of England, is the truss after the ears have been cut off, leaving the clean, sound pipe straw, of which a thickness of 3 inches is laid on the common thatching with spars only. The materials required are straw or reeds, laths, nails, withes, and rods. A load of straw, laid on about 12 to 16 inches in thickness, will do a square and a half; a bundle of oak laths, 1¼ inches wide, and from ¼ to ⅜ths thick, nailed about 8 inches apart, 1 square; a hundred of withes, 3 squares; a pound of rope yarn, 1 square; a hundred of rods, 3 squares; and 2½ hundred of nails, 1 square. Probably thatched roofs were formerly ornamented by a species of cresting, for in some parts of the country the withes or willow twigs that bind the thatch are sometimes arranged on the tops of ricks and cottages in an interlacing manner, terminating at the apex or at each end with a spike with a rudely formed cock. Viollet-le-Duc, in his *Dictionnaire*, alludes to the custom of forming the ridge in mud, in which plants and grasses were inserted to prevent the earth being dissolved and washed away by the rain.

Plumber-work

Lead, as the name imports, is the material in and with which the plumber works. The principal operations of this trade are directed to the covering of roofs and flats, laying gutters, covering hips, ridges, and valleys, fixing water trunks, making cisterns and reservoirs, and laying on the requisite pipes and cocks to them, fixing water-closet apparatus, setting up pumps, and applying indeed all the hydraulic machinery required in economic building. The plumber's tools are knives, chisels, and gouges for cutting and trimming, rasps or files and planes for fitting and jointing, a dressing and flatting tool for the purposes its name expresses, iron hammers and wooden mallets for driving and fixing, ladles in which to melt solder, grozing irons to assist in soldering, a hand-grate or stove which may be conveniently moved from place to place for melting solder and heating the grozing irons, a stock and bits for boring holes, and a rule of two feet in length divided into three parts, two of boxwood, the third of steel, for passing into places he may have to examine; also compasses, lines, and chalk for setting out and marking, and centre-bits of all sizes for making perforations, together with weighing apparatus, as the quantities of most of the materials used by the plumber must be either proved or determined by weight. The waste of lead in working is very trifling, as cuttings all go to the melting pot again with little or no loss but that of refounding or casting; and even old lead is taken by the lead merchant in exchange for new at a very trifling allowance for tare and the cost of reworking. A plumber is always attended by a labourer, who does the more laborious work of carrying the materials from place to place, helps to move them when necessary, melts the solder and heats the grozing irons, attends to hold the one or the other, as neither may be set down or put out of hand when in use, and assists in some of the minor and coarser operations.

In boarding roofs, flats, and gutters for lead, clasp-nails or flooring brads should be used; and the first care of the plumber should be to punch them all in from an eighth to a quarter of an inch below the surface, and stop the holes carefully and completely with putty, or a chemical process will ensue on the slightest access of moisture should the iron heads of the nails come in contact with the lead, and the latter will, in the course of no long period, be completely perforated over every one of them. Neither should lead in surfaces of any extent be soldered, or in any manner fastened at the edges, without being turned up so as to make sufficient allowance for the expansion and contraction which it is constantly undergoing during the various changes in the temperature of the atmosphere. It may be taken, indeed, as a general rule, that solder should be dispensed with as much as possible. Like glue to the joiner, it is indispensable in many cases; but like glue also, it is in common practice made to cover many defects, and much bad work, that ought not to exist. The soft solder used by plumbers on account of its melting easily is a composition of tin and lead in equal parts, fused together, and run into moulds in shape not unlike the bars of a gridiron. In the operation of soldering, the surfaces of the metal intended to be joined are scraped and rendered very clean; they are then brought close together, and sprinkled with resin or borax at the joints to prevent oxidation while soldering. The heated solder is then brought in a ladle and poured on the joint, and smoothed and finished by a hot grozing iron and rubbed down with a cloth.

