

operation was as follows: drilling in the small headings was done in the usual manner, using in general Leyner drills, making an advance of 6 or 7 ft. for each round of holes. The muck was shovelled by hand from steel plates into "half yard" cars and hauled back, either by a mule or small compressed air locomotive. The latter was used entirely when the haul had reached a considerable distance. The muck from the headings A and B on the progress diagram was carried out through the cross cuts E and D respectively into the pioneer tunnel, where it was carried back to cross cut C, and then out on a trestle over the standard gauge tracks through the main tunnel, and dumped into standard gauge cars. The material was then removed to the fills, as was also the muck loaded by steam shovels in the enlargement. The muck from heading F on the west end was in a similar manner conveyed into the pioneer tunnel at cross cut H and back to the main tunnel in cross cut G, where it was dumped into

which would require immediate timbering. As there was some 1,660 ft. of such ground, the time limit of the contract was extended into June, 1917.

The work completed up to Dec. 19, 1915, was as follows:—19,610 ft. of pioneer tunnel, 24,612 ft. of centre heading, 1,660 ft. of earth tunnel, and 14,342 ft. of tunnel enlargement in rock. At the same date there remained to be driven:—288 ft. of centre heading, 10,398 ft. of tunnel enlargement. The best progress made in driving the pioneer tunnel heading was in Jan., 1915, when 932 ft. in the west heading were completed. The best record for a week in the enlargement was 267 ft., and for a month was for Aug., 1915, in which the enlarging was 827 ft. in the west end.

From April 1, 1915, to Dec. 15, 1915, 12,346 ft. of tunnel enlargement was made. This was during the time that the shovels were both working in rock and at a normal rate of speed. Such a rate would require only a little over seven

up the muck, thus making an advance of from 30 to 35 ft. The shooting was usually continued until the tunnel became so full of muck that no more could be done. The largest amount shot at one time was 84 ft. in 11 hours, which was the record for Nov. 20, 1915.

All expectations as to speed in the execution of the work have been more than realized. For rock tunnelling where the rock is of sufficient hardness to stand until the mucking has been completed, the method described can be most successfully worked, and a speed of three miles a year can be easily made at a much less cost than tunnels driven at the same speed by the European method. Furthermore, the practice of radial shooting has given a great deal less overbreak than would have resulted had the holes been drilled parallel to the axis of the tunnel.

The work was laid out and commenced under F. F. Busted, M.Can.Soc.C.E., Engineer in Charge of Double Tracking, with J. W. Sheppard as Assitant Engin-

