such depths be secured with so small an amount of material in the piles. To drive them in sand, with the resistance it gives, would be difficult, and, of course, the disc at the base must be foregone. If screw piles be employed an increased thickness of metal would be necessary to resist the torsion, and the process would be slow and costly compared to this. Of course this process will only answer in sand, but we can see no reason why the screwing down of large piles, or even the sinking of cylinders, should not be greatly facilitated by the use of a stream of water to loosen and wash away the sand and mud that is mixed with the gravel, or act as a lubricant on clay.

**MILROY’S EXCAVATOR.**

**PLATE XCIV.**

PLATE XCIV. illustrates an arrangement of excavating machinery which was employed with much success in sinking the cast-iron cylinders of the piers for the Clyde Bridge of the City of Glasgow Union Railway. This excavator was designed by Mr. T. Milroy, the agent of Mr. T. Brassey, who was the contractor for the work. It consists, as will be seen from the enlarged section and plan, Figs. 2 and 3, of an octagonal frame of cast iron, measuring 5 ft. across, the sides of this frame having hinged to their lower edges eight flaps or spades, which, when turned up at right angles to the sides, form the bottom of the frame, as shown in Fig. 3. In Fig. 2 the spades are shown hanging straight down in the position they occupy when the apparatus is being lowered into the ground, as will be described presently. The spades shut against a small central octagonal frame, which is connected with the outer frame by eight radial T-irons; and both the T-irons and central frame have india-rubber fixed to them on their undersides, so that water-tight joints are formed when the spades are closed. Referring to Figs. 2 and 3, it will be seen that the cast-iron frame is suspended by four chains from a ring which is secured to the main chain by an arrangement of catch-hook, which can be readily liberated. Each spade is also connected by a chain to a kind of conical ball at the lower end of the main chain, the length of these spade chains being such that, when the frame is held up by the catch-hook, all the spades hang open, as shown in Fig. 2.

The cast-iron frame was made heavy under the impression that its weight would be sufficient to force it into the ground; but this was not the case, and it was necessary to adopt special means for causing the spades to penetrate. The arrangement used for this purpose is shown in our engravings. It consisted of a frame of four vertical timbers placed in pairs opposite each other, each pair of timbers being sufficiently wide apart to allow sheaves to be placed between them at the top and bottom. Two other battens were also placed one on each side of the line, joining the main battens or “leaders,” and the whole of the battens were tied together at intervals of 30 ft. by cast-iron rings placed around and secured to them. This frame rested upon the ground, and it was lengthened from time to time as the sinking of the cylinder went on. The excavator was hauled down by two chains attached to it above the point where it entered the ground, and led from it under the bottom sheaves of the “leaders” up to a pair of winding drums, each worked by three men. When a sufficient penetration had been effected, the spades were closed, and the excavator, with its contents, hauled up by a 12-horse engine and suitable winding gear arranged as shown. When the excavator had thus been raised to the top of its lift, its contents were discharged into a lorry run under it, and it was again sent down for another charge.

The river piers of the Clyde Bridge are each formed of a pair of cast-iron cylinders, 8 ft. 4 in. in diameter, placed at a distance apart of 27 ft. from centre to centre, and these cylinders were sunk through an average depth of 75 ft. of white sand down to a firm substratum of dense sand and boulders. The sand through which the cylinders were sunk varied from a fine and silty material in the upper layers to a dense sand below; and although it was very difficult to drive piles into it, yet, when disturbed, it ran freely, and the cylinders were consequently full of water during the process of sinking. In