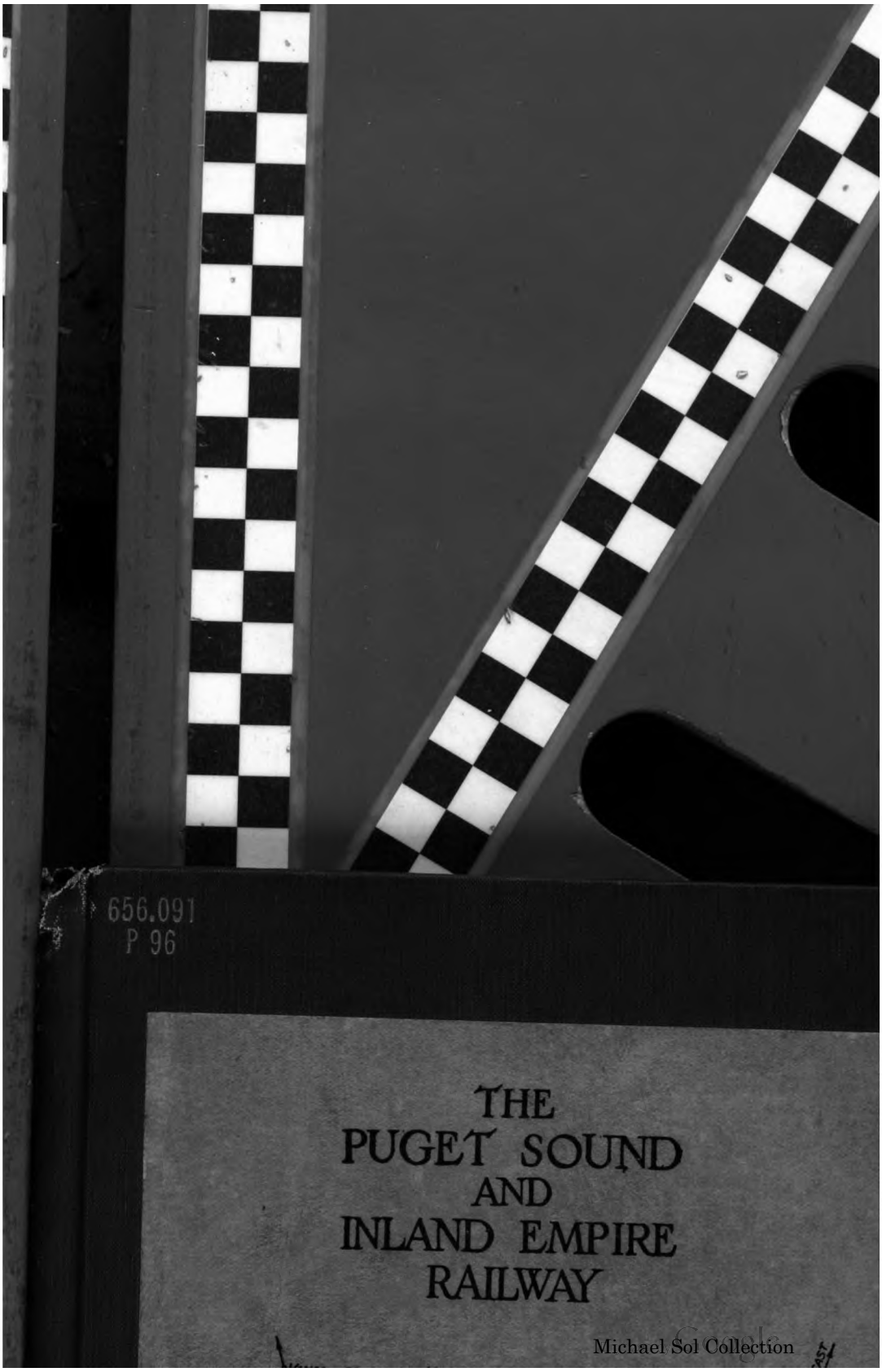
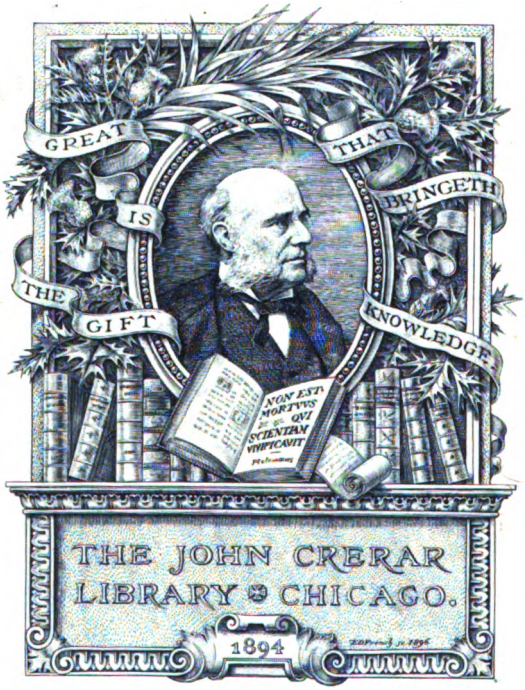


