A comparison of the results of this second supplementary report with my report of the 17th February, 1902, and my supplementary report of the 16th May, 1902, shows a substantial confirmation of the results and conclusions therein contained.

Tunnel-ventilation.

Attached hereto is a copy of the *Railroad Gazette*, describing the apparatus for ventilating the Elkhorn Tunnel, on the Norfolk and Western Railway, the method of finding the volume of air required per minute, and the power required to obtain satisfactory results. I have determined these for the tunnels of lines A and B, and from the horse-power required and the estimated cost of construction of the ventilating-plant I have calculated the annual cost of ventilation for each case. It will be seen that, while the average of these results is only about 14 per cent. higher than the figure used for tunnel-ventilation in my former reports, the difference between the highest and lowest annual cost for the several cases is £464 sterling, and therefore a more accurate comparison is now obtained.

It is proper to remark here that the ventilation of the Elkhorn Tunnel by the apparatus mentioned has been satisfactory. While the Elkhorn Tunnel has a length of only about 3,000 ft., the line upon which it is situated is a coal-road, having a heavy traffic requiring many locomotives, which produce smoke and gases to an excessive degree.

Maintenance of Track in Tunnels.

Attached hereto is an extract from a paper read before the Institute of Civil Engineers by Mr. Thomas Andrews, F.R.S., M.Inst.C.E., on the wear of rails in tunnels, and reports of Division Superintendents of the Northern Pacific Railway. Taking these, in connection with the letter from Mr. H. Bissell, Chief Engineer of the Boston and Maine Railroad, relative to the cost of maintenance of track in Hoosac Tunnel, and which was attached to my first supplementary report, I have decided that a much fairer comparison of the several lines will be obtained by estimating the cost of maintenance of way in tunnels at twice the average cost outside. This I have done by adding to the costs given in my first supplementary report the cost obtained by multiplying the number of train-miles *in tunnels* for the several lines and cases considered by the average cost of maintenance of way per train-mile of all New Zealand roads for the year 1900–1.

The final result of this more accurate and refined analysis emphasizes the conclusion that the best line is either line B or line C, or some line between the two.

Analysis of Working-costs.

The best of any number of alternate railway-lines between two common points *for any given volume of traffic* will be that which has the least aggregate annual charges, and the relative advantage of the several lines will vary inversely as these charges.

The aggregate annual charges include—first, interest on cost of construction; second, motive power; third, train-service; fourth, maintenance of way and structures; fifth, car-repairs; sixth, other expenses of conducting transportation; and, seventh, general expenses.

General expenses and expenses of conducting transportation, other than motive power, train-service, and car-repairs, will usually be so nearly the same for any line that they may be neglected in computing the relative economy. Maintenance of way and structures, and car (carriages and wagons) repairs, will often be so nearly the same for the several lines discussed that they need not be considered in detail, but only kept in mind in a general way. Train-service affects the relative cost only when the total number of train-miles varies.

Motive power and interest on cost of construction are the chief and often the only items that will determine the relative advantages of alternate lines between common points. The second of these is a simple matter of quantities, costs, and rate of interest, but the cost of motive power is affected by so many conditions that its determination for any given case becomes complex. Variations in the cost of motive power, caused by changes in one or more of the elements that govern it, are so great that any estimate for a complicated case with undulating grades that is not based on consideration of all the elements that affect it is liable to lead to erroneous conclusions.

To obtain a comparison of the several Arthur's Pass lines, substantially complete and accurate, maintenance of way and structures and car (carriages and wagons) repairs have been included. Train-service has been omitted since the difference in its cost for these lines would not appreciably affect the results, the maximum variation being about £39 per annum with 340 trains up to £115 per annum for 1,000 trains.

The cost per engine-mile, which is the unit of the cost of motive power, is based on the locomotive returns which I have received from eight different railway systems. These cover all classes of service and conditions of operation. Table 1 shows these reduced to common units and assembled to facilitate the investigation of the effect of the various elements and conditions of service on the cost of the locomotive-mile.

Except where the tractive power of the engine is given, the returns are not of much value in determining the cost of fuel per engine-mile. It is, however, clearly indicated, as would naturally be expected, that much more coal is consumed per mile in freight service than in passenger service. Further on it will be shown that this is measured by the speed. The heavy-grade service of the Canadian Pacific and the Rio Grande Western indicate what fuel-consumption becomes with engines working to full capacity at very slow speeds. Assuming that $4\frac{1}{2}$ lb. of coal are consumed per horse-power hour, which is a fair average (see Wellington, p. 460), we can ascertain the coal-consumption from the computed horse-power. This method checks with the actual results of engine No. 401, on the Soldiers' Summit grade of the Rio Grande Western, to within $1\frac{1}{2}$ per cent. It checks with the ten returns shown in Table 1, where the weight on drivers was given, to within $6\frac{1}{10}$ per cent. as shown in Table 2; but it should be noted that in most of the comparisons of