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grade. The position and size were such that lateral holes could be drilled from this heading to break the enlargement to the required dimensions. The air, water; and ventilating pipes for this heading were branches from the mains laid in the pioneer heading. Access to this heading was obtained through the cross-cuts from the pioneer, and muck was handled around the enlargement operations by the pioneer route. This heading was generally driven in a westward direction, on account of the drainage. The system of driving was similar to that in the pioneer. The rounds averaged about 7 ft., and 32 holes were drilled in the hardest rock. The main heading was sometimes driven from several faces. The average daily progress per heading at the east end was slightly more than 16 ft., and the maximum monthly progress was 621 ft. The average daily progress per heading at the west end was 20 ft.; the maximum monthly progress was 762 ft.

Enlargement .- Drilling: The enlargement drilling, after some experimenting, was done as shown by Fig. 2. Each hole was pointed by clinometer, the column carrying the drill being set always at the same distance off the centre line, and the arm for the lower and upper sets being always the same distance above the sub-grade. Line and levels were furnished by the railway company's engineers, and a string was stretched by which the columns and arms were located. Each drill hole had its proper distance from the arm. The drill holes were thus bottomed at a regular distance beyond the neat line of the completed excavation. The holes, being bottomed with reference to the line and grades given by the engineers, were not affected by irregularities in the heading driving. The columns were set by men for that purpose, so that the drillers and helpers had only to do the drilling. The drill steel was brought to the drillers, and the dull steel was taken away. The drillers and helpers were paid their wages in any event, but the footage for each man was kept, and if the price set per foot drilled amounted to more than his wages, he was given the difference as a bonus check. Air and water connections were made for every third ring of holes, and only one drill machine, though handled by each runner of the three daily shifts, completed the three rings, and then moved to the head of the line, taking the next three rings. Congestion of men and material was thus avoided, and each man had a fair chance to work on an equal quantity of hard and soft rock. There was extreme variation in the quantity drilled by different men and in different rock. The same man might do only 6 ft. a shift in the hardest quartzite, and more than 100 ft. per shift in the softer schist. New men, after a month's practice, generally made more lootage than men of long experience in mining. In general, it was found better to train green men than to try to get men accustomed to piston drills to learn to run hammer drills. Most of the rings were 6 or 61/2 ft. apart. When explosives rose in price it was found economical to space the rings 5 ft. apart, as the extra drilling cost was balanced by the saving in explosives, with the added advantage that the muck was broken into smaller pieces and scattered farther back. Where the roof was soft and full of slips, so that trouble was anticipated, the upper set of arms on the column was lowered I ft., in order to leave some trimming of the roof to be done by jackhammer, flat holes and light blasting. The air and water for the enlargement drilling, as well as the supplies, came by the pioneer tunnel and the cross-cuts, so that this drilling was not disturbed by the enlargement blasting. The drilling for the last mile, where no pioneer tunnel was driven, was started at the middle and progressed toward the portal, the track, pipe, etc., being removed as the drilling was finished. The stopping of the pioneer tunnel was well-timed, as the main heading was driven and the enlargement drilling completed just in time to avoid delaying the enlargement blasting and mucking at the east end.

Generally, from ten to fifteen rings were kept loaded ahead. Any part of a hole which had not broken, and could be found, was reloaded and shot with the next ring. Generally, a little muck was left in the face by the power shovel in order to prevent the first ring from scattering back too far. If the previously shot material had not broken to the required width, however, all the muck was loaded, and jack-hammers were used to drill up this tight rock, after which it was shot before the regular rings were blasted. Several bottom rings were first blasted, then a top and bottom ring were blasted together until the muck piled up to within 4 or 5 ft. of the roof. Then blasting



LONGITUDINAL SECTION, SHOWING ENLARGEMENT BLASTING Fig. 3.

was discontinued, and the men scaled and trimmed the roof, working from the muck pile. (Fig. 3.) Where no holes had to be reloaded, rings could be blasted at intervals of from 15 to 20 minutes. The blasting was done with a battery in the main heading, and the bottom holes were all loaded ahead, the wires being wound up and stuck in the holes, from which they could readily be pulled out and connected. The upper holes were loaded, but no primers were put in until ready to blast. The holes were loaded to within 4 ft. of the collar, whether sprung or otherwise.

**Concreting.**—About  $1\frac{1}{2}$  miles of the tunnel, including the soft ground at each end, required concreting. This work was sublet to the Bates and Rogers Construction Company, of Chicago and Spokane. The concrete section is heavily reinforced. The sub-contractors used wooden forms, and deposited the concrete from a platform near the roof reached by an inclined trestle. The concrete mixer was on a car, and the materials were on other cars back of it. The concrete from the mixer flowed into a