Sheet lead

Sheet lead, whether cast or milled, is supplied of various weight or thickness, and is always described as of such weight (4 to 12 pounds) to the superficial foot. There are very few purposes, indeed, in building, in which lead of less than 6 lb to the foot should be used, and very few in which the weight needs to exceed 10. For roofs, flats, and gutters, under ordinary circumstances, 7 or 8 lb lead is a very fair and sufficient average; for hips and ridges, lead of 6 lb to the foot is thick enough; and for flashings 5 lb lead need not be objected to. Cast lead has been preferred for the former purposes, because its surface is harder, but milled lead is of more even thickness throughout, bends without cracking, which is not always the case with cast lead, and makes neater work. Sheets of cast lead run from 16 to 18 feet long and 6 feet wide; milled sheets are made of about the same width, and 6 or 8 feet longer than cast sheets. Neither the one nor the other may be safely used on flats, or in gutters exposed to the wide range of temperature of our climate, in pieces of more than half the length and half the breadth of a sheet; that is to say, from 8 to 12 feet long, and 3 feet wide, are the limits within which sheet lead will expand and contract without puckering and cracking; and to allow it to move freely it is laid with rolls and drips in such a manner that any extent of surface may be covered with the effect of continuity, though the pieces of lead forming the covering be of such small sizes as above stated. But all *fixing*, whether by soldering or otherwise, is to be carefully avoided. A roll is a piece of wood made about 2 inches thick and 2½ inches wide, rounded on one edge, and fixed with that edge uppermost, so as to come 4 inches within half the width of a sheet, that the edges may be turned up and folded round and over it, being lapped by, or lapping the edge of the adjoining sheet (Plate XXVI. fig. 7). Lead sufficiently stout, dressed neatly and closely down to the boards under it, and over the rolls at its edges, will require no fastening of any kind, unless it be so light as to be movable by the wind. Rolls are used mostly in roofs and flats; drips principally in gutters, though they may be required in long flats. The drip is formed in the first instance by the carpenter in laying the gutter boards, according to an arrangement with the plumber. It is a difference made in the height of the gutter of from 1½ inches to 3 inches, where one sheet terminates in length, and meets another in continuation. The end of the lower is turned up against the drip, and that of the upper is dressed down over it, so as effectually to prevent the water from driving up under it. Where the fall is not great, a piece should be cut out across the higher gutter board, so that the top of the under-lead may lie level with the board. Gutters should have a fall of at least an eighth of an inch to the foot, and in flats it should be rather more, for such a covering is only so called in contradistinction to the pitch of a roof: ends and sides which are against a wall should

Cast and milled lead

Rolls

turn up against it from 5 to 7 inches, according to circumstances; and the turning up under the slates, tiles, or other roof covering, to a gutter, should be to the level of that against the wall at the least. The turning up against the wall should be covered by a flashing. This is a piece of lead let into one of the joints of the wall above the edge of the gutter lead, and dressed neatly down over it, to prevent water from getting in behind it (Plate XXVI. fig. 6). Parallel or box-gutters are necessary next parapets where a curb roof is formed, and are useful in valleys of small roofs where the depth for it can be obtained. Fig. 117 is a section of such a gutter next to a parapet wall, in which A is the wall-plate; B the tie-beam of the roof; C a bearer for carrying one end of the gutter bearer D, the other end being tenoned into the pole plate K; E the gutter boards carried by its bearers; G the lead gutter, laid in somewhat of an oval shape by the small angle fillets, which are useful in preventing the lead being returned at a right angle, where it is sometimes cracked in laying; H the flashing; I the eaves' board for raising the last row of slates, over which the lead is fixed; L the common rafter; M the slating; N the principal rafter forming part of the truss of the roof; O the saddle-back coping of the wall, throated on both sides. Where thick walls could be obtained, it was usual to form this sort of gutter below the timbers of the roof, whereby they were kept dry, and damage from the overflowing of the gutter prevented. The same result is occasionally achieved by a cornice projecting more than usual, the gutter being formed on it in place of a real blocking course. If the gutters and flats are to be often walked upon, they should be protected by deal lattice work raised on fillets but not fixed. Snow falling down the slopes is prevented by this from stopping the gutters, and it also lessens the action of the sun upon the lead-work. Lead on ridges and hips and the top and sides of dormers, not being in sufficient masses to be secured by its own weight, must be fastened by nails bossed over.

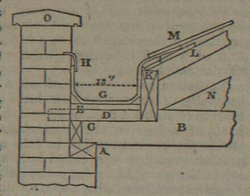

Fig. 117.—Gutter and Roof-Timbers.