THE PUGET SOUND AND INLAND EMPIRE RAILWAY



The PUGET SOUND and INLAND EMPIRE RAILWAY

"Cascade Tunnel Route"

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Chief Engineer P. S. & I. E. R. R.

THE A. HARRIMAN COMPANY
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THE WALL

NO LONGER A BARRIER

The PUGET SOUND and INLAND EMPIRE RAILWAY

"CASCADE TUNNEL ROUTE"

(Extracts from a paper read before the Pacific-Northwest Society of Civil Engineers, Seattle, Wash., at its October (1925) meeting by ITOTHE PHUCHER, member of the Society and Chief Engineer of the road.)

In view of the approaching completion of the P. S. & I. E. Railway it seems fitting to lay before the Society a fairly comprehensive description of this important work with the execution of which so many of its members have been identified. Inasmuch as the essential data contained in this paper are already accessible to the public, I trust that I am not violating the principles of railway ethics in thus publicly discussing a project with which I am officially connected.

As you will recall, it was sixteen years ago this past summer that the Spokane, Portland and Seattle (the "North Bank") Railroad was opened to traffic. This road is everywhere considered one of the finest ever built. From Spokane to Portland, 378 miles, there is a descending gradient all the way (except for a short climb out of Spokane) nowhere exceeding 0.4 per cent. The maximum curvature is 3 degrees. The road has been double-tracked all the way and the roadbed, bridges, etc., have been built in the most substantial manner. As a transportation route it represents the highest result of the railroad builder's art.

While the City of Seattle is given a place in the *name* of the new road, her discerning citizens have always regarded this distinction as a doubtful honor—a sort of "joker," in fact, designed to convey the impression that their city was really a co-partner with the other two in the benefits to flow from this splendid work. The com-

mercial interests of Puget Sound have never been quite able to figure out how the North Bank road was to be of any particular benefit to them, and it has been clear from the start that, as between themselves and Portland, the advantage was all in Portland's favor.

Since the opening of this road to traffic another circumstance has developed which operates powerfully in the same direction. This is the completion by the Government of the Columbia River Improvement (for which surveys were begun in 1909) giving unobstructed navigation from the mouth to Kettle Falls near the British line. This work has been taken full advantage of and there is now a considerable fleet of boats operating on the river. The cheapness with which grain and other products can be floated down to tide-water, even in the absence of a large amount of return traffic, has given the river complete control of freight rates throughout the extensive territory which it traverses. From the North Bank crossing of the Columbia at Pasco the Northern Pacific had already planned, as early as 1909, to build a line up the valley to the Great Northern crossing, and the latter road had completed its surveys for a line from Wenatchee north to the Okanogan country and beyond. The completion of both these lines and of the river improvement thus gave a navigation route and a water-grade rail route from the British Boundary to the mouth of the Columbia.

