphide of lead known as galena, which is smelted in a furnace. Lead is very soft and plastic, heavy, fusible, malleable, and with little tenacity or elasticity.

For roofing purposes it is sold in sheets of different thicknesses described by the weight of a superficial foot, such as 4 lbs., 6 lbs., 8 lbs.

Cast lead is made on a casting bench (see Fig. 36) in sheets about 18' \times 6'. At the upper end of the bench is a trough which is filled with molten lead, the bench has a flat surface



·SKETCH OF CASTING BENCH·

·FIG. 36·

which is covered with sand struck off level with the striker and then compressed with a tool resembling a plasterer's float; at the foot is a small gutter or trough to take the superfluous lead. Molten lead is poured into the large trough at the head of the bench, this is then emptied on to the bench and spread over its surface with the striker, a piece of wood cut at the ends so that it squeezes the lead before it leaving a thickness of lead on the table top in the form of a sheet. The thickness is the distance between the pressed sand and the striker. Cast lead may be made by any plumber using old lead taken from buildings, waste cuttings, &c.

It is usually thicker and heavier than milled lead, is not so regular in thickness and more liable to defects such as sand-

holes, but has a harder surface due to the fusing of the lead and sand; which makes it more durable, but it does not make such neat work.

On account of its irregular thickness it should not be used of less than 6 lbs. per foot weight.

Milled lead is rolled to a regular thickness, is more uniform in quality, bends easily, and will make much neater work than cast lead. It is not so durable as cast lead and has a tendency to crack when exposed to great heat from the sun. Milled lead may be obtained in sheets 25' to 35' long and 6' to 7½' wide. The weights used in building work are 4-5 lbs. for flashings and aprons, ridges and hips 6 lbs., flats and gutters 6, 7, or 8 lbs., gutters being thicker than flats, and the heavier material being used wherever possible on better-class work; 4 lbs. should be used for soakers as it fits in better between the slates or tiles than heavier lead.

The thickness of lead for each weight may be worked out from the following information.

Thickness of a superficial foot of 1 lb. weight = 0.017". Multiply this figure by the number of pounds per foot and we get $0.017 \times 4 = 0.068"$, for 4 lbs., say $\frac{1}{18}"$; 6 lbs. = $0.102"$, = $\frac{1}{10}"$; and 8 lbs. = $0.136" = \frac{1}{8}"$.

The student is recommended to work out a complete table and put it with his papers. He will learn the thicknesses more thoroughly if he does this than if he copies a ready-made table. If he wishes to memorize these values he should either learn the value for 1 lb. or the values for 4 lbs., 6 lbs., and 8 lbs., so that each intermediate value may be calculated. Every opportunity should be taken of testing samples on buildings. As an exercise the thicknesses may be worked out on a graph.

Lead is not suitable for steep roofs owing to the way in which it will creep down the slope. It expands with the heat, the action of gravity pulls it down the roof; when cold it contracts and the action of gravity tends to prevent it going back to its original position. It is said that on a moderate slope lead has been known to creep down 18 inches in ten years.

The fall for lead flats and gutters should be $1\frac{1}{2}$ inches in 10 feet, or as a minimum 1 inch in 9 feet, the boarding under the lead should be laid to an even fall and be perfectly smooth, the joints being traversed with a plane to bring the

edges down to the general level of the boarding. If this is not done the edges will stand up and show through the lead and tend to form pools which will hold water, especially if they run across the slope; but to prevent any possibility of this the boards should be laid with the long edges running with the fall.

Gutters are better if formed with narrow boards because the shrinkage is less to each width.

Owing to the contraction and expansion of lead it should only be fixed along one edge and only comparatively small pieces should be used. The expansion and contraction will then be slight and distributed over several joints.

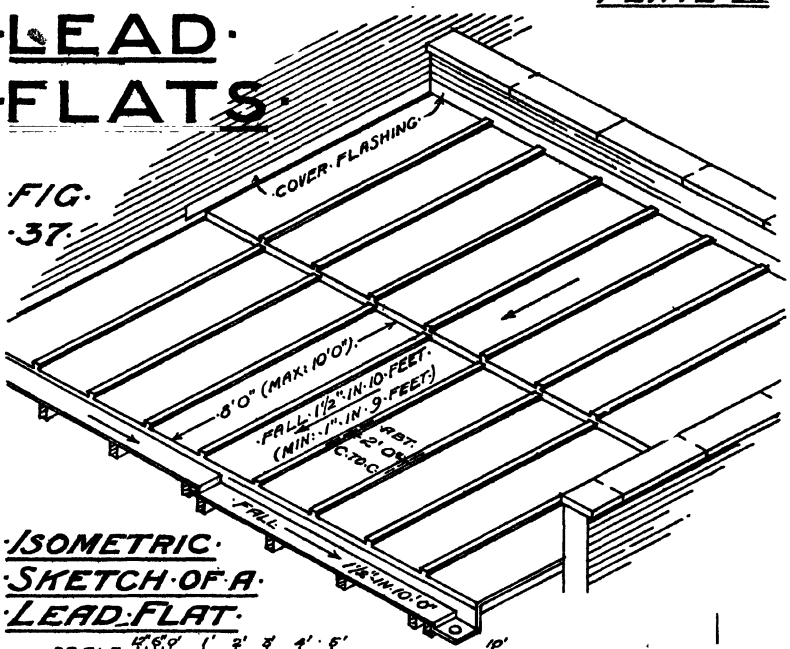
All leadwork should be fixed so as to allow expansion to take place. It should not be laid on oak.

Fig. 37 is an isometric sketch of a small lead flat with a parapet wall shown on two sides, and the high wall on a third side. There would be another wall against gutter. Drips, wooden rolls, a gutter and cesspool are shown. For details of gutter and cesspool see Figs. 38 and 38A. The maximum distance centre to centre of the rolls recommended by the Lead Development Association = 2 feet. The lead is turned up against the brickwork about 6 inches and a strip of lead called a cover flashing is turned into a joint in the brickwork wedged with lead wedges, and brought down over the upturned edge of lead as shown in Fig. 38. The cover flashing is pointed and the lower edge should be about 2 inches above the level of the flat. The dog-eared fold in Fig. 43 shows a workmanlike angle to the upturned lead of flat next walls.

The flat is divided into bays by rolls, which form the joints between the bays, and which run with the current. Wood rolls are first fixed to the boarding of the flat and the lead is laid with one edge over the roll and well dressed down, the edge of the next sheet is then dressed over to within about $\frac{1}{4}$ – $\frac{1}{2}$ inch of the flat (see Figs. 39 and 40). The edge of the overcloak should be on the side of the roll away from the rainy quarter. Sometimes the overcloak is carried down on to the flat, as shown by dotted lines in Figs. 39 and 40; but this is not considered good practice because water can penetrate under the overcloak and may be drawn by capillary attraction up over the roll, and cause decay in the woodwork. Hollow rolls are sometimes used, especially in the North of

LEAD FLATS

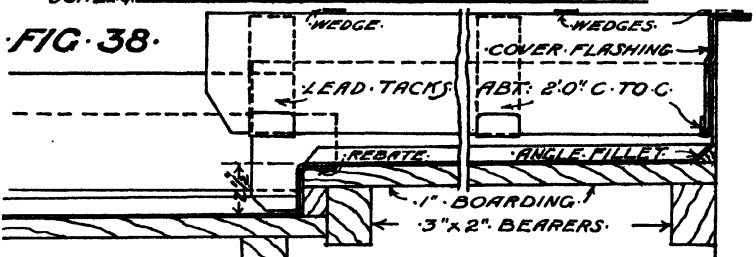
FIG. 37



ISOMETRIC SKETCH OF A LEAD FLAT

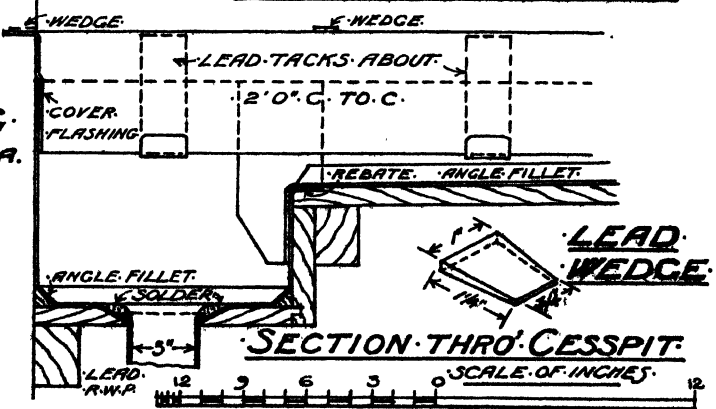
SCALE 1" = 2' 0"

FIG. 38



SECTION THRO' GUTTER

FIG. 38 A



SECTION THRO' CESSPIT

England and in Scotland. The ends of the two adjoining sheets are turned up against each other with strips of lead let into the boarding and screwed or nailed to the wood (see Figs. 41 and 42); the upturned lead is then turned over until its end touches the flat and it forms a roll very similar in appearance to the ordinary wood-lined roll previously described. The tacks or tingles are fixed at about 2-foot intervals and effectively secure the rolls to the boarding. If these rolls are trodden upon and become cracked along the side, marked by a cross in Figs. 41 and 42, the rainwater may be carried into the roof. Flats should always be protected if they are walked upon, but it is more important that there should be protection when hollow rolls are used.

Drips are formed across the flow of all flats and gutters at intervals of 10 feet or less. The woodwork of the flat is stepped down $1\frac{1}{2}$ –3 inches and the upper edge of the woodwork is rebated. The lower sheet of lead is dressed up the vertical face of the drip and turned over the top into the rebate and close copper nailed, and the upper sheet is turned down over the lower sheet to within about $\frac{3}{4}$ inch of the flat or gutter below. The rebate allows the drip to be formed without a ridge which would tend to form a pool of water above the drip (see Fig. 44).

Sometimes the lead is carried down over the drip and on to the surface of the flat or gutter below, but this practice is open to the same objection as with the rolls. This overcloak is shown on Fig. 44 by a dotted line.

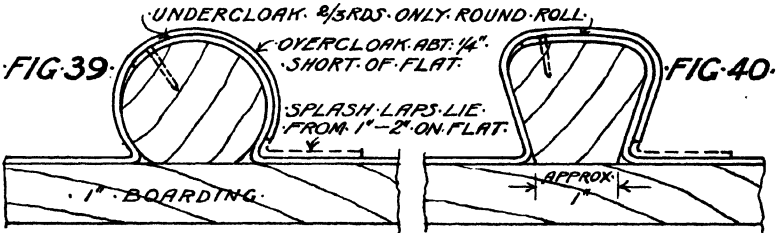
There are several improved forms of drip, for instance, in exposed situations; where the edges of the lead are likely to be blown up by the wind, a deep drip is used similar to the ordinary type, but lead tacks or tingles are fixed at intervals to hold down the upper sheet. In very good work the woodwork has a groove formed along the whole length of the drip and the lead is dressed into the groove. This prevents water being drawn up by capillary attraction. (See dotted lines in Fig. 44.)

Two other forms of drip or nosing are illustrated by Figs. 45 and 46.