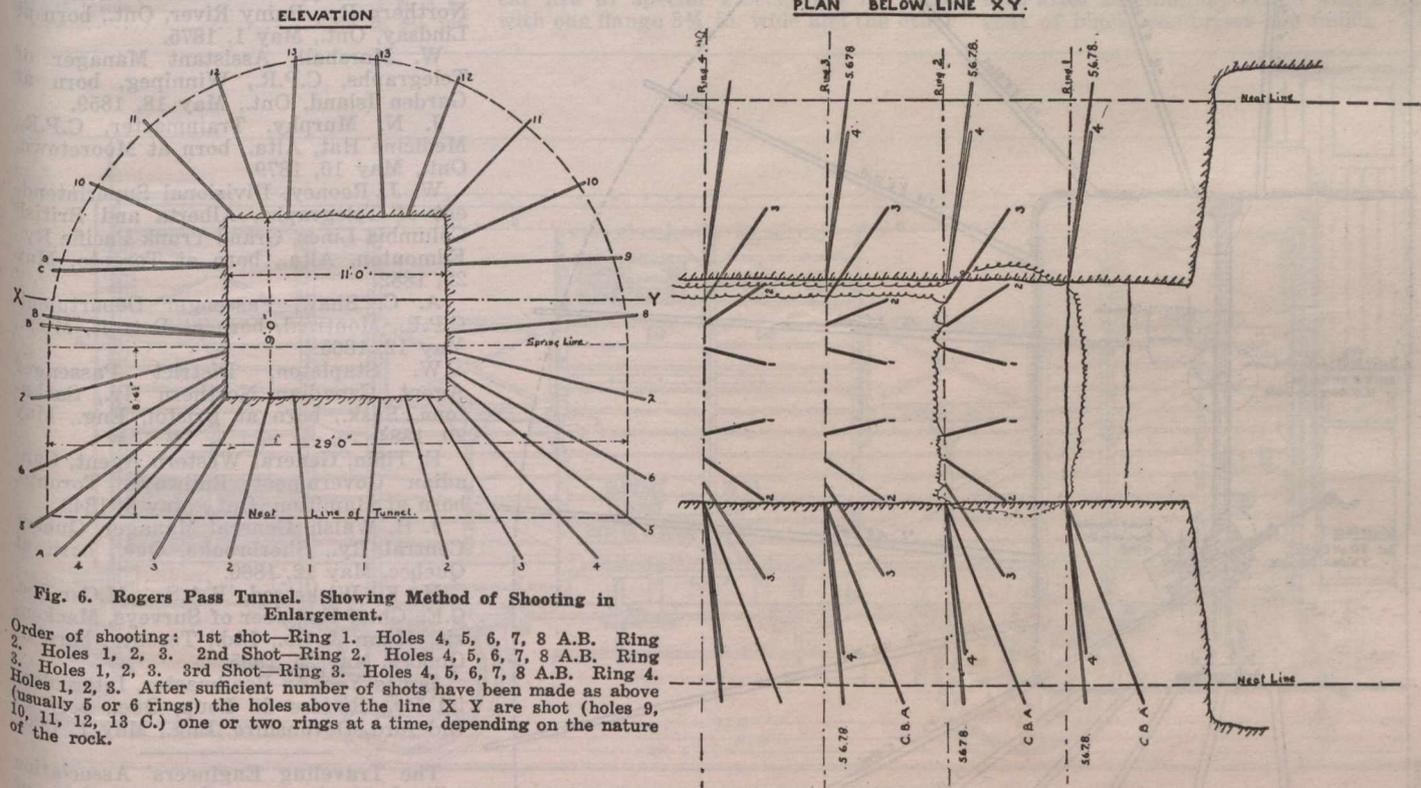


Fig. 6. Rogers Pass Tunnel. Showing Method of Shooting in Enlargement.

Order of shooting: 1st shot—Ring 1. Holes 4, 5, 6, 7, 8 A.B. Ring 2. Holes 1, 2, 3. 2nd Shot—Ring 2. Holes 4, 5, 6, 7, 8 A.B. Ring 3. Holes 1, 2, 3. 3rd Shot—Ring 3. Holes 4, 5, 6, 7, 8 A.B. Ring 4. Holes 1, 2, 3. After sufficient number of shots have been made as above (usually 5 or 6 rings) the holes above the line X Y are shot (holes 9, 10, 11, 12, 13 C.) one or two rings at a time, depending on the nature of the rock.

standard gauge cars. In the enlargement of the main tunnel the drilling was done well ahead of the shooting. Figs. 6 and 7 show the manner in which the drilling was carried out. The radial holes were at first drilled at right angles to the axis of the tunnel, but the results were not satisfactory, and a change was made, to the method shown in fig. 6, in which the holes have an inclination of about 1 in 4 from the direction in which the tunnel was being driven. The muck was all loaded by steam shovels into standard gauge 12 yard capacity dump cars. The shovels had dippers of 1½ cubic yards capacity and were worked by compressed air. The cars were hauled to the mouth of the tunnel by standard gauge compressed air locomotives and taken from there to the dumps by standard steam locomotives.

The contract for this work was let on July 1, 1913. The limit of time for completion was 3½ years, which would end on Jan. 1, 1917. There was an allowance in extension of time of one day for every ten feet of soft ground encountered,

months in which to complete the tunnel. There will, however, be some slowing up in the enlargement between cross cuts H and F, which are at the ends of the pioneer tunnels, for the reason that, at present, fans are installed at these points. Doors were placed at the cross cuts between the pioneer and the centre heading, and those which were at the back of the shovel were kept closed. When shooting occurred in the enlargement, the door at the first cross cut beyond the point of shooting was opened and a strong draught was thus created over the pile of freshly shot muck, making it possible for the men to return to work in 10 or 15 minutes after a shot had been fired. The methods employed in shooting in the enlargement were as follows:—One round of holes was shot at a time, the holes in the bottom of the tunnel being shot in advance of the holes on the sides or on top (see fig. 6). In some cases the top holes were not shot until all the bottom holes were finished. Usually 6 or 7 rounds of holes were shot before the steam shovel began to take

eer. It has recently been under the supervision of W. A. James, M.Can.Soc.C.E., Engineer of Construction, Western Lines, with H. C. Barber as Assitant Engineer, T. Martin, Resident Engineer at the west end and J. R. C. Macredie, M.Can.Soc.C.E., Resident Engineer at the east end. The contractors are Foley Bros., Welch & Stewart. The construction work has been supervised for the contractors by A. C. Dennis, M.Can.Soc.C.E.

The foregoing paper was read before the Canadian Society of Civil Engineers recently.

**Canadian Society of Civil Engineers.—**

At the regular monthly meeting in Montreal, April 13, John Murphy, chairman of the Ottawa Branch, gave an informal talk, illustrated by views, describing his trip over the Panama Canal, and referring particularly to the difficulties of earth slides in the Culebra Cut. Lt.-Col. F. A. Snyder described an original diagram for making military scales for interpolation of contours and reduction and enlargement of maps.