The North Bank road, with connecting lines, and the Columbia River Improvement early set Puget-Sounders thinking. The only offset to Portland's advantage in this respect lay in her inferior facilities for deep-sea shipping. But Portland, fully alive to this inferiority, has spared neither time nor money in overcoming it. The Government has loyally assisted her and there seems to be no limit to its willingness to sink money in the great Columbia jetty. If this work should ultimately fail, as many believed it would, Portland still held a card up her sleeve ready to play it whenever necessity should require. That was to build an entrance just south of the jetty and open a ship canal from it to the river across the spit

south of Fort Stevens, thus cutting out the bar altogether. Portland was and still is determined to make good the deficiences of nature, that she may realize the consummation foretold by one of her own poets,

"When through this gate the treasures of the North
Flow outward to the sea."

But the North Bank road, it was rumored, had a card up *its* sleeve also. It was not from any consuming love of Portland and her harbor, as against the ports of Puget Sound, that the North Bank road was built. It was, in part at least, for the purpose of reaching a deep-sea harbor without climbing over the Cascade Mountains. If Portland could furnish such a harbor, well and good; if not, the North Bank would find one on its own account. That the second alternative was the one adopted early became probable by the survey of a route down the north shore of the river to the outlet, and thence north to Willapa and Gray's Harbor. Inasmuch as the Northern Pacific already had good lines to both these points, leading directly from the main line between Portland and Tacoma, and reaching the entire region tributary to these harbors, the wisdom of building this long and expensive route into the same territory was not at first apparent. But when the public came to realize that Willapa Bay affords an almost perfect harbor without the bar handicap of the Columbia and Gray's Harbor, the suspicion that an outlet on this bay was the real objective of the North Bank road grew into a conviction. The answer of one of its officials to an inquiry by a citizen of Seattle as to what was the purpose of this new road, that it was to secure a low grade route into *Seattle*, was therefore more diplomatic than accurate. The real purpose was to secure a low grade route to tide-water, and by tide-water Puget Sound was not meant.

That the commercial interests of Puget Sound should feel somewhat uneasy in the presence of these developments was only natural. The loss of some of their trade was not merely threatened, it was becoming a fact. They had great advantages, to be sure. The vast inland sea upon whose shores they were located, with its many ex-

cellent harbors, was an asset of unquestioned value. The Government had generously expended money in perfecting these harbors already favored by nature beyond almost any others and Puget Sound enjoyed every physical advantage from a maritime point of view that could be asked for. Commercially, also, it occupied a stragetic position of the first importance. Its relation to the Oriental and Alaska trade was of acknowledged superiority over that of any competitor, while the immense lumber trade found shipping facilities here with which no other situation could compare.

But on the land side the case was very different. Portland's situation was exactly reversed. The great obstacle of the Columbia bar was matched by the greater obstacle of the Cascade Mountains—a mighty wall that shut off the interior of the country without a break from Fraser river on the north to the Columbia on the south. Jutting out from the main wall through the great buttresses of Mt. Baker and Mt. Rainier, branch walls extended to the coast at Bellingham and Gray's Harbor respectively, thus entirely enclosing Puget Sound and making ingress and egress impossible except by climbing over the wall. It is true that the wall drops down to below 500 feet elevation on the line between Tacoma and Portland, but the great increase of distance to Eastern traffic by this route more than offsets its advantage of elevation over the direct routes.

Some conception of the magnitude of this obstacle may be had from a comparison of the vertical lift of freight passing over the mountains by the routes to Puget Sound with that via the North Bank between Spokane and Portland. West-bound freight must overcome 3520 feet vertical ascent on the Northern Pacific, 3543 feet on the Great Northern and 3655 feet on the Milwaukee. For east-bound freight these figures are 5400, 5406 and 5518 feet respectively.* On the North Bank route the west-bound ascent is 375 feet, all concentrated at Spokane; the east-bound ascent is 2238 feet. It thus appears that

*See explanatory note preceding Table I.

traffic by any of these lines has to overcome about 3200 feet more of adverse grade each way than by the North Bank route to Portland. The cost of lifting all freight to and from Puget Sound, a vertical height three-fifths of a mile, constitutes a tremendous handicap.