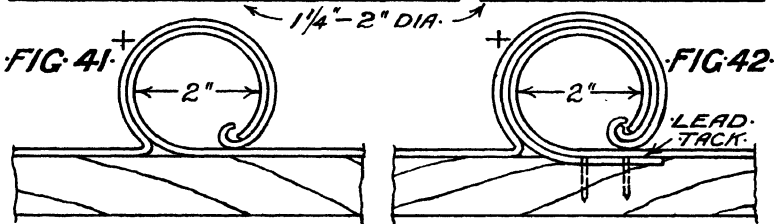
Nosings are formed to make the joint between a lead flat and a sloping roof. A lead flashing is dressed about 8 inches down the slope and carried vertically up the boarding to the top edge, a wood roll is then nailed to the edge of the boarding

LEAD FLATS

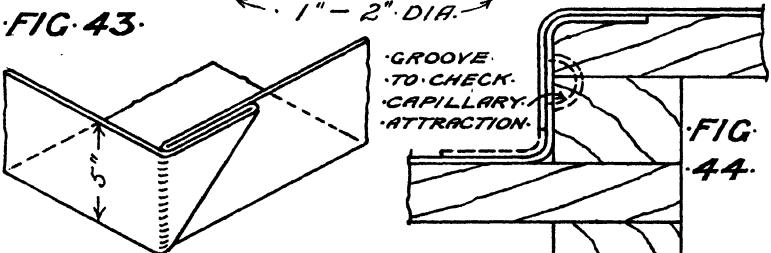
DETAILS



COMMON ROUNDED ROLL · SPLAYED ROLL



2" · HOLLOW · ROLLS.



ISOMETRIC SKETCH · DRIP · OF · DOG-EARED FOLD.

ABT. 1" TO 1'

ABT. 8' 0" APART.
2 1/2" - 3" DEEP.

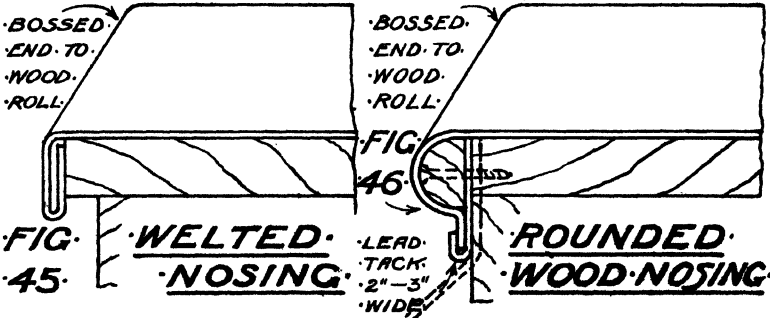


FIG. 45 · WELTED · NOSING

FIG. 46 · ROUNDED · WOOD · NOSING

and the upper sheet of lead is then dressed over the roll (see Fig. 46).

The dotted line showing the lead flashing carried over the slates or tiles.

SPECIFICATION FOR A LEAD FLAT

The joists having been fixed to give the necessary fall and covered with rough boarding, drips and rolls and cesspool having been constructed, the plumber is able to cover it all in and form a watertight roof. The fall should be say— $1\frac{1}{2}$ inches in 10 feet. All nails used to be of copper.

Lay the flat with 6 lbs. milled lead, turned up 6 inches against brickwork and properly dressed over 2-inch wood rolls. Form drips, as indicated on the plan and nail undercloak to rebate in boarding. Lay the gutter with 7 lbs. lead turned up against brickwork at least 6 inches and up and into rebate of the drip. Form cesspool in similar lead soldered where necessary at angles and copper nailed. Form outlet and solder 3 inches heavy lead waste pipe to same and carry through wall to discharge over rainwater head. Cover the upturned lead next wall with 5 lbs. lead flashing taken into joint of brickwork, wedged with lead wedges, and pointed in gauged mortar. Lead tacks of 7 lbs. lead to be fixed as directed. The cesspool to have an overflow pipe in addition to the outlet and similarly constructed, but placed so that it will prevent water in cesspool rising over upper edge of lead. All roll ends and intersections to be bossed.

Various Roofing Requirements.

Chimney Flashings, &c. Lay the chimney gutters with 6 lbs. lead dressed over roll in centre, to fall both ways. Carry up over fillet under tiles and vertically at least 6 inches against chimney-stack and return round sides of stack. Flash with 5 lbs. lead. Cover the lead soakers laid by tiler with 5 lbs. stepped flashings return at ends, and to lower face of stack fix 5 lbs. lead apron returned round sides, and dressed down on to tiles.

Valley Gutter. Lay the valleys with 6 lbs. lead dressed up over tilting fillets and copper nailed, no length to exceed 7 feet. Laps to be 6 inches.

Leadwork to Roofs.

Measurement. Lead is measured net and no allowance is made for waste. It is given in the Quantity Surveyors' Bills by weight and classified under headings which suggest the amount of labour involved. The following are the most important, and while the practical builder may in his own quantities vary them, when tendering on a Surveyor's Bill, he will find them set out on similar lines.

1. Flats.

2. Gutters, including cesspools, valleys, over flashings, aprons, dormer cheeks, hips, and ridges.

(Note that there is more labour than in the plain flat with large sheets.)

3. Stepped flashings.

4. Soakers.

5. Weatherings to cornices.

6. Flèches and turrets.

7. Domes.

The following allowances are made over the flat surface:

2-inch drips, 6 inches;

2-inch rolls, 9 inches.

Passings in running length to flashings, &c.,

4 inches in 7 feet run.

Passings in Valleys, &c., 6 inches in 7 feet; welted laps, 4 inches.

Turn ups next walls 6 inches and on other side of gutter the lead shall be taken to the same vertical height. The actual width to allow this will vary with the roof slope.

Burning into grooves, copper nailing, lead wedging to flashings, dressing into hollows, &c., should be given per foot run describing the labour involved. Copper nailing should be described as close when the space does not exceed $1\frac{1}{2}$ inches.

The following items are numbered:

Bossed ends to rolls, soldered dots, extra labour to cesspools, &c.

CHAPTER V

COPPER ROOFING

COPPER is a thoroughly well-tried material for roofing, having been used for centuries for many different purposes. It is easily worked, light, malleable, and ductile: when exposed to the atmosphere it oxidizes, and the thin coating of oxide protects the metal from further action. It does not creep like lead and it resists fire.

It is stated by authorities that 100 feet super. of copper roofing of the usual thickness weighs only 1.2 cwt., as compared with 8.5 cwts. if covered with 6 lbs. lead, 13.2 cwts. if covered with tiles, 6-12 cwts. if covered with slates, and 3½ cwts. if zinc. This leads to lighter construction and a useful saving on first cost, while its long life makes it far superior to many more popular materials.

The Copper Development Association recommends that the quality and purity of the metal for roofs should be equal to the British Standard Specification 61, clause 2, which is really for tubes. This gives not less than 99.25 per cent. copper, and 0.25 per cent. to 0.45 per cent. must consist of Arsenic; so that the maximum of injurious impurity must not exceed 0.5 per cent.

Copper expands under the influence of heat and contracts when cold, but not to the same extent as lead or zinc. This expansion and contraction must be allowed to take place freely so that there is no buckling of the sheets, which would if permitted tend to harden the metal.

For flats the fall should be at least 1½ inches in 10 feet (1 in 80), 1-inch butt jointed boarding should first be laid on rafters or joists spaced sufficiently near to each other to prevent springiness. As with lead flats it is best for the boarding to be laid with the joints in the direction of the fall, and it is better laid diagonally than at right angles to the flow.

In first-class work felt should be laid on the boarding and nailed with copper nails so that contact with iron and other metals will be avoided. The felt keeps the nails of the boarding away from the copper, deadens the sound of rain, prevents

moisture from condensing and tends to lessen the effects of heat and cold on the temperature inside a building.

Copper should be laid by experts as excessive hammering tends to harden the metal, and with proper treatment the material is almost everlasting.

The metal usually employed for roofing is either 23 or 24 S.W.G. (Standard Wire Gauge), known as '19 ozs. and 16 ozs.', the thickness being 0.024 inch and 0.022 inch respectively. The basic price is the cost per pound for sheets not exceeding 14 sq. feet in area, say, 4' × 3' 6", 5' 3" × 2' 8" or 7' × 2'; larger sheets are priced at a higher rate, but, on the other hand, the labour costs will probably be less and will more than compensate for the extra on the metal. Sheets as large as 8' × 3' are sometimes used for roofing.

The ordinary joints between the sheets and running with the flow are the wood roll and the standing seam; as with leadwork, the wood roll should be used where there is likely to be traffic over the roof. (See Figs. 47 and 47A for the conical roll and Figs. 52 and 52A for the standing seam. Other types of wood rolls are shown in Figs. 48, 49 and 50.) These will be at 2 feet 5 inch centres if the sheets are 2 feet 8 inches wide and conical rolls are used, 3 inches being deducted from the width of the sheet. It will be noticed that this is the width of the overcloak, the undercloak being 2 inches, which is the width of the base of the roll. For joints across the flow the single-lock or double-lock cross-welts are used (see Figs. 51, 51A and 51B). The single-lock cross-welt is sometimes soldered, but it is considered better practice to use the double-lock cross-welt.

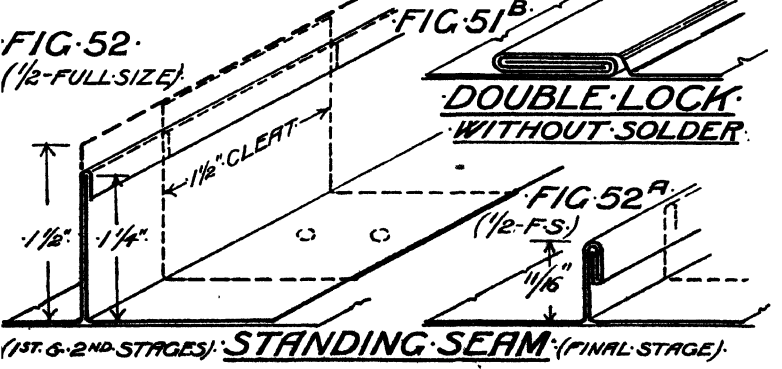
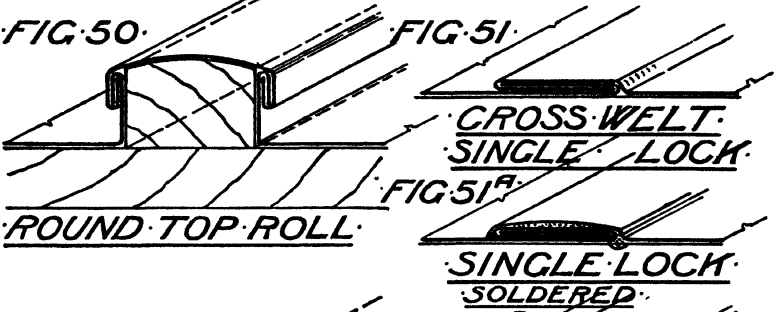
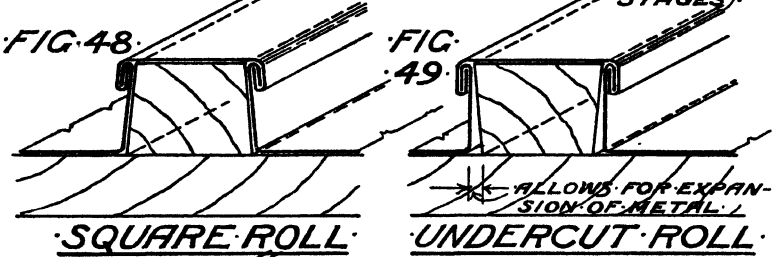
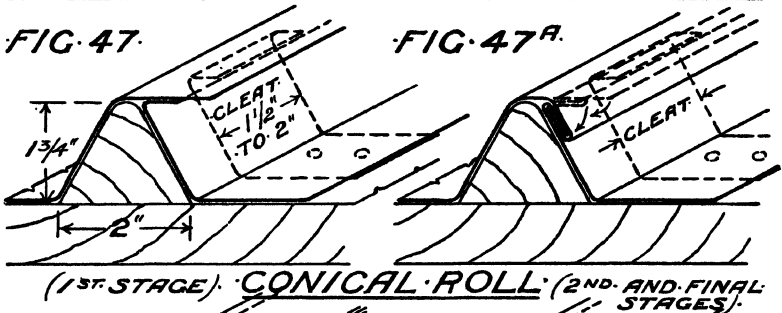
Where the fall is small and the welts would tend to hold up water, the boarding is sometimes gouged out so that the copper sinks into the wood and the flow is not obstructed.

