pressure, are themselves opposed to the back of the same joints, so that its power of resistance is made equal to that of the bricks themselves, except at the ends; which, in such works as we have supposed, are remote, and may be protected by the use of cement in their joints, whilst mortar is used in the rest. Rough arches are those in which the bricks are roughly cut with an axe to a wedge form, and are used over openings, such as doors and windows, when the work is to be plastered on the outside, or in plain back fronts, outhouses, garden-walls, &c., when, however, they are neatly pointed with what is called a tuck or tucked joint. Semicircular and elliptical arches are generally made plain, or without cutting the bricks; but arches composed of a smaller segment of a circle (vulgarly and technically called *scheme* arches), if not gauged, are cut or axed. Very flat arches are distinguished by the term camber, from the French *cambrer*, to round like an arch. It is arches of this kind which are generally employed over windows and doors in external work, and they too are either cut or gauged. Gauged arches are composed of bricks which are cut and rubbed to gauges and moulds, so as to form perfectly fitting parts, as in masonry. Gauging is equally applicable to arches and to walling, as it means no more than the bringing every brick exactly to a certain form, by cutting and rubbing, or grinding it to a certain gauge or measure, so that it will exactly fit into its place, as in the finer works of masonry. Gauged brickwork is set in a putty instead of common mortar, but it is seldom used except for arches in the fronts of houses, &c., which are to be neatly finished. These are for the most part straight, and are generally from 11 to 12 inches in depth, or the height of four courses of brickwork Their value as arches will be best understood by reference to the diagram, fig. 7, Plate XX., by which it appears that all the material between the soffit of the straight arch or head of the opening *b c*, and the dotted line *l f c*, is useless, the intrados or soffit of the really efficient part of the arch being at that dotted line itself. This is the arc of an angle of 60°,—its chord, the width of the opening, being the base of an equilateral triangle constructed on it, and the joints are the radii of a circle whose centre is at *a*. *b d* and *c e*, the continuations of the sides of the triangle or radii *a b* and *a c*, are technically termed the skew-back of the arch. Sometimes the arc is made under a more acute angle, in which case the skew-back is less, that is, the external angles *c b d* and *b c e* are less obtuse; a smaller unavailable portion of the arch is thus left between the arc and its chord, but that portion is less securely retained under the flatter segment, because the joints or radii diverge less, or are more nearly parallel. These gauged arches being, as they for the most part are, but a half brick in thickness, and not being tied by a bond to anything behind them—for, indeed, almost the whole, if not the whole, of their height is occupied behind by the reveal and the wooden lintel—require to be executed with great care and nicety. It is a common fault with workmen to rub the bricks thinner behind than before, to insure a very fine joint in front. This tends to make the work bow outwards; it should rather be inverted, if it be done at all, though the best work is that in which the bricks are gauged to exactly the same thickness throughout. The same fault occurs when a gauged arch is inserted in an old wall, on account of the difficulty of filling up with cement the space behind the bricks. Fig. 8, Plate XX. is a transverse section of fig. 7, and the gauged arch, lintel, &c., in it show the total disconnection of the gauged arch with any surrounding brickwork to which it might be bonded. The absurdity of constructing arches circular on plan, especially in a thin unbonded shell of bricks, is so clear as hardly to require notice.

Gauged arches.

It is generally held that nothing but its own components should be admitted into a brick wall, except what is absolutely necessary for its connection with the other parts of a building, such as wall-plates and wood-bricks (and that these should be avoided as much as possible), templets, lintels, &c. Wall-plates are applied to receive the ends of the joists, and distribute the weight of the floor to which they belong equably along the walls. If the joists tailed singly on the naked bricks, their thin edges would crush those immediately under them, and the rest of the brickwork would escape immediate pressure altogether. Wall-plates may be avoided by the use of framed floors, which are carried by a few large beams, under whose ends stout pieces of timber or stone, 2 or 3 feet in length, are placed. These supports are intended, like a wall-plate, to distribute the weight over a considerable part of the wall, and prevent the necessity of placing the beam on the naked friable bricks, and are called templates. As bond timbers and wood-plates are now interdicted by the Buildings Act in London, the joists have to be tenoned into trimming joists carried by brick, stone, or iron corbels. Lintels are used over square-headed windows and doors, instead of arches in brickwork. They are useful to preserve the square form and receive the joiner's fittings, but they should always have discharging arches over them, and should not tail into the wall at either end more than a few inches, that the discharging arch be not wider than is absolutely necessary. Fig. 9, Plate XX., indicates the elevation of the inside of part of an external wall with a window in it, and shows the lintel over the opening with a discharging arch over it, and wood-bricks under its ends, on the jambs of the opening. Discharging arches should be turned over the ends of beams, and templets also, as in fig. 10. They may generally be quadrants of a circle or even flatter, and should be turned in two or more half bricks over doors and windows, and other wide openings, but over the ends of beams they need not be in more than one half brick. Wood-bricks are used to prevent the necessity of driving wedges into the joints of brickwork to nail the joiner's work to. They are pieces of timber generally cut to the size and shape of a brick, or portion of one, and worked in as bricks in the inner face of a wall, where it is known the joiners have occasion for something of the kind. This is principally in the jambs of the windows and doors for their fittings, and along the walls, at proper heights, for the skirtings or wainscotting, as the case may be. The use of bond timbers in brick walls is objectionable because of their liability to shrink and swell, to decay, and to be set on fire; and in England the use of timber in walls has, since the extension of the manufacture of iron in these countries, been in a great degree superseded by that metal in the form known as hoop iron. Thin and narrow strips of this metal are laid in the bed joints of mortar, at intervals more or less frequent according to the nature and character of the work, with the best effect in respect of compactness and consequent strength. An improvement on the straight band has been introduced by Mr Tyerman, whereby a notch is made and the tongue bent down, which coming at each hollow of the bricks tends to afford a better hold on the mortar.