But there were other serious drawbacks to the mountain routes. The winter snows in the Cascades are a great impediment and have more than once completely blockaded traffic, such blockade amounting on one occasion to several weeks. The construction and maintenance of extensive snowsheds, the wear and tear of sharp curves and steep grades, the losses from landslides on steep slopes and floods in the torrential streams, altogether make a great addition to the cost involved in the vertical lift. Traffic arrangements might minimize, but could not overcome altogether, these immense drawbacks and the natural and inevitable tendency has been to throw traffic along the line of least resistance: viz, to an outlet at or near the mouth of the Columbia. In the matter of local traffic, like the wheat shipments of Eastern Washington, the river route practically forced this result.

It thus early became apparent that Puget Sound was "up against the real thing" in the matter of commercial competition with the ports to the south. The situation did not, of course, spell disaster in any sense of the word. It takes more than one railroad to make or unmake a great city or a great port. The natural advantages of Puget Sound would always count for a great deal. But it was nevertheless clear to those viewing the situation sixteen years ago, that a large part of the commerce which would naturally find its outlet in her ports, the best facilities for transhipment there, and which in the ordinary course of things would seek these superior facilities, was certain to be deflected to ports further south in order to escape the costly haul over the Cascades.*

*The completion of the Lolo Pass cut-off on the Northern Pacific (begun in 1909) by which the main-line distance between Missoula and Pasco has been materially reduced, has a tendency in the same direction, though this has been neutralized to some extent by the high altitude of Lolo Pass.

There was another feature of the situation, not directly connected with the railroads, which was coming to be of serious importance. Until 1909 there was practically no highway communication across the range. In that year a well-graded road was opened through Snoqualmie Pass and another has since been opened south of Mt. Rainier. Both of these routes are long and laborious and are closed a large part of every winter. The western section of the State was therefore cut off from the eastern during a portion of the year, so far as highway traffic was concerned, and was only imperfectly connected during the rest of the year. The great seaboard section and the great agricultural section, which should be in easy touch with each other, were much of the time completely separated except by rail. The unobstructed outlet was to the south and the isolation of the eastern section from the Puget Sound section was so complete that it had much to do with the effort which had been made to effect a division of the State. The necessity of bringing these two sections into closer commercial relationship was daily becoming more manifest.

A circumstance of world-wide importance was developing at this time which turned the attention of the railroads themselves strongly to this question. This was the certainty that the Panama Canal would be built. With the visit of President-elect Taft and a board of consulting engineers to Panama early in the year 1909, their emphatic approval of the lock type of canal and their expressed opinion that the canal would be completed by 1915, were everywhere accepted as the final word upon the subject. It was at last evident that the canal would be built, and the great trans-continental railway systems were face to face with the fact that within ten years at the farthest they would have to compete in trans-continental traffic with a practical and effective all-water route. That this fact would have a powerful influence upon the commerce to and from Puget Sound was not to be doubted. Traffic which had hitherto gone overland would in part, at least, be surely diverted to the water route, and the extent of such diversion would depend

upon the ability of the roads to compete with the ships. This was a matter that concerned the railroads more than it did the Sound country itself. It behooved them to introduce every practicable improvement in their lines which might lessen the cost of freight movement, and their attention naturally turned to the greatest single obstacle with which they had to contend—the Cascade Wall.

It thus gradually forced itself on the public mind from more than one point of view that this handicap to the commerce of the Sound must be removed. It was evident that the greatest boon which could come to the State of Washington or to the railroads centering on Puget Sound would be to pierce the Cascade Wall with a route for railway and highway traffic that would be equal to the route along the Columbia where it breaks through the mountains to the south. But was such a feat possible? James J. Hill, in a newspaper interview in the early days of North Bank construction, had expressed himself in the negative, stating that nothing further of a radical nature could be done to diminish the cost of freight hauling over the mountains until the tunnels were lowered, and he did not consider that a practical proposition in his time. His opinion was generally accepted as settling the question, but the gravity of the situation forced it to the front again and there developed a strong determination to have the whole matter reinvestigated. To a degree theretofore scarcely ever witnessed, business and public interests outside the railroads took part in solving a railroad problem, and probably hastened action on the part of the roads themselves in re-examining the possibility of better communication across the mountains.

