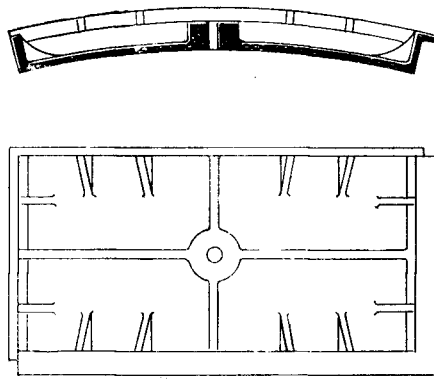




— Fig 4. —

Cast-iron Tubbing.

making an absolutely watertight lining. If it is necessary to take special precautions to insure staunchness the rings may be built up on the surface and faced in a lathe before erecting them in the shaft. In some parts of France the segments of tubbing are made as much as 5 ft. in height, and the joints are packed with sheets of lead instead of wood.

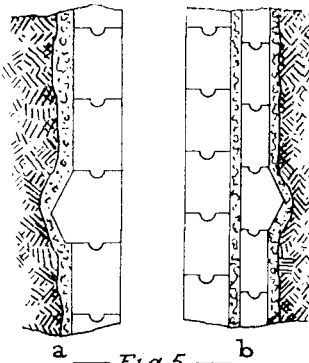
For some special processes of shaft-sinking it would not be possible to make use of tubbing with external flanges, so that in these cases internal flanges must be employed, and the different rings are bolted together. Spaces behind the tubbing should always be filled in with either concrete or clay.

An interesting system of lining due to Mr. Pattberg was made use of at the Rhein-Preussen Colliery. This method, known as compound lining, consists of cast-iron tubbing, about 2 in. thick, having its joints packed with asbestos, and lined inside with brickwork. At intervals down the shaft, at distances apart varying with the height of the column, annular iron rings of width equal to the thickness of the brickwork were bolted on to the inside of the tubbing, and served to divide up the masonry into lengths. These rings were tied together by longitudinal iron rods extending throughout the depth of the shaft, with the object of giving the lining great rigidity in spite of the small thickness of the tubbing, an object which the brickwork also tends to gain. This shaft was sunk by the Pattberg process, and it was hoped that the great weight of the lining would make it possible to sink to a greater depth without reducing the diameter of the shaft than would be the case with ordinary tubbing, but this end was not realised.

Coming now to concrete, we may divide linings of this material into three classes—concrete tubbing, monolithic concrete, and armoured or reinforced concrete.

Concrete tubbing-blocks have been employed to some extent in Germany, where they take the form of segmental blocks of concrete fluted or grooved at the top and sides, and provided underneath with a projection to fit in the top groove of the blocks below. Sections showing two methods of applying these blocks are given in Fig. 5. In all cases the blocks are set in cement, and in the double wall shown in the figure the space between the two rings is also filled with cement. As these blocks are rather heavy, means are provided for lifting them by forming a vertical hole through them and a horizontal hole to intersect the vertical one. A ring bolt is inserted in the vertical hole, and is held in by a cotter inserted through the horizontal hole. When the block is in place the holes are filled up with cement.

The Foxdale Lead-mine, in the Isle of Man, presents an example of a monolithic concrete lining, this particular shaft being rectangular; and another example, a circular shaft, is at Ougrée, in Belgium, the lining in this case being much thinner than would have been necessary if brickwork had been employed. Lining of this kind may be put in by means of ordinary timber shuttering, but a more convenient method would seem to be M. Badiou's "cintre mobile," which was employed at the Conte-Grandchamps shaft at the Chapelle-sous-Dun Colliery. This apparatus consists of a shallow cylinder carrying a working platform, the whole being suspended by chains from the surface. The external diameter of the cylinder is made equal to the inside diameter of the shaft, so that its sides act as shuttering; the concrete is put in in lengths, and the cintre mobile is raised as required by winding up the suspending chains, a special device being employed to release the apparatus from the grip of the finished length. The level of the platform is adjusted from the surface by means of the chains, and the apparatus is centred in the shaft by means of four adjustable arms which are inserted in



a — Fig 5. — b

Concrete Tubbing.