It is usual to have a double welt joint at intervals of 5 feet along the fall of the flat and drips at 10 feet, but with welted joints at 5-foot intervals the drips may be 15 to 20 feet apart.

Using the small flat in Fig. 37 as an example the rolls might be any one of those illustrated. The joint next the walls would be as Fig. 53, the copper being turned up against the vertical face of the wall and a cover flashing formed as shown. The drips would be formed as Fig. 54 with a single welt. Special care is required at the ends of the rolls next walls or drips and the special welted saddle and solid stopped ends

COPPER FLATS

DETAILS



COPPER FLATS.

DETAILS.

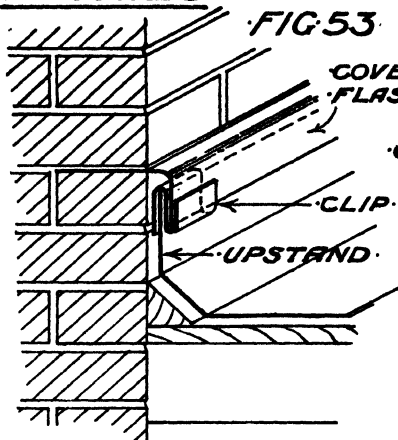


FIG. 53.

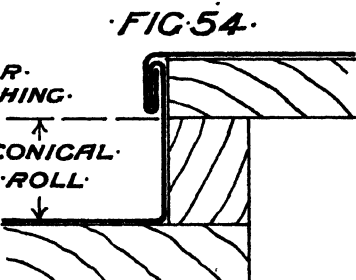


FIG. 54.

DETAIL OF DRIP.
1/4 TH. FULL-SIZE.

JOINT NEXT WALL.

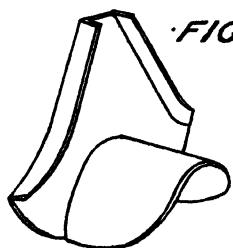


FIG. 55.

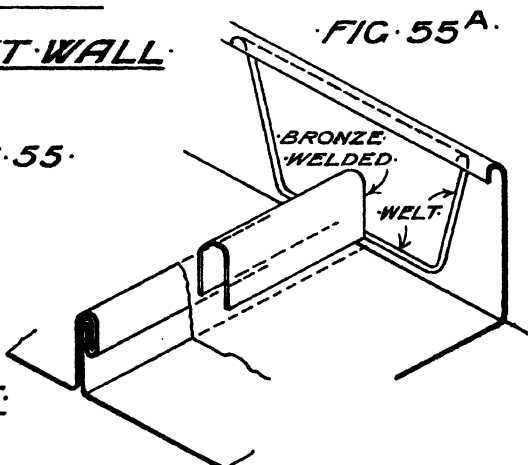


FIG. 55 A.

SKETCH OF
STAMPED
SADDLE-
PIECE FOR
CONICAL
WOOD ROLL.

SADDLE-PIECE FOR
STANDING SEAM (1/2 FS).

SKETCH OF FLAT
DISCHARGING OVER
TILED ROOF.

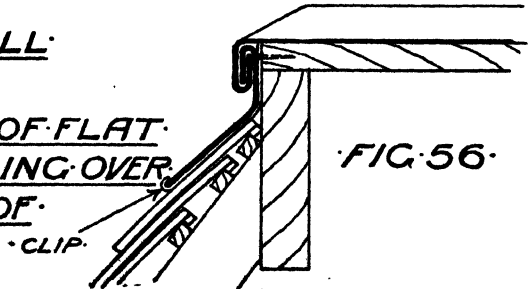


FIG. 56.

made by firms such as Messrs. Ewart make a thoroughly sound job. Fig. 55 illustrates a stamped saddle piece also made by Messrs. Ewart. Fig. 55A shows a bronze welded saddle piece for use where standing seams take the place of wood rolls.

If the flat discharges over a tiled roof the finish should be as shown in Fig. 56; this is similar to the treatment when a lead flat discharges under like conditions. The bead formed on the lower edge of the copper prevents the wind blowing up the flashing, which is also held down by a copper clip.

The rolls on copper flats are usually staggered, when the fall is made both ways as in an ordinary pitch roof, those down one slope being central with those on the other slope.

Copper may also be obtained in the form of corrugated sheets fixed in a similar manner to corrugated iron sheets. They are not much used, but where exposed to chemical action, their use, bearing in mind the long life of copper, might be advantageous and cheaper in the long run than galvanized iron. Special ridges, verges for gables, and angles for vertical work may be obtained.

Copper tiles may also be used for roofing, and are obtainable in a variety of shapes, Spanish or Italian, and ornamental. These tiles are usually laid on boarding and the addition of felt is advisable on account of its sound deadening and insulating properties.

The prices of copper and lead vary from time to time, and in all cases of roofing the architect or builder should carefully consider the relative cost of copper, lead, and the cheaper roofing materials with a view to obtaining the best results. There can be little doubt that copper will be the cheapest in the long run if not actually so on first cost.

For further information on copper as a roofing material and on the technical details, the student is referred to the excellent handbooks issued by the Copper Development Association, and by Messrs. Braby and Messrs. G. A. Harvey, Ltd.

SPECIFICATION FOR A COPPER COVERED FLAT

Cover the flat roof of study with No. 24 S.W.G. copper sheets, hot rolled and of dead-soft temper. (These are laid on boarding and roofing felt or building paper.) The copper

sheets to be fixed by means of clips to splayed rolls in such a manner as to allow the copper to expand and contract freely, the clips to be turned and folded in the welts. The clips are to be secured with copper nails and no other metal to be allowed in contact with the copper. All joints in the copper running across the flow to be double lock welts, and drips to be formed with single lock welts forming a nosing to lower edge of the upper part of flat.

Turn up against vertical faces of brickwork 6 inches and cover upper edge of standups with copper cover flashing of similar thickness connected to upstands with a welted joint. Fix flashings with lead wedges. Cover the rolls next walls with properly formed aprons or saddle pieces and the ends next drips with solid stopped ends.

The fall to be at least $1\frac{1}{2}$ inches in 10 feet.

Form the gutter as shown on plan, with cesspool at end and 3-inch copper pipe leading from the cesspool to discharge over a rainwater head.

Leave all clean and perfect at completion.

Note that 24-gauge copper is suitable for ordinary buildings but 23-gauge is recommended for more important work.

COPPERSMITH

MEASUREMENT OF COPPER ROOFING

The copper should be described and its thickness given according to the Imperial Standard Wire Gauge—(I.S.W.G.).

Measure net, add clips, describe the work generally under the headings given in 'Zinc Worker', keeping circular work separate.

Allow the following:

Welted laps—4 inches.

Rolls—5 inches and add $6" \times 2"$. Clips every 2 feet 6 inches.

Laps to cover flashings 3 inches in 3 feet.

Gutters to give a vertical depth of 6 inches.

Labours such as copper nailing, wedging to flashings, dressings over glass including risk, &c., per foot run.

Ends to rolls, extra labour to cesspools, &c., are numbered.

CHAPTER VI

ZINC ROOFING

THIS metal is produced from the carbonate, the sulphide, or the oxide; it is heated in a special kind of retort in which it vaporizes, is condensed, and fused.

Zinc is very fusible, is acted upon by moist air, and oxidizes; but the thin film of oxide tends to prevent further action.

Acids act upon zinc, and near the sea and in large towns the metal is very quickly destroyed. It should not be used where cats have access, or where it will be exposed to lime water, or used on oak or any other wood containing acid. Contact with iron, copper, or lead, will set up voltaic action and destroy the zinc. When heated sufficiently it will give off an inflammable vapour which burns very rapidly.

Although zinc has disadvantages it forms a comparatively cheap roof covering if properly laid and fixed so as to allow of contraction and expansion.

The gauges to be used are 15 or 16 for gutters, 15 for flats; 13 or 14 are sometimes used where first cost must be kept down to the lowest possible limits, but this is not recommended.

Zinc is comparatively little used in these days, probably because there are so many cheap coverings available, particularly the asphalted felts or the roofs of the type of Ruberoid; but if properly laid, zinc flats will last for forty years at least, and the architect and builder should give careful consideration to zinc, and use it when suitable. It can be used on the steep slopes of a Mansard roof because the metal does not creep.

The drawing of a lead flat in the chapter on lead roofs may be taken as applying to a zinc flat, the roll, drip, wall flashing, and cesspool details given in Figs. 57-62 and 64-5 applying to such a flat.

In pitched roofs (over 1 in 8) welted joints are generally used in lieu of drips (see Figs. 63 and 63A).