In making cisterns and reservoirs, unless they be cast (and these are now disused), the sheets of lead must of necessity be joined by soldering; but the water they are intended to contain protects the lead from the frequent and sudden changes to which in other and more exposed situations it is exposed. The lead-work forms a lining to a wood case, which has grooved and tongued sides and a bottom. But cisterns are now commonly made of zinc, or of galvanized iron, or of slate; the last two do not require a casing, but may perhaps be enclosed in a closet. Service or water pipes to and from the cisterns, as also waste or overflow pipes, are also made of lead, and described by their bore, as ½ in., ¾ in., inch, and so on. They are generally supported and attached to the wall by means of iron holdfasts. Iron water pipes are fixed where lead will probably be stolen. The opinion that some waters are injured by coming in contact with the lead of cisterns and pipes, has led to the formation of pipes of tin encased in lead. The water companies are now requiring a water regulator to be put to each closet, or a water waste preventor where the constant supply is obtained, but these are a very troublesome addition to the plumber's work, on account of the difficulty of keeping them in working order. The constant supply system requires taps of a different construction from those used in other cases; these are called "screw down valves," from their action, and resist the pressure of the water. As repairs must occasionally be needed to the main pipes, it is recommended that, to prevent inconvenience, one or more cisterns be always provided in the house for containing two days' supply of water.

Rain-water trunks and pipes are made of a certain number of pounds weight to the yard in length, according to the bore or calibre that is required. The pipes are fitted with large case heads above, to receive the water from the gutter spouts, and with shoes to deliver the water below; they are fixed or attached to the walls of buildings of stone usually with flanges of lead, which are secured by means of spike nails,—iron and other metals having superseded lead where brick is used or economy requires the substitution.

The varieties of water-closet apparatus, of which Underhay's patent is one of the best, are too numerous to be here described. Pumps of all kinds and powers are amongst the other matters coming within the plumber's province, together with cocks, bosses, ferules, washers, valves, balls, grates, traps, funnels, service boxes, and a numerous collection of other articles.

Patent marine metal.

A metal occasionally used for roofs in lieu of lead is known by the name of Wetterstedt's patent marine metal. It is composed of lead and antimony. Its advantages are its malleability, great tenacity, elasticity, and durability, and its resistance to acids, oxidation, and the action of the sun and atmosphere. It is manufactured in sheets of certain sizes, from 3 lb to 8 ounces per foot, according to the purposes for which it is required, the latter weight being useful for lining damp walls. It should be secured with wrought copper nails. A patent metallic canvas is also manufactured of various substances and strength, serving for waterproof and secure covering.

Copper roofing.

Sheet copper was formerly used on account of its lightness to cover roofs and flats. The thickness generally varied from 12 to 18 ounces per square foot. It was laid like lead, but the plates being of small size were soldered together. It will be well to notice that water collected from copper channels must not be used for culinary purposes, as a film of verdigris is formed, which is poisonous. Copper is much used for roofing in foreign countries.

Zinc roofs.

Lead and copper, where economy is required, are superseded by zinc, which is not only much cheaper, but when good is nearly as durable, and is not so liable to be corrugated by the action of the sun. Zinc is subject to oxidation; but the oxide, instead of scaling off as that of iron does, forms a permanent coating on the metal. Its expansion and contraction are greater than those of any other metal. Zinc sheets as manufactured vary in quality, some being very brittle. That supplied by the Vielle Montagne Zinc Mining Company possesses a high reputation for purity and excellence. Zinc must be laid like lead, without fixing either by nails or solder. No. 13 gauge, weighing 19 oz. 10 drs., is the least for roofs, flats, and gutters on boarding. No. 14, a medium thickness, weighing 21 oz. 13 drs., is used for roofs and flats; and No. 15 or 16, weighing 24 oz. and 26 oz. 3 drs. per foot superficial, for best work and roofs without boards. Zinc pipes are extensively used as chimney pots; stamped and moulded ornamental zinc for dormers, Mansard roofs, vanes, guttering, and rain-water pipes, cisterns, &c.; and perforated zinc for blinds and for ventilation.

Tin cannot class with the building materials in England, although it is extensively used for covering roofs in America and in Russia.

The best publications on this trade are the makers' price books and lists of articles made and sold by them. See also the article Metallurgy.

