of similar stone to that of the steps. If left exposed, the brickwork would be finished with flush mortar joints. As shown, the floor covering can be of stone slabs bedded on concrete.

If there is not sufficient width available for an open well stair, it would be designed of the dog-leg type (see B, Fig. 29, Vol. III).

REINFORCED CONCRETE STAIRS.—It has been already stated that important stairs, especially those required for public buildings, are now constructed of reinforced concrete and that this has largely replaced masonry for this purpose. The reasons for this are: A reinforced concrete stair, suitably finished, (1) has a more attractive appearance, (2) it may be more fire-resistant, (3) its width is less restricted, as it can be designed to take heavy traffic over a large transverse span without resorting to any intermediate support (such as walls which encroach upon the hall), (4) the treads can be rendered non-slip (stone treads wear smooth and may become dangerous), and (5) it can be more easily kept clean.

Although reinforced concrete design is deferred until the advanced years of a course, a stair of contemporary construction is briefly referred to here in order that a comparison may be made between stairs of traditional design and those in which newer materials are employed.

A key part plan and cross-section of a portion of a flight of a *typical* open well reinforced concrete stair are shown at C and D, Fig. 46. The section shows the structure to be built into the wall at one end and supported by a string at the other. The details show that the concrete (which resists the compression stresses) is reinforced with $\frac{1}{2}$-in. diameter mild steel transverse bars (which resist the tension stresses) at 7-in. centres; $\frac{5}{16}$-in. diameter longitudinal bars are placed immediately over and wired to these transverse bars at 9-in. centres; $\frac{5}{16}$-in. diameter bars, called *stirrups*, are wired at 6-in. centres to the $\frac{1}{2}$-in. diameter bars and $\frac{3}{8}$-in. diameter transverse bars placed near to the top corners of the concrete steps; the thickness of the concrete at K is $4\frac{1}{2}$-in.; the upper surface of the concrete is shaped to suit the risers—two alternative forms being shown at A. The concrete string is reinforced with four 1-in. diameter steel longitudinal (tension) bars and two similar (compression) bars near the top surface; $\frac{1}{4}$-in. diameter steel stirrups are wired to these bars at 9-in. centres and at right angles to the pitch of the stair. *Note, the above sizes vary according to the width of the stair and the load to be supported*, and are determined by calculation.

Because of its unattractive appearance a stair constructed entirely of reinforced concrete would not be suitable for a public building in which it was to be an important feature. Hence the structure is covered or veneered with marble, tiles, terrazzo or other suitable material.

Detail A shows alternative forms of risers, one being vertical and the other inclined. These risers are formed of $\frac{3}{4}$-in. thick slabs of marble bedded to the concrete. The tread at H is formed of a $1\frac{1}{2}$-in. thick slab of marble, solidly bedded. As polished marble, especially when wet, has a slippery surface, non-slip tile nosings, which are artificial products, are often incorporated with the treads; that shown at J is grooved to give a key for the bedding. Care must be taken to use a mortar for bedding which will not stain the marble.

The string and soffit are also shown covered with marble or quartzite (a natural very hard stone, imported from Italy, and obtainable in several attractive colours—see p. 97) slabs. The walls may also be covered with $\frac{3}{4}$-in. thick marble, etc., slabs.

As these covering materials are costly, the soffit may be finished with Keene's or similar cement.

The string shown is of the "open" type; "close" strings (see p. 80, Vol. III) may be employed.

Expensive veneers are only applied when the appearance is of importance. Reinforced concrete stairs, such as are required for warehouses, etc., are often left uncovered, the treads only being provided with non-slip nosings.

The stair shown in Fig. 46 is cast *in situ*, *i.e.*, it is constructed on the site. It is therefore necessary to provide a temporary wood support, called *formwork* or *shuttering*, for this purpose. Briefly, this consists of butt-jointed boards or sheets for the soffit, fixed at the correct level and pitch to bearers supported by struts. This would be continued to form a suitable frame or box for the string, and this would be strutted; riser boards, etc., would also be fixed. The concrete is placed in position after the reinforcement has been fixed, and the formwork is not removed until the concrete has adequately set.

Concrete steps for narrow stairs are often pre-cast, *i.e.*, are separately formed in wood moulds of the required shape. These, when sufficiently set, are removed and fixed as described for stone steps.

Details of the bronze balusters and handrails are shown at B. These are alternative to those illustrated in Fig. 45 and are fixed as previously described.

NOTE.—The section through the string at B has been taken at a normal from the intersection between the concrete tread and riser (bottom). The baluster has been shown in section to illustrate more clearly the construction; as this would be in the centre of the tread, the distance L would be approximately 4-in., and therefore the bottom of the baluster is well clear of the top main reinforcement.