Zinc sheets are usually 7 or 8 feet long by 2 feet 8 inches or 3 feet wide, but can be rolled up to 10 feet long if necessary. When 3 feet wide, the rolls are spaced at 2 feet 10½ inch

ZINC FLATS

DETAILS

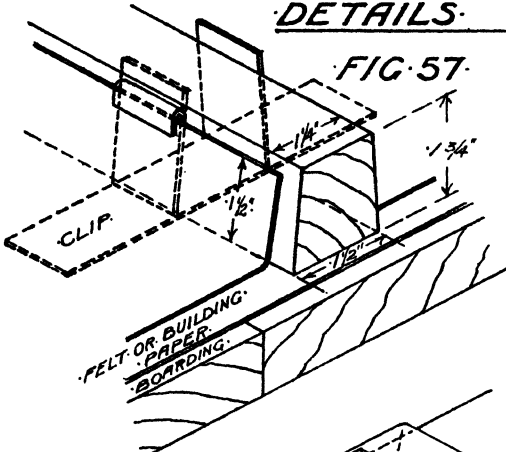
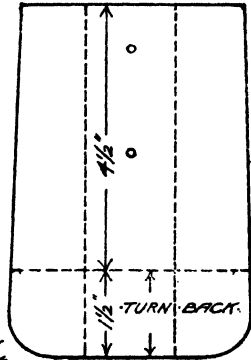


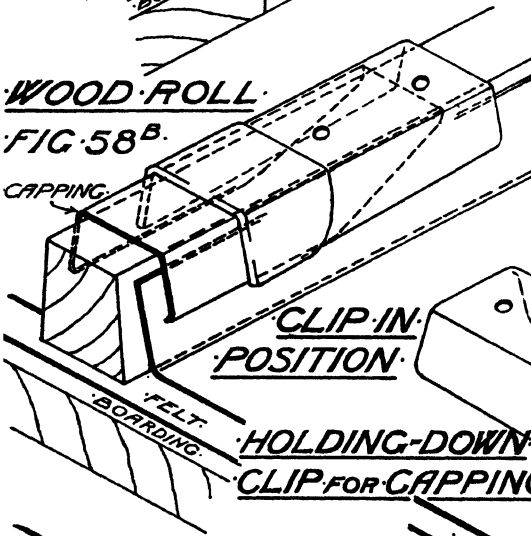
FIG. 57

FIG. 58^A



WOOD ROLL

FIG. 58B



TEMPLATE OF HOLDING-DOWN CLIP

FIG. 58

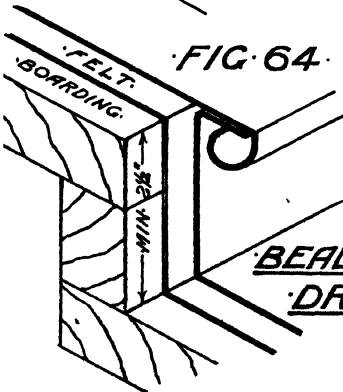
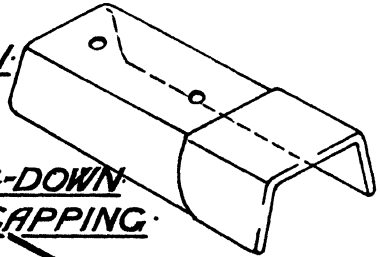


FIG. 64

BEADED DRIP

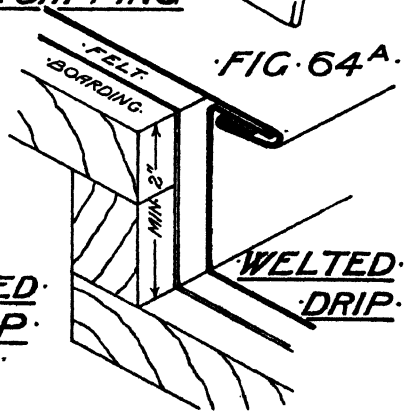
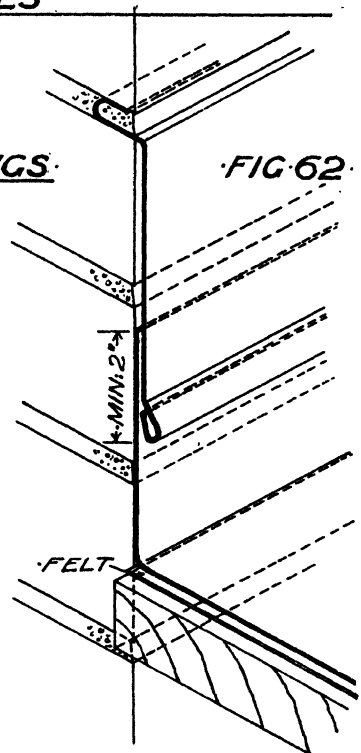
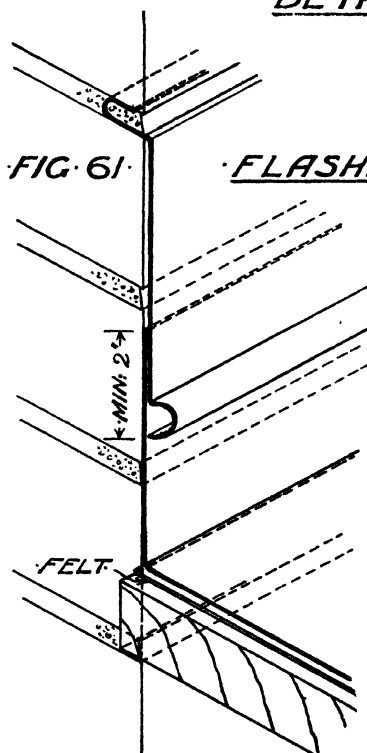


FIG. 64^A

WELTED DRIP

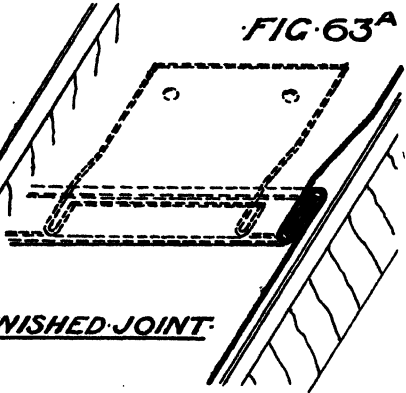
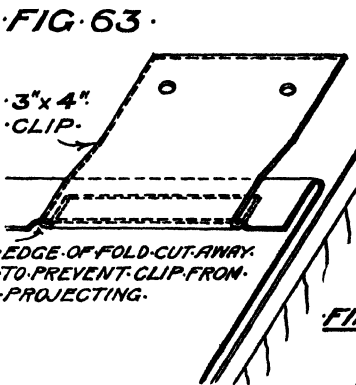
ZINC FLATS

DETAILS



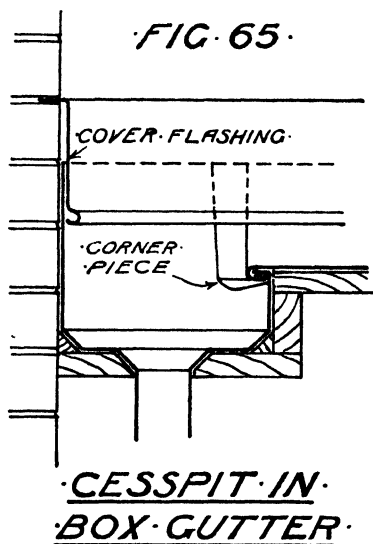
BEADED EDGE

WELTED EDGE



PITCHED ROOFS (OVER 1 IN 8) WELTED JOINTS IN LIEU OF DRIPS.

centres, the 2 feet 8 inch sheets working to 2 feet 6½ inch centres.

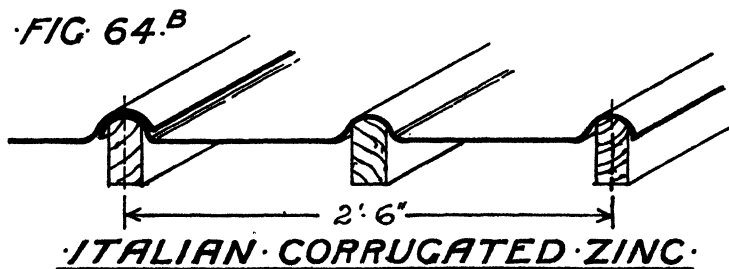


The following table will prove useful for reference, but need not be committed to memory:

Gauge.	Approx. Weight per sq. ft. in ozs.	Approx. thickness.
13 . . .	17.0	0.028
14 . . .	18.6	0.031
15 . . .	21.6	0.036
16 . . .	24.6	0.041

Italian Corrugated Zinc Roof.

In this type of roof the zinc sheets are formed with corrugations at intervals of 1 foot 3 inches centre to centre. They



may be laid upon rafters spaced to fit the corrugation and with the top edges rounded to fit the corrugations, as Fig. 64B. For better work they may be laid on boarding.

Zinc may be rolled in corrugated sheets similar to iron and used in exactly the same way. Bolts and nuts, &c., for fixings should be heavily galvanized.

SPECIFICATION FOR ZINC FLAT

The zinc to be of good colour, free from cracks and other defects. No iron or copper to be used in contact with zinc, and heavily galvanized nails or screws are to be used for fixing.

The boarding to support the zinc to be well-seasoned deal, laid with long joints in direction of the fall, or diagonally, and covered with approved asphalt paper or inodorous felt.

Lay the flat over kitchen wing with No. 15 gauge zinc, turned up 6 inches against vertical faces, and the upturned edge of zinc to be covered with 6 inches cover flashing with a bead formed to lower edge. Dress over rolls and fix to same with zinc clips, the rolls not to exceed 2 feet $10\frac{1}{2}$ inches centre to centre and to have proper saddle-pieces next vertical faces and approved stopped ends next drips.

Form $2\frac{1}{2}$ -inch drips as shown on the drawings, the edges of the metal being connected by a welted joint.

Form gutter and cesspool as shown on drawings, and fix 3-inch zinc pipe to carry water and discharge into rainwater head, forming bends as necessary. Drips to be $2\frac{1}{2}$ inches as before.

The whole to be jointed in the best approved manner so as to allow free expansion and contraction.

Leave all clean and perfect at completion.

ZINC WORKER MEASUREMENT OF WORK IN FLATS

The zinc is measured net as fixed, clips measured and added to the general area. Circular work being kept separate. A description is given of the thickness of the zinc and the labour, keeping this under headings such as:

1. Flats.
2. Gutters, &c., as with leadwork.

3. Stepped flashings.
4. Soakers.
5. Weathering to cornices.
6. Covering to turrets, &c.
7. Domes.

Sheets over 7 feet 6 inches in length must be kept separate.
The allowances are on similar lines to those in leadwork.

Rolls 6 inches—holding down clips 4 feet apart.

2½-inch Drips—6 inches.

Gutters 6 inches vertical height, e.g. 6 inches against walls
and under tiling or slating, so that the gutter is effective
in holding water to a depth of 6 inches.

Ends and saddles to rolls are numbered.

CHAPTER VII

ASPHALT ROOFS

THE word asphalt is used a little loosely in the building trades to mean the natural rock asphalts found in France, Switzerland, Sicily, and Germany, the bitumen found in the Island of Trinidad, artificial asphalts, and even tar paving. Natural rock asphalts are limestone rocks consisting of about 80–92 per cent. limestone and 8–20 per cent. bitumen. These are ground, mixed with grit and bitumen until thoroughly amalgamated, reduced to a mastic, and run into blocks. Bitumen is the material which makes the natural rock so valuable and it is really asphalt. Artificial asphalts are mixtures of some of the following materials: lime, pitch, sawdust, and ground iron slag or coal tar pitch, chalk, and sand.

Tar paving is made with a mixture of coal tar pitch and broken stone or granite.

The following are well-known asphalts:

The Seyssel, obtained from the Jura Mountains in France; the Val de Travers from Neuchatel in Switzerland, Ragusa from Sicily.

There are three grades of mastic in general use, they are:

1. Fine.
2. Fine gritted.
3. Coarse gritted.

The fine gritted is generally used for roofs.

