speed for each condition as described, we can ascertain from the diagrams 1 to 6, inclusive, the corresponding costs per engine-mile. The cost of the engine-mile running under steam multiplied by the total number of engine-miles made under steam during the round trip gives the cost of motive power for the distance run under steam per round trip. In like manner the cost of motive power for the distance run with steam shut off, per round trip, is found. The sum of these two gives the total cost of motive power per round-trip train.

Table 6 gives the costs of the engine round-trips for the Arthur's Pass lines, found as described above, and also the cost standing, not running, with steam up.

As shown in my first supplementary report, when assistant engines average less than eighty miles per day, a charge must be made for the time standing, not running, with steam up. The difference between eighty miles per day and the average daily mileage of assistant engines for the lines and number of trains considered is given in Table 7.

Multiplying the figures on Table 7 by the costs from Table 6, which corresponds with the engines required for each line, as given in Table 2 of the first supplementary report, and by 312 working-days per annum, the result will be the annual cost of assistant engines while standing, not running, with steam up, and is given in Table 8.

Multiplying the cost per round trip of the road engines and assistant engines from Table 6 by the number of round trips per annum, and adding the cost of assistant engines while standing with steam up from Table 8, gives the total annual cost of motive power as found in Table 9.

A comparison of these results with those of Table 9 of the first supplementary report shows a difference of only 2 per cent. in the general average. This 2 per cent. lower average cost of the engine-mile is caused by the average speed, as determined from the virtual profiles, being somewhat higher than the speed assumed for the calculations of the report mentioned. These speeds are no higher than can be attained under the conditions governing the operation of these lines.

The cost of the engine-mile being lower, the difference in annual cost of motive power is greater for the cases having the larger volume of traffic and engine-miles, as would naturally be expected.

Line C 1, which had higher annual cost of motive power in the supplementary report referred to than line C, is now seen to have slightly less total motive-power cost. This is due to the shorter length of the ruling grade, which more than balances the slight excess in mileage.

The relatively greater reductions for lines E and F are due to the fact that in each case the ruling grade is a smaller percentage of the total length of the line, a fact not fully discussed in the former report. The effect of reduction in cost by higher speed for line A was partially discounted in the calculations of the first supplementary report by the reductions there made in the cost of fuel per engine-mile for this particular line. The alternate arrangement of motive power for line E shows less favourably than the others, and for 500 and 700 trains per annum in each direction shows an increase in cost on the figures of the said supplementary report. This is due in part to the higher cost now found for engines standing with steam up, and in part to the fact that the road engine stands with steam up, like the assistant engine, for a large part of the time, which was not considered.

Analysis of Tunnel-ventilation.

Applying the formula used for the design of the ventilating apparatus of the Elkhorn Tunnel, of the Norfolk and Western Railroad, hereto attached, to the conditions of lines A and B at Arthur's Pass, we have—

Area of cross section = 200 sq. ft.
Line A, length 31837 ft. = 6·03 miles.
Line B, length 20328 ft. = 3·85 miles.

$$\text{Then, for line A, } R = \sqrt{\frac{\cdot042 \times 31837}{\sqrt{200}}} + 1 = 9\cdot775;$$

$$\text{and for line B, } R = \sqrt{\frac{\cdot042 \times 20328}{\sqrt{200}}} + 1 = 7\cdot86.$$

Let V., the velocity of the air-current in the tunnel = 1500 ft. per minute, which is slightly higher than the highest assumed train-velocity under steam in tunnels. Let S = the velocity of the blast at the outlet of the air passage-way, and C = the required area of the outlet in square feet.

Then for Line A—

$S = 1500 \times 9\cdot775 = 14670$ ft. per minute.

$C = \frac{200}{1\cdot2 \times 9\cdot775} = 17\cdot05$ square feet.

Volume of air = $14670 \times 17\cdot05 = 250000$ cubic feet per minute.

And for Line B—

$S = 1500 \times 7\cdot86 = 11800$ ft. per minute.

$C = \frac{200}{1\cdot2 \times 7\cdot86} = 21\cdot20$ square feet.

Volume of air = $11800 \times 21\cdot20 = 250000$ cubic feet per minute.

The horse-power required will be $\frac{250}{213} \times 150 = 176$ h.p., to which must be added something to provide for the higher velocity of discharge in this case. It will be safe to use 200-horse power. The cost of fuel, repairs, and stores will be taken at one-half of that for Class B engines. Wages and general expenses will be taken at the same figures as have been used for Class B locomotives.