Discharging arches over openings.

Wood-bricks.

Bond timbers.

It will be generally found that a brick wall built with mortar and faced with ashlar has settled inward to a less or greater extent, as the work has been more or less carefully performed. Indeed, in the nature of things it cannot be otherwise, unless the brick backing be worked in some cement which sets and hardens at once; for the outer face is composed of a layer of unyielding material, with few and very thin joints, which perhaps do not occupy a fiftieth part of its height, while the back is built up of an infinity of small parts, with fully one-eighth its height of joints, which are composed of material that must both yield to pressure and shrink in drying. Some part of the ill effect attendant on this is obviated by the bond-stones, which tail in or run through the wall, and tend to keep the discordant materials together; but still much of it remains. And besides this, the internal or cross walls, which have no stone in them, will either settle down and shrink away from the external walls, or drag them inward, as they happen to be well or ill bonded or tied. For these reasons, brickwork built in this manner with masonry should be executed with exceedingly well-tempered mortar, made with no more lime than is absolutely necessary to cement the particles of sand together, and the sand again to the bricks, worked as stiff as it can be, and laid in as thin courses as may be to answer the purpose required of it. Above all, work of this kind must not be hurried, but allowed time to dry and shrink as it goes on. In some large edifices the brickwork is carried up and completed, and after a sufficient time has elapsed for the work to have settled, the ashlaring is carried up and worked in with the bond stones set in the brickwork for the purpose.

Discharging arches over vacuities having been disposed of incidentally, we have now only to speak of them under openings, in which situation their use is to distribute the superincumbent weight equally over the substructure, or along the foundation as the case may be. For this purpose the arch is inverted, as shown in fig. 4, Plate XXI.; and by means of it the weight brought down by the piers is carried along the footings, which are thus equally borne upon throughout their whole length. Arches of two half bricks are indicated here, that being sufficient for ordinary purposes, and to develop the principle; in large and heavy works, arches of three half bricks, and even greater may be judged necessary. Any arc between a quadrant and a semicircle may be used with advantage; but an arc of less than 45° cannot be recommended for the inverted discharging arch under piers. Arches require abutments whether they are erect or inverted, this is often forgotten when inverted arches are used.

Not the least important part of the bricklayer's art is the formation of chimney and other flues. Great tact is required in gathering-over properly above the fire-place, so as to conduct the smoke into the smaller flue, which itself requires to be built with great care and precision, that it be not of various capacity in different parts, in one place contracted to a narrow straight, and in another more widely expanded, and so on. There is now often introduced at the level of the mantel, a plate with an opening in it through which the smoke ascends. This, which is called a chimney-hopper or chimney lintel, is very useful not only to ensure the proper gathering of the flue, as the brickwork of the flue is formed at once upon it, but as a substitute for the usual register, and it also renders needless the usual iron chimney bar required to support the breast. It is absolutely necessary that flues be of a certain magnitude, but the bore should be regulated by the size of the fire-place, or rather by the quantity of smoke to which it is required to give vent. For large kitchen fires it is considered best to have two flues.

Practical men differ as to whether a tapering flue, or an enlarging flue is best for carrying away smoke. They are usually made of one size throughout. Of late years cylindrical earthenware tubes have been used with advantage, and of a smaller bore than the common 9-inch by 14-inch capacity. With glazed tubes it has been found that the soot falls down with thunderclaps and other strong vibrations. Flues of brick are plastered or pargetted with a mortar in which a certain proportion of cow-dung is mixed, which prevents it from cracking and peeling off with the heat to which it is exposed. The part brought out into the room from the wall, and over the opening, is called the breast. The flooring in the opening is called the hearth, fig. 8, Plate XXI.; it is set on the bricks or stones of the wall, and is usually of stone, although cement and iron plate are sometimes used. The slab is that part of the floor of a room which is immediately before the fire-place, and along the extent of its front. In basement rooms, this slab is supported by a brick wall brought up from the ground; but in upper rooms the slab is supported by a flat half brick arch called a brick trimmer, which is turned from the chimney breast under the hearth on one side to the trimmer joist on the other, which is generally made somewhat thicker than the other joists for this purpose. The chimney-piece which comes in front is fixed by the mason after the carpenter's work is done.