For use on roofs the blocks of mastic are broken up and melted in boilers or cauldrons, a little bitumen being added, and it is spread in a semi-fluid state and worked to a smooth face. Two thicknesses each of $\frac{3}{8}$ inch are usually specified, making the final thickness $\frac{3}{4}$ inch. If the roofs will be subject to heavy traffic the thickness may be increased to 1 inch. There should be a fall to flats of 1 in 80. In good work the asphalt is laid with a layer of felt on top of the concrete and under the asphalt, this allows the concrete and asphalt to expand without injury to one another.

If laid to a fall of more than 1 in 10 a good key should be formed in the concrete foundation, otherwise the asphalt may

run if exposed to great heat. The foundation should be dry, if the surface is wet the water expands as steam and 'blows' the asphalt; this steam can be freed by the layer digging in his trowel, but for roof work the concrete should be quite dry. For steep slopes the asphalt should be reinforced with expanded metal or other suitable reinforcement.

The angles next the walls are formed with a triangular thickening and a skirting is carried up about 6 inches and then turned into the wall using a joint in the brickwork into which the asphalt is tucked.

Asphalt is sanitary, damp-resisting, non-absorbent, and easily applied. Its damp-resisting quality may be estimated by the quickness with which a road paved with this material will dry after rain. It may interest the student to know that asphalt roads are laid in a different manner from roofs, the material being applied as a hot powder and then compressed.

Artificial asphalts are applied in a semi-fluid state as described for roofs, but they are not considered so good as the natural variety, probably because it is difficult to mix the materials as in nature, and partly because some manufacturers use cheap materials, such as coal tar pitch instead of bitumen, giving all the artificial mixtures a bad name.

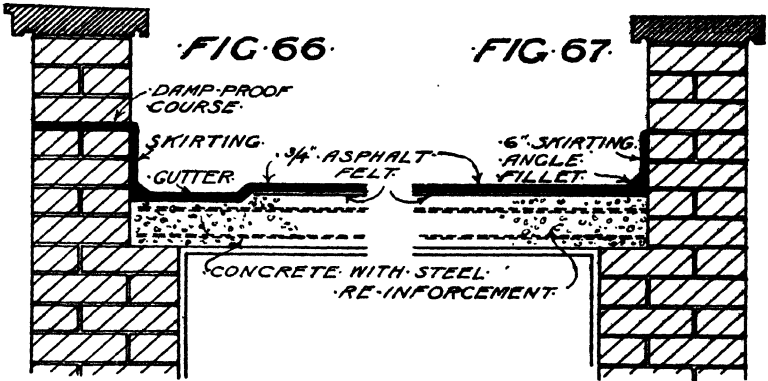
Figs. 66 and 67 give the details of a flat with a gutter and parapet wall. Alternative arrangements are shown, in one example the asphalt being taken through the parapet as a damp-proof course to prevent downward penetration.

Asphalt may be used to form gutters to ordinary sloping roofs, when it should be laid as to flats and carried up over tilting fillets or vertically as necessary. Both sides should finish at the same height as with lead gutters (Fig. 68).

Asphalt Flat Specification.

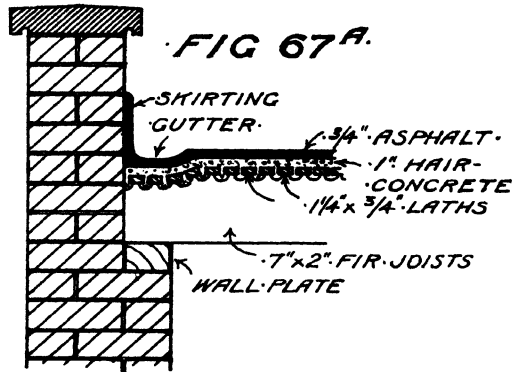
Cover the flat and concrete roofs of the main building with $\frac{3}{4}$ -inch asphalt laid on felt and turned up against all vertical faces at least 6 inches with angle fillet next flat and carried through wall as a horizontal damp course. Form gutter along the northern wall carried through parapet wall to discharge over rainwater head. Turn up against all lantern lights and turn in 1 inch under sills. Flash with 5 lbs. lead. The fall to be 1 in 80. The asphalt to be of an approved brand applied in two thicknesses and to be guaranteed for five years.

ASPHALT.

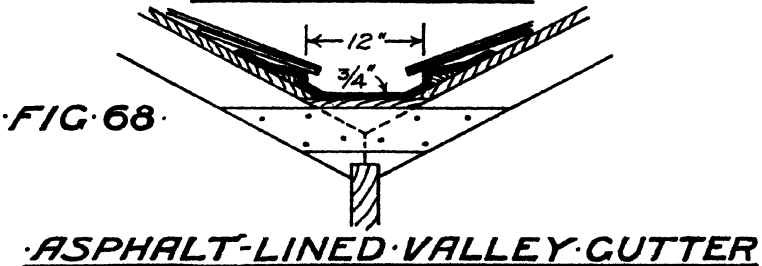


SECTION THRO' GUTTER.

SECTION THRO' SKIRTING.



SECTION THRO' GUTTER (TIMBER CONSTRUCTION).



SCALE OF FEET

Asphalter. Measurement.

It is customary to obtain estimates from special firms for this work and they will estimate from the drawings and a specification, in which case quantities are not taken out by a Quantity Surveyor, but the method of measuring is given briefly here:

The asphalt should be described, thickness, height of work above ground, number of coats given, fall described, and area given in yards superficial.

If the work is in small areas it should be kept separate and fully described.

Angle fillets, rounded external angles, &c., are described by the foot run, also skirtings and gutters.

Cesspool linings, outlets, angles and stopped ends to skirtings are numbered.

CHAPTER VIII

ROOFING FELTS

THERE are various types of felt used for roofing, some as an underlay to tiles, or to asphalt, others are a complete roof covering.

These may be classified as:

1. Bitumen Felt, consisting of a fibrous base impregnated with asphaltic bitumen. These may be tabulated as below, which is based upon the Building Research Station pamphlet. This should be obtained by students specially interested.

Class.	Impregnated with	Coating.	Surfacing.	Uses.
Bitumen felt	Bitumen	None	None	Underlayers
	"	"	Sand	Temporary roofing or lower layers of 'built up' roof
	"	Bitumen	Talc, mica	Bitumen roofing outer layers, general purposes
	"	"	Granite, slate, or other chippings	External layer on single or cut to slate sizes
Bitumen felt Reinforced with Hessian backing	"	"	Talc	Underslating — 'Untearable'
2. Hair Felts:				
Flax or jute	Coal tar pitch	None	None	Sarking
Cowhair and flax or jute	Wood tars or pitches			
	Coal tar pitch	"	"	
Hair only	Wood tars or pitches	"	"	
3. Tar Felts:				
Various fibres	Coal tar pitch	"	"	Temporary sheds
			Sanded. Can be periodically tarred and sanded	

British Standard Specification 747 refers to sarking and roofing felts.

The life of felt roofs varies considerably and depends to a great extent upon the surfacing with sand, mica, or mineral granules, which protect the bitumen. Generally these roofs can be resurfaced with bitumen, applied hot and covered with gravel.

If on timber, the roofs should be thoroughly ventilated and preferably should be laid on boarding just butted and not grooved and tongued.

Bituminous Roofing.

A form of roof covering which has now become very popular is the bituminous sheeting used on flats. Various forms are in use, each maker having his own specification and selling name. In some examples it is usual to finish on top with gravel or tiles. These roofs are light, cheap, and generally guaranteed for a period of years, the length of the term varying with the number of layers. The number of these roofings make it impossible in such a small work to refer to them all, but the following are well-known types, and generally the manufacturer lays the material. Even if the material can be bought and fixed by the local contractor it is advisable to arrange for the work to be done by men experienced in the special material. This applies to many branches of building work, as there are little tricks which make all the difference between success and failure, and only the practised hand can know the exact treatment necessary. These roofs can usually be renewed by the addition of another layer, and being light they are very economical.

Name.	Construction.	Finished Surface.
Combinite . . .	Alternative layers of felt and bitumen	Plain or grit and macadam or asbestos tiles
Macasfelt . . .	Similar in type	Macadam
Corona	” ” ”	Plain. Asphalt. Tar-mac. Gravel
Ruberoid (Standard) .	” ” ”	Similar
Vulcanite	” ” ”	Gravel. Pebbles. Bitumacadam. Tiles. Concrete
Veribest	” ” ”	A special type of mineral finish

PLATE XVI.

BITUMINOUS ROOFING

FIG. 69.

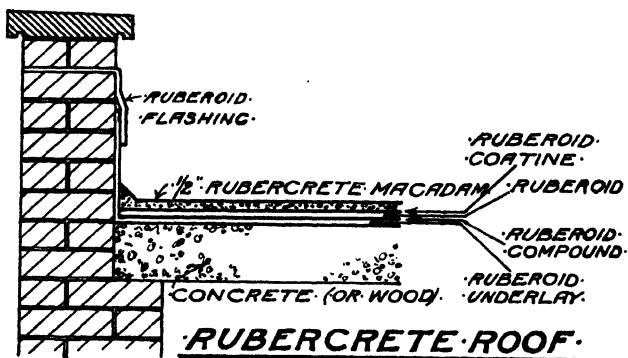


FIG. 69A.

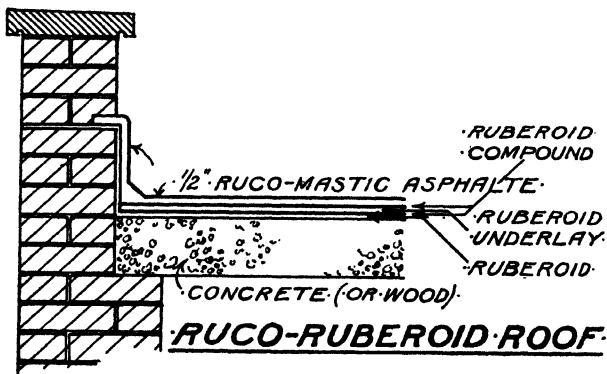
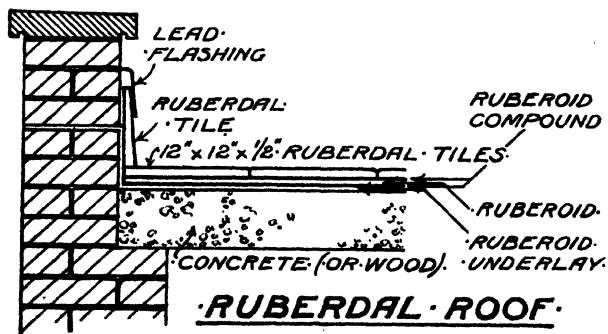


FIG. 70.



SCALE OF FEET

These are generally used with parapet walls and as with asphalt the construction of the junction between the flat and the wall is most important. It is generally better to carry the material right through the wall as a D.P.C. (see Fig. 69).

With timber construction below, good roof ventilation is essential in order to prevent dry rot, as the tendency is to seal the roof completely, and with a moist atmosphere this is fatal to the timber.

It is advisable to obtain estimates from the makers with their guarantees, comparing the price charged with the type of roof offered and the standing of the firms. All firms estimating should give prices on a similar type of roof approximately of same thickness, number of layers and guarantee.

Figs. 69, 69A, and 70 give examples of the finish of bituminous roofing felts, but there are many types of these and the makers will usually send full particulars.