Plaster-work.

No art in the economy of building contributes more to produce internal neatness and elegance, and no one is less absolutely important, so far as the use and stability of a structure are concerned, than that of the plasterer. The very general application of plaster is of comparatively late date; for wainscoted walls, and boarded or boarded and canvased ceilings, or naked joists alone, are frequently found in houses of rather over a century old, both in England and on the Continent; and a return to this state of completion in the present day is the result of the attempts of the mediæval school of architects, and their cry of "no shams," which has not been quite successful among themselves, for plaster and cement are used by many. The walls of houses were formerly plastered above the wainscoting and coloured, while the ornamented plaster ceilings of the time of Henry VIII., Elizabeth, and James I., are still the admiration of lovers of the art. Still earlier specimens of the plasterer's skill are extant in the pargetted and ornamented fronts of half-timber houses.

Tools.

For the more common operations of plastering comparatively few tools and few materials are required. The plasterer is attended by a labourer, who supplies his boards with mortar, and by a boy on the scaffold with him to feed his hawk, which is a piece of wood about 10 inches square with a handle under it, for carrying up small portions of plastering mortar to the wall or ceiling, to be there delivered and spread by the trowel, a thin plate of hardened iron or steel with a wooden handle, similar to that used by the bricklayer. The plasterer is obliged to keep this implement particularly clean and dry when he is not actually using it, lest it rust in the slightest degree, as it is clear that the brown oxide of iron would sadly discolour his finer work on touching it again with the trowel. He is necessarily furnished with a lathing hammer, a hand float, a quirk float, and a derby or darby, which is a long two-handled float for forming the floated coat of lime and hair; brushes for fine or rough work; three or four jointing trowels for mitres, &c.; jointing rules; moulds for cornices, which are of wood, but for work of any importance the frame is made of wood and the outline cut out of a copper (or more usually zinc) plate,—these are inserted in the wooden stock, and narrow pieces of wood are fixed to the moulds transversely to guide and steady them along the screeds; a straight edge, wherewith to bring the plastering on a wall or ceiling to a perfectly even surface by traversing it in every direction; a screen, having metal wires to act as a sieve for separating the coarser materials which enter into the composition of plastering mortar,—these are thrown against its outer face, to separate the particles which are too large for the purpose from the finer,—the sand and lime, too, are mixed much more efficiently and completely by screening them together than in any other manner; a spade and hod like those of the bricklayer's labourer; a rake to separate the hair used in the mortar and distribute it throughout the mass; and a server for the hawk boy to beat up the mortar, and to deliver it in small pats on the hawk.

The plasterer, as the term imports, works in plastic, adhesive compositions, which are laid on walls, both internally and externally, to stop crevices, reduce inequalities, and produce an even, delicate surface, capable of receiving any decoration that may be applied to it, either in colour or otherwise. These compositions are as various as the modes of applying them, the rudest being a compost of loam, a marly clay, and lime; this is used only for the commonest purposes, and being laid on in one coat, is washed over with a thin mixture of lime and water, a process termed lime-whiting. There are many grades from this to the highest work of the plasterer,—the making imitations of marbles and other costly stones, from the purest calcined gypsum mixed with a solution of gum and isinglass and colouring matter to produce the required imitation. His materials are laths, lath nails, lime, sand, hair, and plaster, a variety of stuccoes and cements, together with various ingredients to form colouring washes, &c. Scaffolding is not generally required for new work, but with old work it is sometimes necessary. Under ordinary circumstances, the plasterer is enabled to wash, stop, and whiten the ceilings and walls of rooms from trestles, with boards laid across them. In lofty saloons and halls, churches, &c., scaffolding is indispensable. It is necessary, too, to a front that is to be plastered in any way; but this may be afterwards washed, repaired, and coloured from a ladder, without the intervention of a scaffold, except perhaps the suspended scaffold now so much used.

Lathing.