The plate above mentioned assists in ensuring a proper draught to the flue, and preventing a smoky chimney. These are frequently caused by want of sufficient air to feed the fire, which must be supplied from the room itself or by a tube brought from the outside of the building. Another cause of smoke is too short a funnel, especially if the flue be a large one, as formerly built for sweeping by boys. Every fire-place must have its own flue. Other causes are—one fire overpowering the other, when there are two in one large room, or two rooms communicating by a doorway, or when the tops of chimneys are commanded by higher buildings, or by a hill, so that the wind sometimes blows almost perpendicularly into the tops of the chimneys that lie in its way and beats down the smoke. A down-draught is usually produced by the difference of the external atmosphere from that in the room; this often brings down the smoke of a neighbouring chimney; it can occasionally be obviated by raising one of them, or by fixing on it one of the exhausting pots now manufactured for the purpose. The bad construetion of fire-places is another cause of smoky chimneys, the throat being too large for the fire. We shall not attempt to describe the many patent and other inventions submitted for curing these nuisances, but what is known as Billings's terminal must be excepted. It consists of a low conical top about a foot high, placed on the flue, and screened on each side by a terra-cotta baffler, rising somewhat higher than the pot; the wind striking the former is thrown upwards and assists in extracting the smoke; the latter prevents the smoke of one flue being blown down the adjoining ones in the same stack. The common terra-cotta pot with louvre sides is also useful and ornamental.

Paving in brick

Brick and tile paving is performed by the bricklayer. Brick-paving is either flat or on edge, in sand or in mortar or cement. Brick flat-paving in sand, that is, with the bricks laid on their broadest surfaces, and bedded in and on dry sand, is very slight and fragile, and brick flat-paving set and bedded in mortar is very little better; for if the soil on which the paving is laid be light and sandy, the bricks are easily displaced by being pressed unequally; and if it be clayey it will probably be moist, and the thin porous brick absorbing the moisture, will generally become saturated, and present a damp unwholesome floor. Paving with bricks on their edges, however, forms a much better floor, and is preferable to a stone paving, if the latter be laid on the ground without the intervention of footings. Brick-on-edge paving in sand is generally used in beer cellars, pantries, dairies, stables, &c., as its numerous open joints allow wasted or discharged fluids readily to escape; and it is both cool and dry under ordinary circumstances. In mortar or cement, bricks on their edges form a sound, dry floor; the smallness of the surface exposed by each brick in this manner leaves them, of course, less susceptible of partial pressures, and the depth from the soil to the

surface is such that damp rarely shows through. The paving brick differs from the common brick only in thickness, its dimension in that direction being rather less than 2 inches, instead of $2\frac{1}{2}$ inches, and in being rather harder and more compact. Dutch clinkers are paving bricks, smaller and much harder than the English, and of a light yellow colour; they are 6 inches long, 3 inches wide, and $1\frac{1}{2}$ inch thick, and are always set on edge and herring-boned, that is, instead of being placed in parallel lines, they are set at right angles to each other, as in fig. 14, yet with a perfectly even face. Paving tiles are made $9\frac{1}{2}$ inches and $11\frac{1}{2}$ inches square, though they are called 10-inch and 12-inch or foot tiles respectively, the former being 1 inch, and the latter $1\frac{1}{2}$ inch thick; they are set in courses, as stone paving would be, the alternating courses breaking joint. A sort of tiles called terro-metallic are manufactured for stabling and similar purposes.

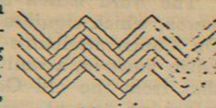
FIG. 14.—Paving of Dutch Clinkers.

Ornamental and other tiles.

Here may be mentioned the extended manufacture of ornamental tiles. The tiles formed in intaglio and enamelled, similar to those used by the Moors in Spain, have enabled the architect to break through the monotonous surface of brick buildings, and to introduce ornamental forms and colour without the necessity of resorting to plaster and stucco. From the geological position of London and many other towns, bricks must always be the prevailing material for building purposes; such means, therefore, for the safe introduction of colour and ornament are especially desirable and should be carefully studied. With this, too, has come the extended use of ornamental brickwork by the introduction of moulded bricks of all forms, and of many colours, together with a material of a like nature, by which decorative work of a more ornamental character can be obtained, namely terra-cotta, or prepared clay moulded or wrought and then burnt in a kiln. Tiles as above referred to are made for mosaic and tesselated pavements in plain colours (some being enamelled), for halls, footways of landings, conservatories, &c., also glazed tiles for hearths, and white and toned tiles, with the encaustic tiles of many colours, for walls. The former are manufactured of all sizes, so that by the combination of certain forms and colours an endless variety of patterns are obtainable. For pavements they require to be carefully set in cement on concrete, and in cement on walls.