CHAPTER IX

GLASS ROOFING

IN large glazed roofs the bars are usually of steel rolled to special sections, each manufacturer having his own type. The general idea in each case is to construct the bar so that it will carry away condensation water and also any water which may drive through between the edges of the glass and the bars. Some of these bars or the caps which secure the glass are of very ingenious design. The material used is generally steel for the bars, and this is sometimes sheathed with lead to prevent corrosion, otherwise the capping and channelling for condensation are distinct from the bar, or the bar is specially treated to prevent oxidation. Special arrangements are made to prevent cracking of the glass, cushions being formed, usually of asbestos cord, or the metal is shaped so as to give and adjust to expansion and contraction, and air spaces are formed to prevent capillary attraction. Some of the systems may be used with wooden bars. Metal stops are fixed to support the bottom edge of the glass (see Figs. 72A and 72B).

The following are well-known systems grouped under their appropriate types.

1. Sheathed Steel Bars. British Challenge (see Fig. 71). Croydon. Eclipse (Mellows). Heywood's system. Helliwell's system. Pennycook's system.

2. Special Bars not requiring Sheathing. Aluminex system—solid bars of an alloy specially made, the cover strip holds the glass in position and allows glass to expand and contract (see Fig. 72).

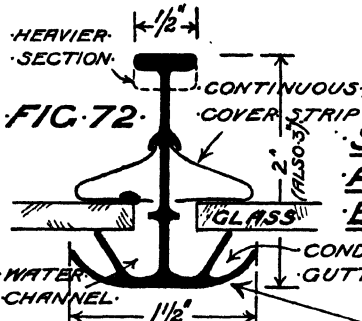
3. Special Glazing Bars supported on Steel or Wood. Braby's Drop Dry system is a system of grooves and capping which may be supported on an ordinary steel or wooden bar. Rendle's Invincible system, copper or zinc capping and channels carried on wood or steel (see Figs. 73 and 73A). Rendle's 'Kew' type is shown in Fig. 73B.

4. Steel Grooved Bar and Special Capping. Drylite and Grover's Simplex (see Figs. 69 and 70). Hayward's Reform, Grover's Simplex on wood and on steel bars (see Figs. 76-7A, 74 and 75).

GLAZING.

DETAILS.

WILLIAMS' "ALUMINEX"



NON-FERROUS BAR. RENDEL'S "INVINCIBLE"

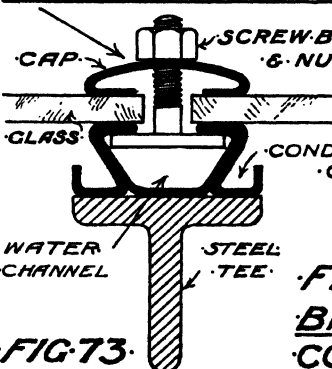
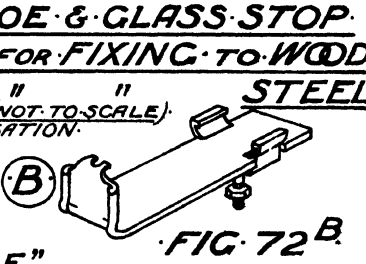
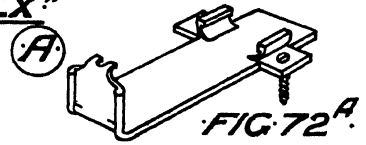
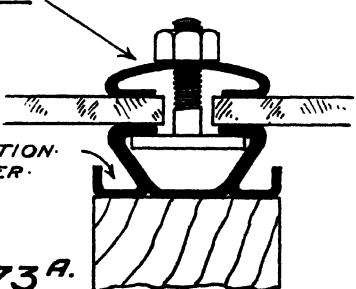


FIG. 73 A. BAR FIXED TO WOOD. CORE.



BAR FIXED TO STEEL TEE.

"BRITISH CHALLENGE"

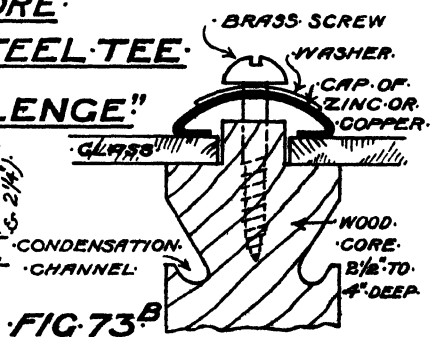
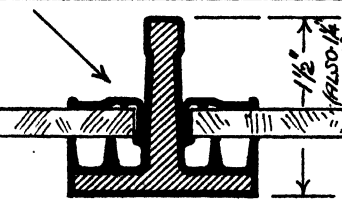


FIG. 71. LEAD CLOTHED TEE.

RENDEL'S "KEW" TYPE.

The glass used for roof lights is generally selected from the following four types:

Rough Cast, $\frac{1}{8}$ inch, $\frac{3}{16}$ inch, $\frac{1}{4}$ inch, $\frac{5}{16}$ inch.

Rough Cast, double rolled, $\frac{3}{16}$ inch to $\frac{1}{2}$ inch.

Rolled Plate, $\frac{1}{8}$ inch to $\frac{5}{16}$ inch.

Rolled Plate, fluted, $\frac{1}{8}$ inch to $\frac{5}{16}$ inch.

The thickness required is usually $\frac{3}{8}$ inch for roofing lights.

For washing down spaces in large stables and garages sand-blasted glass or acid-obscured glass is sometimes used and gives a very subdued light and prevents blistering of the paintwork of carriages.

Glass and Concrete Roofs.

The large roofs spanning open spaces often required in modern buildings, the wide continuous canopies to stores, theatres and railway stations have led to the construction of domed and flat roofs constructed of concrete and glass in some respects similar to pavements lights. Well-known examples of this type of roofing are Lenscrete, Glasscrete, Novalux, and Crete-o-lux. This type of flat glazed roof is suitable for use over the lower floors of buildings with large open light areas above. Curved and domical soffits allow very effective internal architectural treatment, and the light received being top or zenith light, the whole enclosed area is well lighted (see Figs. 78 and 79). This form of construction may be used on top of lantern lights in ordinary flats instead of slopes glazed with the roof light bars referred to earlier in this chapter. These flat tops have a wide margin all round formed in ferro-concrete with weathered tops, rounded edge and drip underneath. They may be supported on curbs of concrete or on side-lights. A section through a top light in Crete-o-lux standing on a solid curb is given in Fig. 80. The lenses are shown insulated in order to allow for expansion and contraction of the glass.

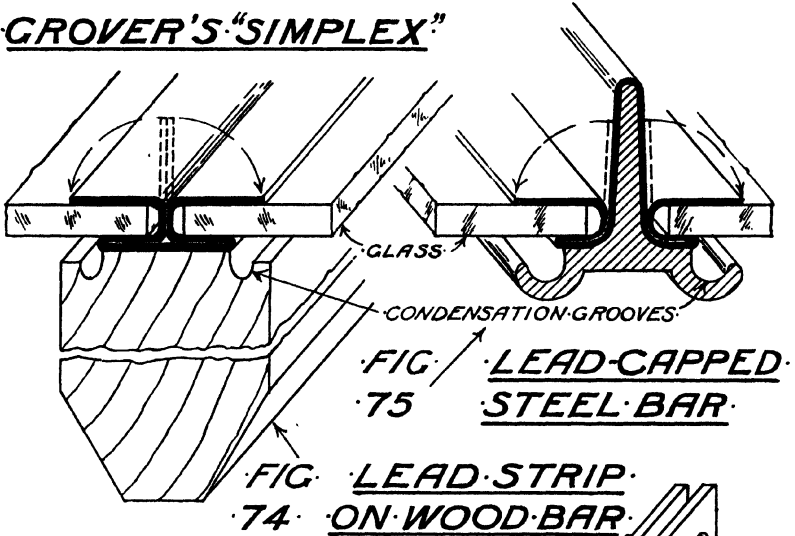
If there is a possibility that water from condensation will be troublesome the makers of this type of roof construction recommend double glass with an air space between.

When the lenses are thin it is claimed that the glass may be annealed more completely and therefore will not be so liable to fracture from internal stresses. The lenses may be toughened.

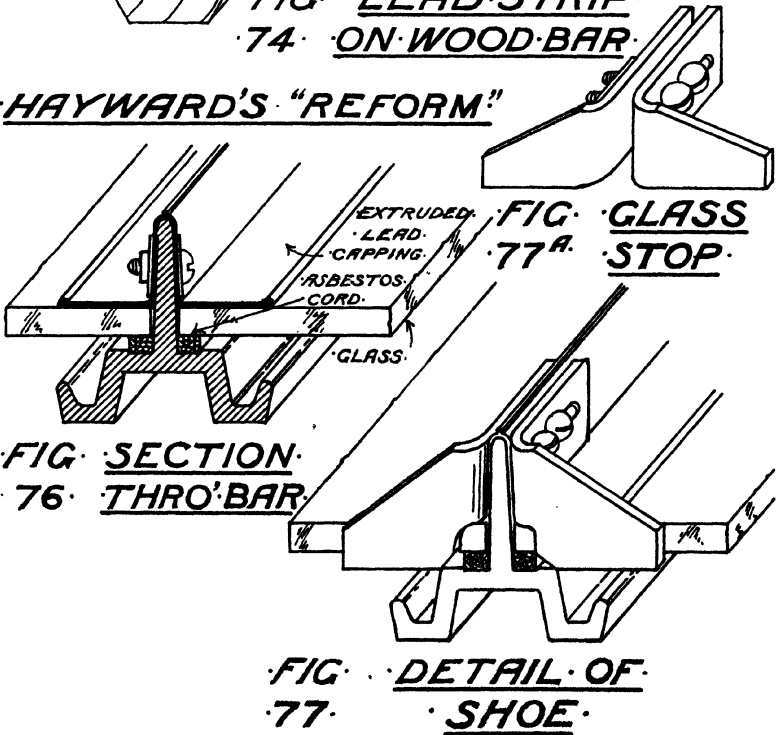
GLAZING

DETAILS

GROVER'S "SIMPLEX"



HAYWARD'S "REFORM"



GLASS & CONCRETE

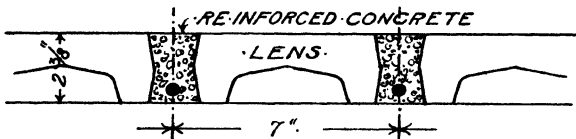
FIG. 78.



LENSCRETE LTD. PART SECTION OF SEGMENTAL ROOF LIGHT.

CRYSTALLUX SOLID GLASS LENSES.
 9" x 2" x 1 1/2" 3/8" RE-INFORCED CONCRETE.
 JOINTS BETWEEN.

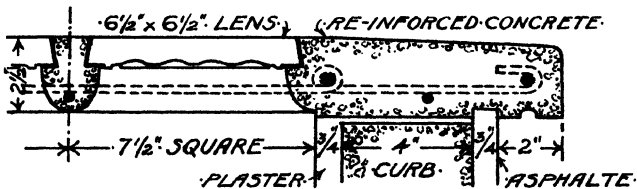
FIG. 79.



