Volume 25 Toronto, Oct. 16, 1913 Contents of this issue on page 591

The Canadian Engineer

A weekly paper for engineers and engineering-contractors

AN EXAMPLE OF DIFFICULT TUNNELING

THE COMBINED USE OF SHIELD AND COMPRESSED AIR ON WORK SUBJECTED TO UNUSUALLY COMPLEX CONDITIONS

By J. M. M. GREIG, A.M.I.C.E.
City Engineer's Department, Toronto

THE driving of a sewer tunnel under somewhat unusual circumstances arose in connection with one of the low-level intercepting sewers of the city of Glasgow. Starting from a shaft some 25 feet deep, the tunnel passed beneath the foundations of a very heavy retaining wall (clearing them by a foot or two) into running sand lying below an extensive freight yard bordering on the Queen's Dock. There were only 9 feet of cover between the top of the sewer and the rails, and at one point the centre line approached within 80 feet of the quay wall. To open-cut this section was out of the question owing to traffic conditions, and to drive a tunnel through quicksand with an unlimited supply of water close by was no light task.

It was decided that the tunnel should be driven with cast-iron segments, so as to minimize the ground opening; but, as the railway company had doubts as to the effect of their extremely heavy loads on the roof of the finished iron tunnel, a thick brickwork lining of these segments was insisted upon. This made the section one of great strength, but of an external diameter somewhat out of proportion with the inner diameter, as will be seen by reference to Fig. 1.

There were 420 linear feet of sewer immediately below the rails, and the ground throughout was clean sand, varying in fineness, and full of water.

Work Previous to Arrival of Shield.—A shaft was sunk, and from it the tunnel was driven, at first with cap-and-leg settings of timber and a brickwork lining. This did not prove a satisfactory method, the street showing signs of subsidence, owing, no doubt, to the exceedingly unstable condition of the bottom, rendering effective propping impossible. An attempt to tunnel with iron lining turned out equally unsuccessful, and, after the necessary plant had been put to work, a third trial was made with iron and compressed air.

About 30 feet of tunnel were driven thus under the deep cover of the street, but the openness of the ground and the large area of exposed face caused a great escape of air, little improvement being effected, therefore, in the conditions of the bottom. The air pressure gradually fell from 5 to 2 pds. per sq. in. as the tunnel approached the wall, and mining operations became exceedingly difficult toward the end, only one ring being built per day. It was evident from the disturbance of the surface that the miners were not holding the ground, and that the continuation of this method of tunneling beneath the retaining wall would be attended with great risks; so it was decided to try a shield.

Description of Shield.—The outer shell of the shield consisted of a cylinder of steel plates, the clear inside diameter being 8 ft. 8½ in. and the length over all 7 ft. 10 in. Inside this shell and about 2 ft. behind the cutting edge was a bulkhead or diaphragm formed of plates, stiffened with channels and angle gussets off the front upper portion of the shell, called the hood. This diaphragm had two openings, 1 ft. 7 in. by 4 ft. 8 in., separated by an I-beam in the centre, which, with the side channels, formed two sets of grooves, into which stop-planks might be placed, should it be necessary to close the face or reduce its area. Besides these working openings there were two small hand-holes in the lowest part of the diaphragm through which the sand was forced as the shield drove forward. In very bad ground a great amount of the excavation might have been taken out through them with the larger openings closed.

Below springer level the cutting edge receded from 2 ft. to 4 in. off the diaphragm; thus there was a hood above that portion of the ground being excavated, while it was still possible to reach the ground immediately in front of the lower portion of the cutting edge and so clear the way for the bottom of the shield, thus obviating the possibility of boulders damaging the cutting edge. The hood was stiffened with an additional plate, so that the cutting edge was really formed by the bevelled edges of three plates above springer, and of two below.

Behind the diaphragm there was a cast-iron ring formed of six flanged segments fixed to the shell by taps, while screws running through casting and shell held the ram castings in position. The rams, six in number, arranged symmetrically around the circle, were 4 in. in diameter, and had a maximum travel of nearly 2 ft. There was a sufficient length of shell (8 ft. 8½ in., inside diameter) behind the segments to admit of one ring being erected inside the tail of the shield with about 6 in. of the shell overlapping the iron already erected.

The main hydraulic feed-pipe was fixed to the shield on one side, about springer level, and from it the high-pressure water was separately distributed through smaller pipes to each ram, small valves on these pipes giving independent control of each ram. Thus the shield consisted of a steel shell divided into three portions—the hood with the cutting edge, underneath which the excavation was taken out, the body containing the means of propulsion, and the tail, in which the tunnel rings were built.

To obtain the necessary hydraulic pressure an air-compressor on the surface supplied an air-engine or