use. Notwithstanding the immense weight of this shield it was on a number of occasions thrown high enough into the air to come down reverse side up. It will be readily understood how a blast with such lifting power would shatter the rock fine enough to be shovelled and that too with very little use of the pick. The width of trench so shattered was seldom more than 4 feet and never wider than the five feet to prevent the use of the shield.

From its weight and form this shield was very difficult to handle, but by the use of two pairs of wheels that could be readily detached and removed from danger when firing a blast, there was very little loss of time in moving it forward its own length into position for the next blast. These wheels were 60 inches in diameter made on the same principle as the ordinary cart wheel, the wheel was two and one quarter inches thick, four inches wide, covered with a tire one half inch thick. The axles were of machinery steel three inches square, five feet in length between inside of hubs, and seven feet four inches in length over all. At its centre for a length of sixteen inches this axle was widened to six inches, and had an opening four inches by two and one half inches, through which passed a square threaded screw one and one-half inches in diameter and three feet long with a swivel link attached to the lower end of the screw for linking into a hook in the shield. This screw has no direct connection with the axle but passes through a nut with both ends working on the axle, with journal caps bolted to the axle keeping it in position, thus giving it a side swing motion, the axle giving the forward and back motion. When brought into use the wheels are run into position at the front and rear end of the shield and each screw is linked to the hook on the shield, which by means of a hand wheel eighteen inches in diameter at the upper end of the screw is screwed up from the ground until suspended from the axle by means of these two screws. The whole is then moved forward, the wheels running on planks on either side of the trench. When over its new position the shield is lowered over the trench by the screws, the wheels detached and removed until wanted to again move the shield forward after the blast.

By means of this shield five men could blast in about ⅔ of a day what the two drills would cover in one day, so that it was not kept continuously in use. It was easily moved in continuous trench blasting, but when moved any distance to a new street was trouble sure enough, for as each set of wheels was entirely independent of the other, they could not be guided when drawn by a team, for the wheels would persist in going any way but the right way, in just about as helpless a fashion as a man without a backbone. In moving the shield then to a distance, it was necessary to do so by hand, laying down planks for the wheels to run on with a man at each wheel, a rather slow operation, but one which was so seldom required that it did not prove a great inconvenience. But this difficulty might be overcome if it was often necessary to move the shield any distance at a time, as it seldom was on this work.

Drilling operations commenced about the middle of April and were carried on continuously thereafter with 25 steam drills until the middle of August in doing about 25000 lineal feet of trenching with a probable average of about 5 feet in depth of rock. Part of the time, for a few weeks when running day and night, there was drilled, blasted, excavated with pipe laid complete, about an average of 400 ft. per day. With trench well opened ahead so as not to delay pipe laying, the biggest day laying of 12 inch pipe in a rock trench was about 380 feet of six inch pipe, about 120 feet including hydrant, settings, etc. The biggest day's pipe laying of 8 inch was 710 feet without any hydrant settings. It was impossible, however, to keep a pipe laying gang continuously at work using only two drills, so that the average day's pipe laying on each size pipe was much smaller than the above. Usually when the pipe gang caught up to the blasting gang they were shifted to some contiguous street in an earth trench and kept there for some days, allowing them to have a good clear run in the rock trench before commencing again.