HEALEY'S NOVALUX PAVEMENT FLOOR OR ROOF LIGHT.

C. TO C. 5" 7" & 10"
 DEPTH 2 5/8" & 3 1/8"

FIG. 80.



HAYWARD'S CRETE-O-LUX.

SPECIAL FLANGE FOR LIGHTS FIXED ON RAISED CURBS.

SCALE OF 0 3 6 9 12 INCHES.

Provided the first cost is not prohibitive, the upper surface of the concrete may be protected by asphalt, this with the glass forming a perfectly watertight covering.

SPECIFICATION

GLAZED ROOFS

It is usual for the Patent Roof Glazing firms to fix their bars and glaze complete, and the system should be very carefully chosen if possible by comparing with others in similar positions and under similar conditions. The specification should give the system to be adopted, the glass to be used, and the general specification should provide for the use of the scaffolding. The builder working to a Specification or Bill of Quantities should be very careful to ensure that the cost of the work including carriage and cartage is provided for in his estimate.

The measurement of the work is usually carried out by the Quantity Surveyor or the Glazing Company, but should be checked by the builder. The glazing should be measured and described by the foot superficial giving the sizes of the sheets if of special length, width, or area, the length and distance centre to centre of the bars and full particulars stated. Cutting and waste should be given per foot run and described according to expense and difficulty in carrying out.

The opening portions should be numbered and described.

CHAPTER X

CORRUGATED IRON ROOFING

CORRUGATED sheets are made by passing sheets of iron between grooved rollers which bend the sheets in a series of corrugations, the strength of the sheets to resist bending is greatly increased, and this treatment makes them rigid and suitable for spanning the distance between the purlins (see Figs. 81 and 82, illustrating asbestos sheets which are similar in form and method of fixing, which show sections of a roof covered with this material). The iron used must be of good quality or it will crack in the process of rolling, and it should be heavily galvanized after rolling, so that every part of the iron is covered with zinc.

There are several protective coverings used on corrugated sheets which are superior to galvanizing. Cellactite, Dura-steel, and Robertson's protected metal are well-known examples. The sheets are protected with thin layers of asphalt and asbestos felt which is secured to the metal, forming a substantial covering not so easily damaged as galvanizing, in which a scratch exposing the iron will lead to galvanic action and destruction of the iron sheet.

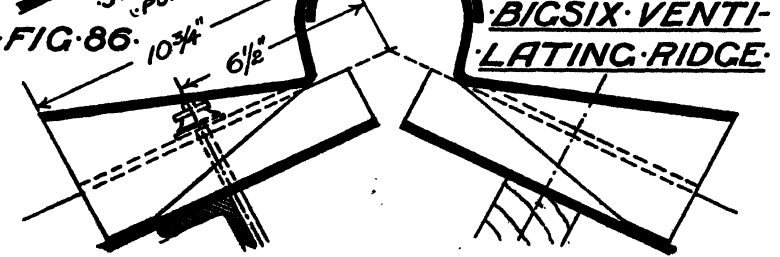
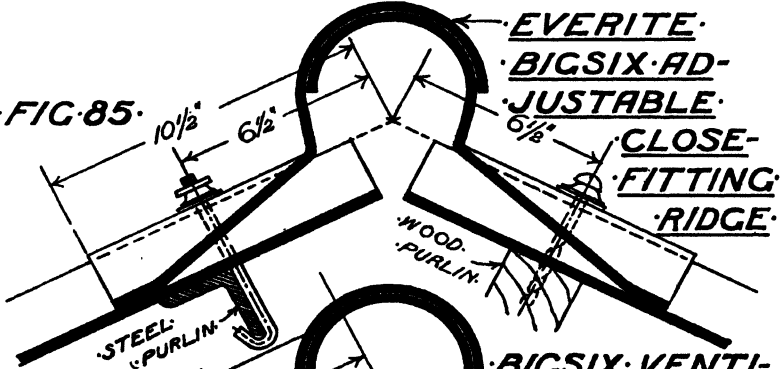
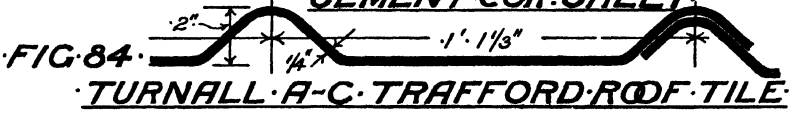
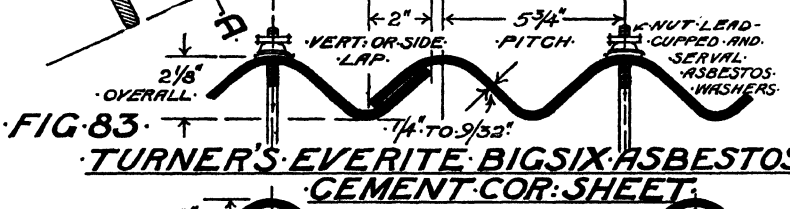
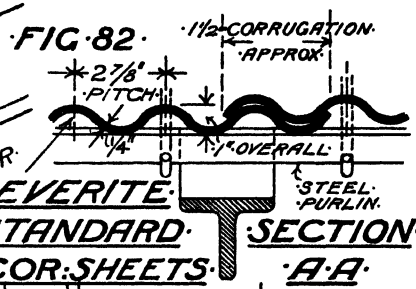
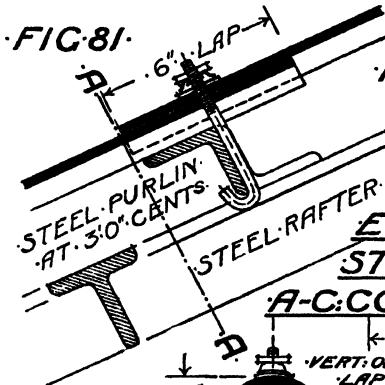
The corrugations are generally 3 inches, 4 inches, or 5 inches apart, centre to centre, the depth being approximately a quarter of the width of the corrugations. The usual sizes of the sheets with 5-inch corrugations are 6' \times 2' 6" and 8' \times 2' 6". With 3-inch corrugations they may be obtained in lengths from 4 feet up to 10 feet and 2 feet 3 inches wide.

Galvanizing is the term used for covering iron with a film of zinc. The metal is cleaned with a weak solution of acid, washed, and then placed in molten zinc, which should completely cover the sheet of iron.

The fixing of corrugated iron to a steel roof is illustrated in Figs. 81 and 82. The asbestos washers shown make a watertight joint and tend to prevent damage to the sheet or the hooked fixing bolt; curved washers bedded in white lead may be used. Galvanized iron is often painted as an additional precaution and while giving extra protection, this

ASBESTOS.

DETAILS OF FITTINGS ETC.



treatment has the advantage that a suitable colour will render the structure less conspicuous.

THICKNESSES AND WEIGHTS OF CORRUGATED IRON SHEETS

Gauge	Thickness in Inches.	Weight per square in lbs.	Width of Flutes in inches.	Uses.
16 .	. 0.065	380	5	Extra strong work
17 .	. 0.058	320	5	
18 .	. 0.049	280	5	} First-class work
19 .	. 0.042	252	5	
20 .	. 0.035	224	3	
21 .	. 0.032	205	3	} Where first cost must be kept down
22 .	. 0.028	185	3	

Asbestos Roofing.

Corrugated asbestos sheets may be obtained similar to those of corrugated iron. They are made with asbestos and Portland cement, and the resulting material is unaffected by most acids, vermin, is fire-resisting and withstands climatic conditions satisfactorily. Asbestos is a mineral found in Canada, Australia, Italy, Russia, &c., and it is used extensively in building work for fire-resisting and insulating purposes. Portland cement is the well-known material made with chalk and clay mixed as slurry, burnt in kilns (usually of the rotary type) and ground in Ball and Tube mills to a fine powder, and used as the cementing material in concrete and in cement mortar for brickwork.

The method of fixing the corrugated sheets is similar to that employed with corrugated iron. Hooks are used, shaped to grip the purlins, a narrow hook to grip the web of a tee iron, or a broad flat hook to grip the lower flange of the H iron purlin. The top of the hook has a screw thread cut, and first a cup washer is fitted over one of the upper corrugations of the sheet, and the whole is fixed by a nut which is screwed down so as to fix the sheet securely to the purlin. The hooks should never be taken through the channel corrugations, which act as gutters, or water will get into the roof.

Various fittings may be obtained to use with corrugated sheeting, and typical examples are shown in Figs. 81-6.

Asbestos sheets are also made without the channel flutes, the upper flutes being also reduced in number; the Turnall

Trafford tiles are of this type, and make a simple roof covering. The tiles are made in standard widths of 3 feet 8 inches and in lengths up to 10 feet with a thickness of $\frac{1}{4}$ inch; in colouring there is a choice of grey, red, or russet brown.

Asbestos tiles may also be used; they form a light covering, leading to economy in roof timbers. Rafters may be fixed at 2 foot 6 inch centres. These tiles were very popular at one time for use on cheap bungalows and were usually laid diagonally, but they do not form an artistic covering, and should only be used where first cost must be kept down to the lowest possible price.

Corrugated Roofs.

The iron and asbestos sheets may be of similar design and fixed in the same manner. A specification for an iron roof is given and the slight variations requisite for the asbestos sheeting.

SPECIFICATION

The roof of the garage to be covered with galvanized corrugated iron sheets, No. 18 gauge, secured to wood rafters with heavily galvanized iron screws, and cup washers bedded in white lead. Provide and fix galvanized iron ridging of approved pattern.

Provide and fix where shown on the drawings—36" \times 18" (Daylight opening) Patent Corrugated Skylight fitted with guide and pulley for cord. The iron to be 20 gauge and the corrugations to match those of roof.

Paint the whole of the corrugated iron inside and out with two coats of bitumastic paint, including the skylight and frame.

With asbestos sheets the thickness will be $\frac{1}{4}$ inch and with the substitution of 'asbestos' for galvanized iron and the colour given, the specification might stand. Dormer lights are also made in asbestos.

Corrugated Sheeting.

Measurement. The area of sheeting is given in squares of 100 feet superficial, stating the gauge, the laps, horizontal and vertical; whether galvanized or treated by other methods.

Curved sheeting should be kept separate and described fully.

Cutting and waste to square abutments. Raking and circular cutting and waste are given per foot run.

The bolts, washers, &c., should be numbered.

Asbestos sheeting is measured and described in the same way as for iron.

CHAPTER XI

OAK SHINGLES

THESE are thin 'slabs' of oak split longitudinally with the grain; they are a little longer than plain tiles, but not so broad. Each shingle is bored with two holes and secured with two oak pins to lathing, or by copper nails, gauge $3\frac{1}{2}$ inches—size of shingles about $12" \times 4"$. They were used to cover the familiar framed church spires, such as are found in Kent, Surrey, and Sussex, and form a picturesque type of roof. They are also suitable for summer-houses, sports pavilions, and weather to a very beautiful grey colour which is restful and unobtrusive in rural surroundings. The junctions with vertical faces, hips, valleys, &c., should be treated as with tiles. It is probable that the cedar wood tiles or shingles from Canada have superseded the oak shingles to some extent.

Specification for Octagonal Roof.

