clay, until the entire cavity is filled with a shell of cement which fits it exactly, and forms an impermeable coat round the subway, protecting it from moisture and oxidation After the shield has been moved forward a ring of segments is bolted in, the rate of progress being about ten feet in thirty-four hours.

The works are being actively pushed on, and already one tunnel is completed from the north to south side of the Thames, and the second is following it. The plan of operations shows the same economy and respect for public convenience which marks the entire scheme. No street surface has been taken to form a contractor's yard, but in place of this a stage has, by the permission of the Thames Conservancy, been erected in the river behind the old Swan pier, and from this a shaft has been sunk through the river bed to the requisite depth. On the stage there is erected a crane which lifts the skeps of clay, and delivers them to a small tramway, along which they run to deliver their contents into barges; there is also a sand and an air compressor driven by a small engine, and a wooden office this constituting the entire present overhead plant of this great undertaking. The shaft is 13 feet in diameter, and is made of cast iron rings, each cast in one piece. The thickness of metal is 1⅛ of an inch, except at the bottom where it is thickened on the inside, contrary to usual practice, to form a cutting edge. This shaft was erected in the usual manner by removing the material from inside it with a grab and descends nearly to the crown of the upper tunnel. From this point it is carried down in brick work, mouthings for the two subways being made in it of the same material. There is no water to be dealt with, the tunnels being absolutely tight, and the work of extension goes most smoothly. Indeed it is impossible to realize, except by personal inspection, what a simple method tunneling in clay has become by the method employed by Mr. Greathead. This plan, however, is by no means restricted to clay, but can be modified to suit mud, sand, gravel and rock.

When the ground is so soft that it can be washed away, the method of removal by pick and spade is abandoned, and in place of this a constant circulation of water is maintained at the outer face of the shield by means of a pump. In the first instance, before the distance from the shaft becomes too great, a very simple plant will suffice. Two pipes, one bent over to dip into the river, are led down the shaft and along the tunnel to the shield, through which they pass, the one near the top and the other near the bottom. Water is drawn by a circulating pump from the river and forced out through the upper pipe against a bank of mud or sand which presses against the face of the bulkhead in the shield. The pressure thus created finds an outlet at the lower pipe, along which the current flows back to the shaft, carrying the solid material with it into the river or barge moored alongside the shaft. The two columns of water balance each other, and all the work required of the pump is to overcome the friction in the pipes and at the working face. As the work proceeds the friction, however, becomes a very important item, and other arrangements have to be adopted. Should there be any boulders in the ground they will become lodged at L and can be broken, by means of the bars, into pieces capable of passing along the pipe. If a boulder should prove refractory to this treatment an air lock would be erected in the shield or tunnel and the forward ends filled with compressed air until the cover of the receptacle could be removed safely and the boulder extracted bodily. In many cases, however, no such difficulty could be met and the process of pumping would suffice to remove the whole of the debris and deposit it in the tank. As the sand or gravel accumulated it would displace an equal quantity of water from the tank, which must have an outlet to permit the shield to move forward. For this purpose the pipe is carried backwards and up the shaft, and through this the surplus will escape. When the tank is to be emptied the valves e e e are closed to cut off all external pressure, and tubs K K filled with water are brought under the outlets f f. These dip into the tubs and when they are opened an interchange of the contents of the vessels F and K takes place. The sand descends into the tub while the water rises to take its place, the arrangement being exceedingly ingenious. To clear out the pipes the entire current can be sent from the pipe D direct to the pipe E through the connection P.

Clay, mud, sand, gravel and boulders do not exhaust, however, the list of substances to be met with in tunneling. There still remains rock to be dealt with, and for this Mr. Greathead has designed the appliances shown in figures three and four. Through the face of the shield A there projects a shaft carrying a two-armed toolholder O fitted with steel tools. The shaft is driven by a compressed air motor; and as long as the tools are in a satisfactory condition it is protruded so far through the shield that the holder stands in the position shown in dotted lines in figure four and bores its way through the rock. When the tools become blunted and require renewal, the holder is set horizontally and is drawn back under the hood end M. It is then set vertically, and the space under the hood is filled with compressed air to permit of a manhole being opened in the shield, and a man entering the chamber. After the tools on one arm of the holder have been removed, the shaft is rotated through 180 degrees, and the other set are renewed. The man then retires, closes the manhole, the shaft is pushed out again, and the work pro-