The question was now "up to" the engineer. With the vast fund of information already in possession of the railroads from former surveys and with ample provision for such additional surveys as might be necessary, the whole line was exhaustively re-examined from Mt. Rainier to the head of Lake Chelan. It will be of interest to dwell somewhat at length upon these prelim-

inary studies, because they pertain exclusively to the engineering profession and have therefore a particular interest to our Society.

* * * * * * * * *

The result of the extensive studies above described was to demonstrate that there were only two routes where even a great length of tunnel would accomplish the desired lowering of grade. One of these was via Lake Chelan and the other approximately on the Great Northern route between the valleys of the Wenatchee and Skykomish Rivers. Lake Chelan is a marvelous natural formation—a long, narrow body of water, only 1080 feet above sea level and only seventy miles in a straight line from tide water, extending back into the very heart of the glacier-covered mountains which tower a mile and a half above its surface. A tunnel would have to be carried directly through the range from the mouth of Railroad Creek near the head of the lake to the Suiattle and Stilaguamish Rivers on the west side. But the much greater length of the tunnel required than on the other route, the exceedingly rough and precipitous character of the lake shore, and the almost total absence of a country capable of anything except mineral development led to the rejection of this route.

The adopted line of the tunnel under the Cascades is between Leavenworth in the Wenatchee Valley and Skykomish in the valley of the Skykomish River. The length is 32.25 miles, the maximum elevation 1175 feet, the tunnel gradient 0.2 per cent ascending westward for a mile beyond Leavenworth and 0.15 per cent descending the rest of the way. The distance is 25 miles shorter than by the Great Northern between the same points.

The project, as originally advanced, contemplated only the tunnel, leaving traffic connections east and west to future development. But it early became evident that an extension of the line on either side sufficiently far to place it in communication with the great railway systems would be necessary if the full benefits of the tunnel were to be realized. On the east side it was felt that Spokane should be made the terminus. That city is the metropolis

and center of the so-called Inland Empire—Eastern Washington, Northern Idaho, and Western Montana—and is a cross-roads or meeting point of all the trans-continental lines seeking the Northwest coast. Some of the roads, like the Northern Pacific and Canadian Pacific could not use the tunnel at all except by a connection from this point. Moreover there were local reasons for this extension in the need of adequate service for the rapidly developing northern portion of the State since the opening of the Colville reservation. The Methow, Okanogan, Sans Poil and upper Columbia valleys were filling with settlers and were in need of more direct rail connection with the coast and would contribute a substantial business to the new road.

On the west side, Puget Sound was considered, in a broad sense, the real terminus, though actual construction of the main line has so far been carried only into Seattle. But the admirable connections to all other points both North and South give these points equal advantage with Seattle in the use of the tunnel route.

It was these considerations that gave the name to the new road. It was not a road connecting specific towns, but uniting important, yet distinct, sections of the State—the seaboard or maritime and the interior or agricultural sections—and so it was called after the names of these sections, **The Puget Sound & Inland Empire Railway.** Popular usage and advertising literature generally refer to it by its great engineering feature as the "Cascade Tunnel Route."

