

ing out a few lengths in this fashion it was found that, by excavating 1 ft. 6 in. forward and building up a ring at once the face would stand with little or no timbering, whereupon the rate of progress increased from 9 ft. to 40 ft. per face per week, and in one case 66 feet of iron was placed in one face in a week, of course, working night and day. In tunnelling this clay, the important point was to keep the face constantly moving as exposure to the air or unnecessary vibration converted it into mud, so fine that it ran through between the poling boards where a knife blade would not go.

The miners, when working for one ring, did not require to stand on the clay at all, which kept it in a fairly stiff condition in the bottom.

length of open-cut long enough to construct air locks in, it was necessary to drive sheet piles, 6 inches thickness, well below formation all round, and to pole the bottom throughout. Within the piling two lengths of sewer were built each way off a centre opening, and air-tight doors, etc., were built in to form air locks for driving the tunnels in both directions. Before filling in above these lengths, the piles which crossed the line of sewer were bored off about top level of tunnel, and horizontal piles were driven in to form a roof for the miners breaking away, and to prevent, if possible, escape of air up the sides of the vertical piles.

This was quite effective and no trouble was experienced in breaking away from the open-cut. With suf-

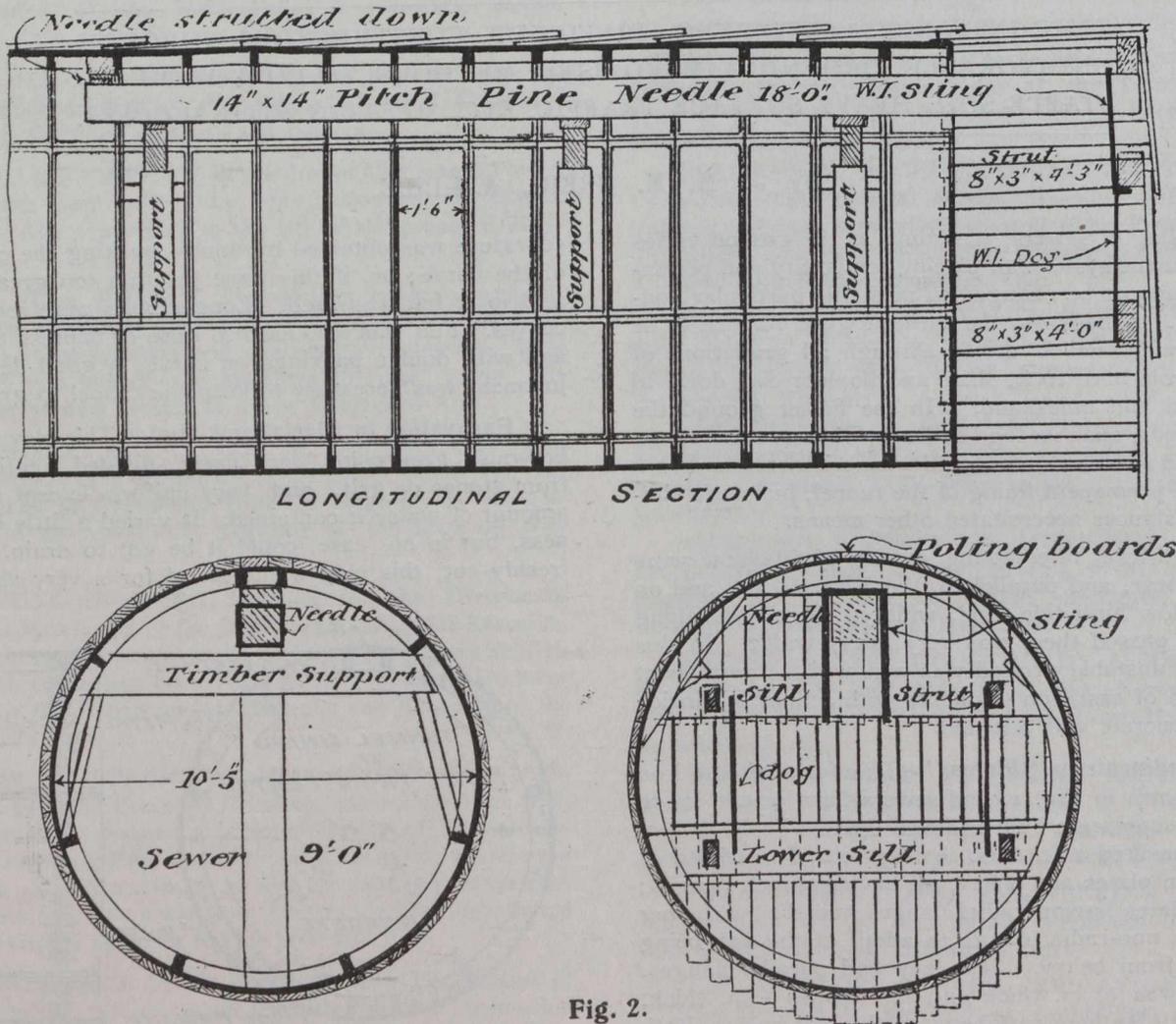


Fig. 2.

On another sewer, 9 ft. diameter, where the ground was getting very near to a condition necessitating air pressure, a considerable length of tunnel was driven by timbering for two rings at a time, with the entire face constantly close poled. Here, however, a difficulty arose through the weight of ground carried, by the end ring giving it a dip. To get over this the "needle" shown in Fig. 2 was used. As soon as the upper part of the face was excavated this "needle" was thrust forward, transferring the weight back to the second ring instead of on the leading one. This arrangement turned seeming failure to success.

About half a mile of this 9-foot sewer was through ground too unstable for any method but that with compressed air. In fact, to get down to grade and form a

ficient air pressure to keep the face dry there was no difficulty in completing this tunnel and good progress was made. The effect of air pressure on the ground all round was remarkable.

Previous to going in for air pressure a narrow shaft had been sunk, with great difficulty, in the neighborhood, the ground being so soft that planks 9 in. by 3 in. and 12 ft. long, were driven to the head with a hand maul. When later it was necessary to sink onto the completed tunnel for a manhole, the ground which had been subjected to air pressure was dry and stiff, so that little timbering was required in sinking.

With air pressure and cast iron segments there is not much difficulty in tunnelling through this clay, so long as it is not so liquid as to refuse to support the