Laths are narrow strips of some straight-grained wood, generally of fir, though oak laths are sometimes used, in lengths of 3 and 4 feet, or to suit the distances at which the joists of a floor or the quarterings of a partition are set, and in thickness from $\frac{1}{8}$th to $\frac{2}{8}$ths of an inch; those of the greater thickness are called lath and a-half. Lath nails are either wrought or cut; cut nails are in common use in England with fir laths. Coarse stuff is composed of ox or horse hair from the hide, in addition to lime and sand mortar; this is intended to act as a sort of mesh to net or tie it together, and form a coarse but plastic felt. The hair should be long, and free from all grease and filth. Road drift is unfit to be used in place of clean sharp sand in mortar, unless it be completely cleansed from all animal and vegetable matter, and of mud and clay.

Coarse stuff.

Fine stuff.

Fine stuff is made of fine white lime, exceedingly well slaked with water, or rather macerated in water to make the slaking complete; for some purposes a small quantity of hair is mixed up with this material. The mere paste, when allowed to evaporate until it is of a sufficient consistence for working, is called putty. Gauge stuff is composed of about three-fourths of putty and one-fourth of calcined gypsum or plaster of Paris; this may be mixed only in small quantities at a time, as the plaster or gauge renders it liable to set very rapidly. Bastard stucco is made of two-thirds fine stuff, without hair, and one-third of very fine and perfectly clean sand. Common stucco is composed of about three-fourths of clean sharp sand and one-fourth of the best lime, well incorporated. This must be protected from the air from the time it is made up until it is required to be laid on the walls. Parker's (or Parker's Roman) cement, when of good quality, with fine clean sharp sand, in the proportion of about three of sand to one of cement, and well executed, forms a very good external coating for walls. It is vulgarly called "comps," a contraction of "composition." Portland cement, so called because the mortar formed by it when mixed with sand is supposed to present the appearance of stone from the Portland quarries, is in much esteem for an outside stucco, as the colour to which it dries is sufficiently agreeable to the eye without any colouring wash, whereas Parker's cement is too often of a dark dirty tint, requiring painting or colouring to render it tolerable. Portland cement is also much valued as being proof against water when used as a mortar in setting brick-work, and in the composition of concrete for foundations. The patent selenitic cement already described (page 459), is stated to be an excellent substitute for Portland cement; it takes double the usual quantity of sand, and is stronger even then than ordinary mortar. Plastering is finished in much less time than by the common mode.

Gauge stuff.

Stucco.

A class of cements capable of taking a brilliant polish resembling marble, and consequently very suitable for internal decoration, deserves to be mentioned. The chief of these are Keene's marble cement and Parian cement. They become excessively hard in a short time, and are capable of being painted in a few days. The principal component is said to be obtained by the precipitation of alum by an alkali, which gives a white powder of great brilliancy. Tints can be made up with these cements for coloured decorative work. Cements made by the mixture of oil with various substances were formerly much used both here and abroad. The best known in England was called Hamelin's mastic, that in France the mastic de Dhil. These cements being very expensive, and requiring to be constantly painted, have now gone nearly out of use. For outside plastering they form a very fine clean surface, as may be seen in the quadrant in Regent Street and other buildings of that date, but in many instances it has been taken off and Portland cement substituted.

Blue lias lime.

Blue lias lime was formerly greatly esteemed as a cement for outside work, but the carelessness of the burners has tended much to limit its use, there being a large proportion of underburnt stone left in it. The workmen also would not take the requisite pains for slaking this lime, and manufacturers therefore ground it, by which operation the core becomes mixed up with the properly burnt material, and the efficiency of the lime is destroyed. The lumps should be broken as small as nutmegs, then immersed in water on a sieve until air-bubbles freely rise to the surface; the lime so wetted is to be left in a heap covered by damp sand for twenty-four hours, after which time it should be screened and mixed with the proper quantity of sand and the least possible quantity of water. To one of lime may be put not more than from two to two and a half of sand. When slaked it does not increase in bulk.

Coats of plastering.

The various coatings of plastering are distinguished thus. On laths, plastering in one coat simply is said to be laid, and in two coats, laid and set. In three-coat plastering on laths, however, the first is called the pricking up, the second is said to be floated, and the third set. On brick or stone walls, plastering in one plain coat is termed rendering; with two coats, a wall is said to be rendered and set; and in three, rendered, floated, and set.

Lathing ceilings.