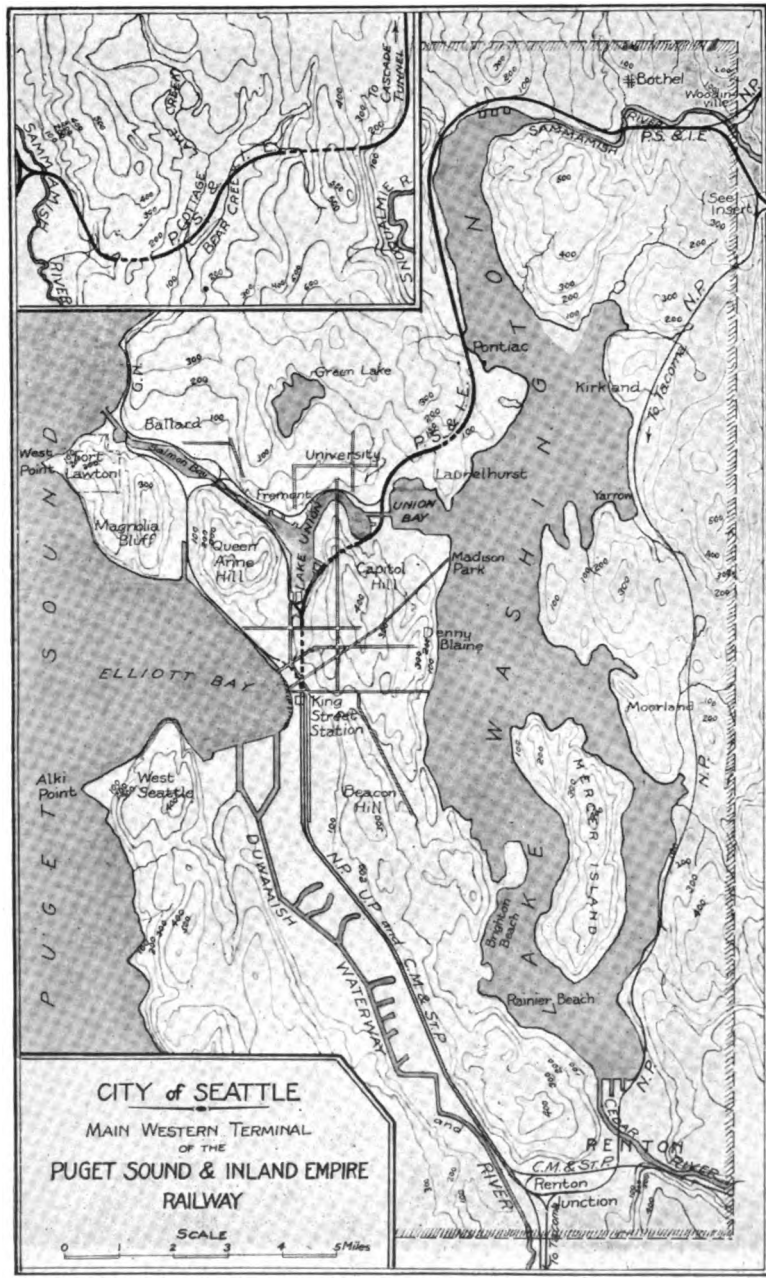
It will thus be seen that the two terminal cities and the tunnel were located on an east and west line running practically through the center of the State. In its easterly course the route reaches the Columbia Valley near Wenatchee where the river attains its westernmost point north of Snake River and nearer tide-water than the Cascade Locks are to the ocean. From this point the valley trends strongly to the northeast and southeast through the fruit and grain belts, giving diagonal short cuts to the vast territory beyond. In the angle between these two divisions of the valley is the celebrated Big

Bend Country which has undergone a tremendous development in the matter of grain production. On the west side of the mountains the route debouches from the foothills nearly at the middle point between Tacoma and Bellingham and serves with a maximum of advantage all parts of the Sound. On the whole, the route is ideal for efficient service not only to the State of Washington but to all eastern traffic to or from the North Pacific coast.

Coming now to the specific location of the route, it follows the Spokane River from Spokane to the Columbia, and the Columbia to the Wenatchee Valley and the latter to Leavenworth, the east portal of the tunnel. The gradient along the Spokane River nowhere exceeds 0.3 per cent and along the Columbia River 0.2 per cent. The line practically follows contour 800 from Chelan to the Wenatchee Valley, and ascends the latter on a gradient of 0.3 per cent.

