RAILWAY TUNNELLING.

Part III.

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PREVIOUS articles of this series on the practical side of tunnel driving dealt with the method of procedure as followed generally in different countries. The sinking of shafts, setting out of tunnel, driving of headings, etc., were taken up in January 15th, 1914, issue of *The Canadian Engineer*. The description was continued as far as, and including in part, operations of mining and timbering, in March 19th issue, while in the following notes the discussion proceeds to the finishing of the brickwork.

From the stage at which the length under construction has been mined down to the top sill and this sill put into position the excavation must be got away quickly, as now begins the paying part of the work. Excavate down to the top of the bottom heading, placing the bars and poling farther apart. These bars may now be only a little longer than the length being mined and about 12 in. diam., one end of them being supported in the brickwork of the toothing which can be cut out for their reception, and the other end supported by temporary raking props, at a point a little back in the length from the front of the sill. About the level of the top of the bottom heading another sill is placed, the bottom of it being kept high enough to clear wagons, etc., passing through the heading. This sill is similar to the top one, but may be stronger and, of necessity, longer, because here the tunnel is nearly full width. It is placed in the same manner, letting each middle sill prop be exactly under one of those above, supporting the bars from the top sill. Two strong rakers must now be got in to support the top sill from formation, more particularly against face weight. They should be on very strong foot-blocks, and when in position, driven up tightly with driving wedges, inserted between the end of raker and the foot-block. The top end of these rakers should be formed into a jaw, to take in the bottom face angle of the sill, and should be provided with a good iron gland, just below the jaw to prevent splitting.

These top sill rakers should be got in as soon as it is possible, even before the middle sill is in, or, in any case, temporary rakers should be used. In getting out the remainder of the length, leave the sides in, and excavate the middle portion only, leaving side slopes like a cutting, and do not undermine the middle sill. Arriving at formation level, place two strong props on good foot-blocks under the middle sill, on either side of the bottom heading, and place 2 rakers to this sill, similar to but shorter than those for the top sill. The face weight is sometimes very heavy, tending to shove the sills into the length, especially when the tunnel is inverted, and in that case, besides these rakers, sill stretchers will be needed, stretching or strutting the sill ends from the last toothing. If this is not effective, "Judkin" rakers must be introduced. These are timbers abutting against one another at the centre of the sill face, and stretching it horizontally across the length to the toothing. The excavation of the slopes may now be worked, extending all to formation level across the tunnel, beginning at the top of the slope, and putting in a light bar here and there, sufficiently near to one another for them to secure the ends of any poling boards that may be required to support the ground. These bars should be supported by raking props at either end. Should the ground be good, no bars will be required below the middle sill. Do not undermine the middle sill, but leave a good footing of ground until the rest of the length is out, then take this out in bays, putting a prop under the sill from a foot-block on formation, one by one as the bays are removed.

The foundations of the side walls are usually carried down 2½ ft. below formation level and should be trenched to the net width of the lowest course of the brick footing. They must be level and solid. Any water accumulating in them can be got out by hand-pumping.

Each gang of miners should always have two faces to work, for if not, it will be idle while the bricklayers are lining. If these two faces be A and B, and the work just described as having been done in A face, while the mining of this length is going on, and before it is finished, the bricklayers should have commenced and keyed the arch of the length last got out in B face. Directly they have keyed it, some of the miners' gang in A should begin to drive the top heading for another length in B. They should be able to get the 5 bars drawn into that length before that in A is finished. There is then about room for the whole gang to get to work in this next length in B face.

By the time a few lengths are finished, it is likely that a good deal of water has been tapped, and that the method of emptying the sump by barrel is not sufficient. A steam pump is really the best and cheapest means to install. One of these occupies little space, and can be fixed in a manhole in the side wall of the tunnel, near the bottom of the shaft, and locked up. The force pipe is conducted up the shaft, and the suction into the sump, with a branch along the side wall to near the length that is being mined. To this latter can be attached a flexible hose. A stop-cock should be fitted to each branch of the suction, so that communication can be cut off from either pipe. The steam for the pump can be supplied from the winding engine's boiler.

Lining the Length.—Having the wall foundations out, everything is ready for setting the side wall frames.

The engineer should put a centre line point accurately in the middle sill, and mark off the face of the walls, and by driving a spike into the timber at any point above rail level properly distanced from the centre line. Set up the frame with its back edge against this spike, and plumb it. The projecting piece of timber marking rail level must be precisely levelled to rail level. Spike this frame securely, its place being at the leading end of the length, and close up to the sill. Put the frame up for the other wall in the same way. Four of these frames will be required for a first side length.

Bricks and mortar are now required in the length. It may be inconvenient to supply them from the open ends for all the faces, because of the number of these faces at work and the traffic in and out of the tunnel. When 8 or 10 lengths have been turned at any face, a turn-out should be put in off the main track, i.e., a siding where wagons can stand and allow others to pass them. For a tunnel of this length a mortar mill can be used in each of the entrance cuttings.

A gang for lining a length is made up of 4 bricklayers and 6 laborers—half the number being on each side and each party working on the same side of the tunnel for all lengths—so that their work will be similar throughout. The best one usually takes the leading end or toothing of the length on his side. The term "toothing" denotes leaving the bricks at the leading end projecting every alternate course, as the bond causes them