Sewers and drains which are not cylindrical should be built with concave bottoms; this keeps the stream more together, and enables it the better to carry its impurities along with it, whereas a flat-bottomed drain offers a large surface for the particles of soil to attach themselves to, and the stream of water being more scattered is less efficient in force. Drains near houses, and in other places where it may be necessary to open them at any time, may be of the form of which *a*, fig. 1, Plate XXI. is a section, with a flat covering of stone paving, or large paving tiles, set and jointed with cement. Gun-barrel drains, of 9-inch or 12-inch diameter, as at *b*, are the best in exposed situations, because they are the strongest; but as there is no mode of cleaning, if they are too long to be raked, but by breaking them up, they should not be employed except with a considerable fall and a frequent or constant stream of water through them, as from a pump trough, rain-water trunks, &c. They are constructed on a barrelled centre of wood, which the bricklayer drags on as he advances with his work, finishing as he goes. No drain should have an inclination or fall of less than one-quarter of an inch to a foot; and where the stream is infrequent and dull, as much more would be a great advantage. Large sewers, which are accessible from the ends, or from side entrances, for men to clear or remove any accidental obstructions, are best made circular, elliptical, or egg-shaped, as in fig. 15. The last two shapes are generally preferred, because in proportion to the capacity the height is greater. The form in fig. 15 maintains the greatest possible depth with a small quantity of fluid, and combines this qualification with those of great strength to resist external pressure and large capacity with a given amount of materials. The form shown at *c*, fig. 1, Plate XXI., is now disused, though it was long advocated for sound workmanship and regular joints. A rate of fall of 1 in 120, or 1 inch in 10 feet, is desirable, although less will suffice for a main sewer.

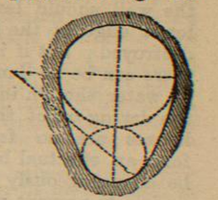
FIG. 15.—Section of Sewer.

Pipes or hollow cylinders of well-made and well-burnt glazed stoneware form the most efficient house-drains. Such pipes are put together with great accuracy with sockets, so as to fit spigot and faucet fashion; movable tops are provided so as to give access to them at any part required, without taking up and relaying the drain from one or other of its ends, as was so often the case with the old brick drain. Proper bends, junctions, syphons, &c., are also made of the same material. In using pipes for drains, it should be borne in mind that a little larger than large enough is better than the reverse of this. No pipes should be laid down for a house-drain of less bore than 6 inches, nor should earthenware be used for drains requiring a greater bore than 12 inches; the material is too weak to allow of more, and the material is not strong enough to stand more than a dead pressure. Glazed stoneware pipes are also employed for small sewers in side streets, or to take off the collected soil and water from a short row of houses into the main brick sewer, and thence to a water-course or to a reservoir of a main drainage scheme.

Traps

In building drains it is of great importance that proper traps should be constructed to prevent the ascent of foul air and the passage of vermin. At every sink there should be a bell-trap, and a well-trap within that, or near the hither end of the drain. Suppose a drain leading from a kitchen or scullery to the common drain of the house, in which it meets that which may come from the water-closet and other places. The bell-trap in the sink itself will prevent the return of smell when it is constantly in use, but it is liable to be left out, broken, or otherwise injured, or it may become dry by evaporation; it is, therefore, necessary to have a trap not so liable to such ordinary contingencies. Let a well be made 18 inches or 2 feet in diameter, square or round, and 2 feet 6 inches or 3 feet deep, across and below the level of the drain, as shown in plan, fig. 2, Plate XXI., and in longitudinal section, fig. 3; it must be built around with brick in cement, and be plastered on the inside with the same material, which will make it capable of retaining fluids. Uprightly across this well, and in the transverse direction of the drain, must be placed a sound piece of paving stone, so long that its ends may be inserted in the sides of the well, as shown in fig. 12, and so wide that its upper edge shall touch the covering of the drain, and that its lower may reach 6 or 9 inches down into the well below the bottom of the drain. Mortar or cement must prevent the passage of air between the upper edge of this trap-stone and the cover of the well and drain, and the trap is complete. The water coming from the sink flows along the drain from *a* to *b* (fig. 3), where it falls into the well and filling it up to that level it flows on again from *c* in the direction of *d*, to the cess-pool or common sewer from which, however, no smell can return; for the trap-stone