Before beginning to lath a ceiling, the plasterer proves the under face of the joists, to which he has to work, by applying a long straight edge, and makes up for any slight inequalities in them, when the work is not to be of a very superior description, by nailing on laths or slips to bring them as nearly even as he can. When the inequalities are great, or if the work is to be of fine quality, he recurs to the carpenter, who takes off inordinate projections with his adze, and nails on properly dressed slips where the joists do not come down low enough, and thus brings the whole to a perfect level. This operation is called firring, or furring. If it be a framed floor with ceiling joists the plaster has to work to, it is tolerably sure to be straight; but the carpenter must have firred down on the beams or binders to the level of the ceiling joists, unless the ceiling joists have been nailed to the beams or binders, when nothing of this kind is necessary. If a ceiling is to be divided into compartments or panels, the projecting or depending portions must be bracketed or cradled down to receive the laths. It is an important point to be attended to in plastering on laths, and in ceilings particularly, that the laths should be attached to as small a surface of timber as possible, because the plastering is not supported or upborne by its adhesion or attachment to the wood, but by the keying of the mortar itself, which passes through between the laths, and bends round over them. If then the laths are in constantly recurring contact with thick joists and beams, the keying is as constantly intercepted, and the plastering in all such places must depend entirely on the portions between them which are properly keyed. Under a single floor, therefore, in which the joists are necessarily thick, a narrow fillet should be nailed along the middle under the whole length of them all, to receive the laths and keep them at a sufficient distance from the timber to allow the plastering to key under it; thus too the surface may be made more perfectly even, as it is in single floors that inequalities mostly occur. This being all arranged, the plasterer commences lathing. The laths should be of the stronger sort. Thin weak laths, if used in a ceiling, are sure to produce inequalities, by sagging with or yielding to the weight attached to them; one or two weak ones in a ceiling of otherwise strong laths may be the ruin of the best piece of work. They should be previously sorted, the weak, crooked, and knotty, if there be such, being reserved for inferior works, and the best and straightest selected for the work of most importance, so that the workman shall find none to his hand that is not fit to be brought in. Taking a lath that will reach across three or four openings, he strikes a nail into it on one of the intermediate joists, at about three-eighths of an inch from the one before it, and then secures the ends of that and the one that it meets of the last row with one nail, leaving the other end of the lath he has just set to be secured in the same manner with that which shall meet it of the next bay in continuation. It is of importance also that in ceiling-work he pay attention to the bonding of his work. In lathing on quartering partitions and battened walls, the bonding is not a matter of much importance; nor is the thickness of the timbers behind the latter of so much consequence as in a ceiling, because the toothing which the thickness of the lath itself affords to the plastering is enough to support it vertically; but, nevertheless, the more complete the keying, even in works of this kind, the better, as the toothing above will not protect it from any exciting cause to fall forwards, or away from the laths. The thinner or weaker sort of lath is generally considered sufficiently strong for partitions.

Plastering on laths.

When the lathing is completed, the work is either laid or pricked up, according as it is to be finished with one, two, or three coats. Laying is a tolerably thick coat of coarse stuff or lime and hair brought to a tolerably even surface with the trowel only; for this the mortar must be well tempered, and of moderate consistence,—thin or moist enough to pass readily through between the laths, and bend with its own weight over them, and at the same time stiff enough to leave no danger that it will fall apart,—a contingency, however, that in practice frequently occurs in consequence of badly composed or badly tempered mortar, unduly close lathing, or sufficient force not having been used with properly consistent mortar to force it through and form keys. If the work is to be of two coats, that is, laid and set, when the laying is sufficiently dry, it is roughly swept with a birch broom to roughen its surface, and then the set, a thin coat of fine stuff, is put on. This is done with the common trowel alone, or only assisted by a wetted hog's bristle brush, which the workman uses with his left hand to strike over the surface of the set, while he presses and smoothes it with the trowel in his right. If the laid work should have become very dry, it must be slightly moistened before the set is put on, or the latter, in shrinking, will crack and fall away. This is generally done by sprinkling or throwing the water over the surface from the brush. For floated or three-coat work, the first, or pricking up, is roughly laid on the laths, the principal object being to make the keying complete, and form a layer of mortar on the laths to which the next coat may attach itself. It must, of course, be kept of tolerably equal thickness throughout, and should stand about one-quarter or three-eighths of an inch on the surface of the laths. When it is finished, and while the mortar is still quite moist, the plasterer scratches or scores it all over