1. *Rubber Bricks, Rubbers, Cutters or Malms.*—These are soft bricks, obtainable in various sizes, and of a warm red or orange colour. They can be readily sawn and rubbed to the desired shape. They are used in the construction of *gauged arches* (see below).

2. *Purpose-made Bricks.*—These are specially hand-moulded to the required shape and are used for good class work in the construction of *purpose-made brick arches* (see below). Owing to the standardized form and size of many arches, stocks of the more commonly used purpose-made voussoirs are carried by the larger manufacturers, and delivery is thereby expedited; such bricks are usually machine-pressed.

3. *Ordinary Bricks Cut to a Wedge Shape.*—These are standard bricks which have been roughly cut to the required wedge shape by the use of the bolster and dressed off with a *scutch* or axe (see 34, Fig. 19). They are used in the construction of *axed brick arches* (see p. 26).

4. *Ordinary Standard Uncut Bricks.*—When such bricks are used in the construction of arches, the bed joints are not of uniform thickness, but are wedge-shaped. They are used for *rough brick arches* (see p. 26).

Flat, Straight or Camber Arch.—There are three varieties of this type, *i.e.*, (*a*) gauged flat arch, (*b*) purpose-made flat arch and (*c*) axed brick flat arch, depending upon the class of bricks and labours used in their construction.

(a) *Gauged Flat or Camber Arch* (see A and J, Fig. 15).—Rubbers are used. The extrados is horizontal and the intrados is given a slight curvature or *camber* by providing a rise of $\frac{1}{16}$ to $\frac{1}{8}$-in. per ft. of span; thus the arch at A would have a rise of approximately $\frac{1}{2}$-in. The reason for the camber is to avoid the appearance of sagging which is produced if the intrados is perfectly horizontal and which defect would be accentuated if the slightest settlement occurred. The angle of the skewbacks may be 60° (as shown at A and J) or the amount of skewback (the horizontal distance between the springing point and the top of the skewback) may equal $1\frac{1}{2}$-in. per ft. of span per foot depth of arch (as shown at A, Fig. 50, and A, Fig. 56). The adoption of the latter rule gives a more pleasing appearance (compare A and J, Fig. 15, with A, Figs. 50 and 56); if it had been applied to the two arches in Fig. 15 the amount of skewback at A would be $1\frac{1}{2}$-in. by $3\frac{3}{4}$ (span) by 1 (depth) $= 5\frac{5}{8}$-in., and at J it would be $1\frac{1}{2}$-in. by $2\frac{1}{4}$ by $1 = 3\frac{3}{8}$-in., as compared with $6\frac{9}{16}$-in., which is common to both arches when the skewback has a slope of 60°.

This type of arch is not very strong and should be limited to spans of from 4 to 5-ft. unless they are strengthened by means of a steel bar or angle, as described on p. 21. Observe that in each case the extrados coincides with a horizontal joint of the adjacent walling and thus a split course is avoided (see p. 21); the intrados of the arch at A, Fig. 15, also coincides with a bed joint; this is not always desirable, as the brick at T is difficult to cut on account of the sharp edge produced; such is avoided if the intrados comes midway up the course (see S, Fig. 15).

"Gauge" means "measure," and a characteristic of gauged work is its exactness. The bricks are accurately shaped as described below and the bed joints are very thin, being as fine as $\frac{1}{32}$-in., although a thickness of joint varying from $\frac{1}{8}$ to $\frac{1}{4}$-in. is much favoured. Such accurate work is possible by the use of rubbers and a jointing material known as *putty lime* (lime chalk which has been well slaked, worked up to a consistency resembling thick cream and passed through a fine sieve).

When drawing this arch to scale, the student should note that all bed joints of the voussoirs radiate towards the centre and that the 3-in. measurements (or 2-in. if the general walling is constructed of 2-in. bricks) are set off along the *extrados*. Students make a common mistake in measuring off along the intrados. When the bricks are 3-in. thick at the extrados, satisfactory jointing results if the number of voussoirs in the arch when divided by 4 gives a remainder of 1, *i.e.*, 13, 17, 21, etc.

Construction of Arch.—In order that the rubbers shall be correctly shaped, a full-size drawing of the arch (showing the voussoirs and joints) is prepared and thin pieces of zinc, called *templets*, are cut to the shape of the voussoirs shown on the drawing. The *bevels* or inclinations are marked on each voussoir by transferring them from the templet which is placed on it. The voussoirs are then sawn to shape with each saw-cut parallel and near to the marks. They are finally dressed down to the marks by rubbing each cut surface on a slab of hard stone or by using a rasp (see p. 130). A 6-in. long groove (about $\frac{1}{2}$-in. deep and 1-in. wide) is formed on each bed to form a key for the mortar and each rubber is numbered in accordance with the corresponding number on the drawing for guidance to the bricklayer.

The wall at each side of the opening will have been built and the skewbacks prepared to receive the arch, as indicated by the thick outline N shown at A, Fig. 15. The *turning piece* (see A, D and E, Fig. 43) upon which the arch is to be constructed will have been carefully fixed in correct position. When very fine joints are required, each voussoir is dipped into the putty and its bed covered, any putty in the groove is removed, and the brick is placed in position by pressing the bed coated with putty against the adjacent brick. When all of the voussoirs have been placed in position, cement grout is poured into the joggles formed by the bed grooves. It is usual to work from each skewback towards the centre and complete with the key brick. The voussoirs are kept plumb by using a *straight-edge* (a 3-in. by $\frac{7}{8}$-in. piece of well-seasoned wood about 6-ft. long) and, as the work proceeds, it is placed horizontally against the faces of the walling at the skewbacks when any voussoir not in true alignment is tapped either backwards or forwards as required.

If thicker joints are desired, the mortar is applied by a *trowel* (see 31, Fig. 19) in the usual way, care being taken that the joints are of uniform thickness and radiate to a common centre. This is ensured by using a cord or "line" as shown at A, Fig. 43; one end of the line is attached to the nail driven into the strut at the centre; the position of each voussoir and its bed joint is marked along the top of the turning piece, and as each voussoir is placed in position the bed is made to coincide with the line which is stretched taut. A piece of wood, called a *trammel* or *radius rod* (see M, Fig. 43), may be used to traverse the face of the arch instead of the line.

A templet or wood *pattern*, shaped as shown at *a*, *b*, *c*, *d* at A, Fig. 15, may be employed to ensure that all of the skewbacks are made to the correct angle. The bricks forming a skewback can be readily and accurately cut if a line parallel to it is marked on the wall, as shown by the broken line X at A, Fig. 15, when the measurements taken along the arrises of the shaded bricks which are intercepted by the mark are transferred to the bricks to be shaped.

(b) *Purpose-made Brick Flat Arch* (see H, Fig. 15, A, Fig. 50, and A, Fig. 56).—This arch differs from the gauged arch type in that purpose-made bricks (see above) are used instead of rubbers; the jointing material and the thickness of the joints are the same as for the general walling; the camber and size of skewback are as described for gauged arches. This type of arch is frequently employed in good-class work.