Cover the summer-house with rent English oak shingles, each shingle secured with two oak pins (or two copper nails) to laths to a $3\frac{1}{2}$ -inch gauge, the hips to be cut and mitred and fitted with light lead soakers. Cover the apex with 5 lbs. lead dressed down on to shingles and held in position by 2-inch strips of 8 lbs. lead turned up 3 inches at lower end, all as shown on detailed drawing. (The drawing is not given, but would probably form the base of a finial of ornamental type.)

Estimates for shingling in oak are usually in connection with small works, and the builder should be given quantities on the lines of tile work and a drawing showing the roof in detail.

Canadian Cedar Wood Tiles or Shingles.

A roof covering which is coming to the front very rapidly is Canadian Red Cedar Wood tile roofing, known in Canada as Shingles. It is claimed for these tiles that they are less pervious to moisture than ordinary tiles, provide a bone-dry roof, are rot-resisting and lap so closely that they resist the strongest gales.

In particulars circulated by the agents it is stated that these shingles have a life of sixty years, that no preservative treatment is necessary, they are cheaper than, and only one-tenth the weight of, ordinary tiles and easy to lay. One bundle will cover 28 square feet of roof, and as there is a triple overlap throughout only one-third of each 'tile' is exposed and the whole roof is covered with a triple thickness of 'tile', ensuring a dry and warm interior in winter, which is also cool in summer.

Each cedar wood tile is 16 inches long, $\frac{2}{5}$ inch thick at the butt, tapering to the top; the widths are random.

Fig. 87 shows the 'tiles' nailed to battens and the following points should be noted:

1. The 'tiles' should be taken at random, but should lap at least $1\frac{1}{2}$ inches so that no vertical joint comes immediately above the vertical joint of the course below.
2. Two nails are required to each 'tile' at about $6\frac{1}{2}$ inches from the bottom and 1 inch from the edges.
3. There should be a gap of $\frac{1}{2}$ inch to $\frac{1}{4}$ inch at the vertical joints between each tile and the next.
4. Form a double course at eaves as with ordinary tiles.

Valleys should be lead lined open valleys (Fig. 89) formed in exactly the same way as similar valleys in slated roofs.

Ridges should be formed by carrying the shingles up to the apex, covering with a strip of felt and on top of this fixing ordinary 'tiles' of regular width, say 4 inches, lapped at right angles and butting alternately against the sides of those on the other face (see Fig. 87), or they may be capped with boarding.

Hips are treated in a similar manner (see Fig. 88).

The nails used should be 1 inch to $1\frac{1}{2}$ inches long with small heads and not thicker than 13 gauge, either galvanized or copper; about $2\frac{1}{2}$ lbs. will be required to each square.

These 'tiles' may be laid with a $5\frac{1}{2}$ -inch exposure down to a slope of 30 degrees; for flatter pitches a 4-inch exposure is recommended.

Canadian Cedar Wood weathers to a very beautiful silvery grey colour in a comparatively short time, and the varying widths and colour combine to make this a very beautiful form of roof covering. A considerable economy in roof timbers may be effected by their use.

RED CEDAR SHINGLES

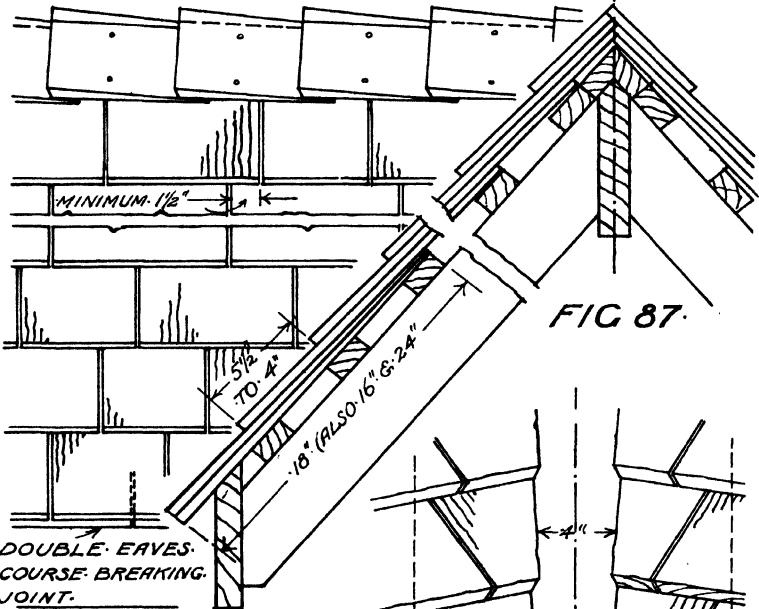
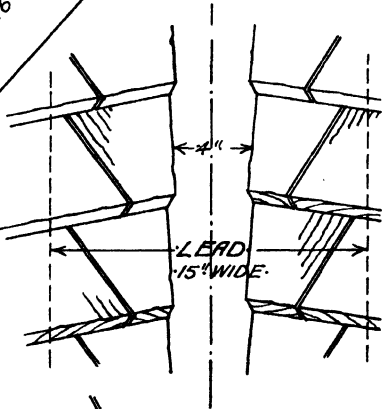
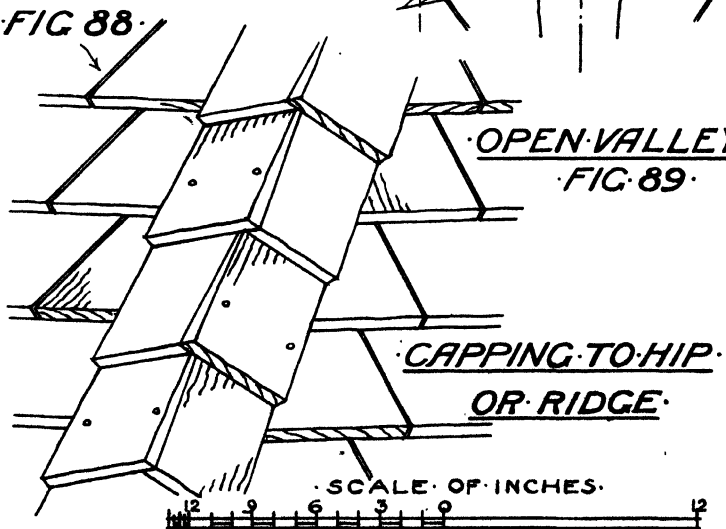


FIG 87

DOUBLE EAVES
 COURSE BREAKING
 JOINT.
PART ELEV'TN. &
SECTN. OF ROOF.

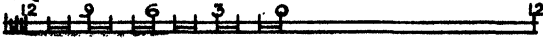


OPEN VALLEY
 FIG 89



CAPPING TO HIP
OR RIDGE

SCALE OF INCHES



Cedar Wood Shingles.**RED CEDAR WOOD TILES (SHINGLES)**

	No. 1. Grade Edge Grain		
	Royals	Perfection	—
Length	24"	18"	16"
Width	4" to 14"	3" to 14"	3" to 14"
Thickness	4 Butts = 2"	5 Butts = 2½"	5 Butts = 2"
Number of courses per bundle	18/14	18/18	20/20
Number of bundles per square	4	4	4
Quantity and size of galvanized nails per square	3 lbs.—1½"	2½ lbs.—1¼"	2½ lbs.—1¼"

Covering Capacity One Bundle.

Exposure in inches.	Sq. feet.	Sq. feet.	Sq. feet.
4		17	20
4½		20	22
5		22	25
5½		25	—
6	20		
6½	22		
7	24		
7½	25		

THATCH

The use of this very beautiful roof-covering has been revived and it is handled very effectively by some of our best-known architects. Thatch is warm in winter and cool in summer and it can be cut to show a pattern, and curved in plan and elevation over dormers and gables. Skilfully applied it is a most beautiful material and the student should study thatch roofs whenever an opportunity occurs. There are two objections to its use, first that the fire risk is greater than with tiles and slates, and secondly that it harbours vermin. Its life is of course shorter than the more substantial forms of roofing.

The best roof covering of this type is Reed Thatching. The reeds grow by large areas of water, such as the Norfolk Broads, in some districts they are found growing with Gladdin, which may be used with the reeds. The pitch of the roof should be steep and the thickness of the thatch varies with the pitch and is usually between 10 and 14 inches. For 50 degrees pitch the thatch should be 12 inches thick.

The reeds are laid on $1\frac{1}{2}$ " \times 1" fir battens. Fillets are fixed at eaves and to verges.

Ridges may be formed with rushes, gladdin, wheat, or rye straw.

Old roofs may be repaired by recovering with comparatively thin thatching, say half, or a little larger proportion of the original thickness.

Wheat or rye straw makes a cheap roofing, but its life is not nearly so long as that of the reeds. The thickness should be greater than with reeds.

Thatching is usually done by specially skilled workmen from the reed districts.

In districts where heather is found, heather thatch is used for summer-houses and small temporary structures.

It is not considered so durable as straw thatch.

Thatch can be treated with a solution to reduce the risk of fire; the Home Office suggests a mixture of:

28 lbs. Sulphate of Ammonia.

14 ,, Carb. ,, ,, (lump)

7 ,, Borax (lump)

7 ,, Boracic Acid

14 ,, Alum (lump)

These are dissolved in hot water and diluted for use. The above quantities in solution should cover about 22 squares, each square taking about 2 gallons.

CHAPTER XII

REPAIRS TO ROOFS

REPAIRS to ordinary slating may be carried out by cutting the nails of the slates with the ripper, removing the defective slates, and inserting new slates and holding in position by strips of copper or lead as described in 'Slater', but where very large slates are used it is an expensive matter to buy perhaps from one to six Rags, Queens, or Imperials to replace cracked slates. In this case good results may be obtained with Masticon, Farotex, Stoniflex, and similar compounds; these materials withstand heat and frost and allow for a certain amount of movement in the defective material which is to be made weathertight. These and the other similar materials are easy to apply and very effective and may also be used to repair lead, concrete, asphalt, tiles, zinc, corrugated iron, glass, and felt.

The Industrial Engineering Company, which uses Masticon, makes roofs watertight and operates on a very large scale; factory and railway station roofs which are very defective are entirely covered with Masticon by the Company's workmen. At important junctions with skylights and wherever the Masticon must be of extra thickness, special strips of tinfoil are used to reinforce the plastic material. This company covers huge roofs with great success, but care must be taken to allow for ventilation or the tendency is for this material to seal up a roof. Work of any magnitude should be done as a rule by men who are experts and whose work is guaranteed. The small builder with a jobbing business would do well to study the use of these materials which may save his customer's money and earn his gratitude, sometimes to the temporary loss of the builder, although in the end he will probably be amply rewarded.

Lead flats can of course be repaired by the plumber, and all minor repairs should normally be done with soldering iron, but materials like Farotex, Masticon, &c., give an alternative solution to the problem of leaky roofs.

Tiles may be taken out and replaced as with slates; if hanging by the nibs, they may be replaced quite easily by

simply sliding into position, care being taken to ascertain that the nibs have caught the feather-edged boarding or lath.

Asphalt may be cut out where defective and replaced by new asphalt.

Felt roofs by a coating of tar; or if bituminous felts, by another layer of bitumen and felt.

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