On the west side of the range, the line descends the Valley of the Skykomish from the west portal, keeping on the south slope, with a gradient of 0.3 per cent. Rounding the point of land between the Skykomish and Snoqualmie Rivers, it crosses the latter stream and follows the west bluffs for several miles south whence it traverses the irregular terrain between the Snoqualmie and Sammamish valleys. It crosses the Sammamish River in the vicinity of Derby, and descends the valley of this stream to the head of Lake Washington, where it virtually reaches tide water. It then follows the old Northern Pacific line around the north and west shore of the lake as far as Union Bay, but leaves it at that point, crossing the Lake Washington Canal and passing by way of the south end of Lake Union to the tide flats of the Duwamish delta and the principal terminal yards of the city.

From the Sammamish River crossing at Derby, the Tacoma branch turns south and follows the reconstructed line of the Northern Pacific along the east shore of Lake Washington through the manufacturing district of Renton to Renton Junction where it joins the main line from Seattle. The distance is eleven miles shorter than



by way of the main line through the city.

From the west portal of the Cascade tunnel the Great Northern leads by a direct line into Everett. Portions of the route, however, have a rather steep grade and to avoid this a line will be built from the P. S. & I. E. crossing of the Snoqualmie River to connect with the Great Northern at Lowell, now a part of the city of Everett, reducing all gradients on that line to within 0.5 per cent. The company is about to open a car-ferry service from Everett into Hood's Canal to connect with the several lines on the Olympic Peninsula.

The work has been very costly, even that outside the great tunnel, owing to the rigid conditions of grade, curvature and thoroughness of construction which have been required. Along the Spokane and Columbia Rivers on the east side and across the irregular glacial deposits around Lake Washington, numerous tunnels and high bridges or trestles have been necessary to secure the desired uniformity of grade. The line is double-tracked all the way. It can be widened in trackage, except through the tunnel, if traffic ever demands it, but the immediate divergence of lines on each side of the tunnel will probably make this unnecessary. The tunnel will constitute an operating unit by itself to insure the more certain and expeditious handling of traffic. Extensive sidings have been provided at each end for the making up of trains and it is considered that it will be practicable to dispatch 200 trains per day each way without confusion. It is therefore not likely that the demands of traffic will ever require a larger tunnel.

The open country work was estimated at $90,000 a mile exclusive of electrification. It is true that the North Bank road had cost over $100,000 per mile, but this was partly due to conditions that did not apply to the present work. The North Bank construction fell in a period of enormously inflated prices of material and labor which increased the cost of construction work of all kinds from 25 to 50 per cent. Engineers have since estimated that under normal conditions the cost of this work would have been much less than it was.

The tunnel was estimated to cost $200 per lineal foot or $1,056,000 per mile, an estimate that was justified by previous experience both in this country and abroad. By many it was feared that the great length of the tunnel would increase its unit cost, and certain elements were undoubtedly increased from this cause. But this increase was more than offset by other causes. The magnitude of the work justified the installation of a very perfect and elaborate plant by which great economies were effected. Certain parts of the work, like the railroads built to reach the working shafts as well as the shafts themselves, are not properly chargeable to the work, for their construction has been justified by other reasons—the roads by their use as logging roads, and the shafts by the water-power that they have made possible of development. But most important of all has been the great familiarity with the details of the work and the skill developed in executing it resulting from its long continuance. This is shown in the fact that the rate of progress at the headings during the last year of the work was fully 50 per cent greater than during the first year.

The cost of the tunnel as just stated was estimated from past experience by established methods long in use. It did not take into account possible progress already foreshadowed by inventions then but recently brought to public attention. One of these in particular, the Sigafoos Tunnel Machine, which works on the principle of pulverizing the rock by means of heavy and rapidly-delivered blows, held out the prospect of reducing the cost of rock-tunnel work to a small portion of the cost by the old methods. But owing to uncertainties as to the character of the rock and other difficulties that might be encountered, no allowance was made in the estimates for these possible reductions in cost.

If time had not been an element of importance, the cost of the work could have ben reduced by driving the tunnel from the two ends only. This would have materially lessened the cost of taking care of the water, and possibly also of removing the material of excavation. But as shafts were considered necessary anyway for

ventilation and waterpower, as explained further on, it was decided to use two of them for tunnel excavation, thus adding four headings and reducing the time of completion at least one half. Whether this saving in time and the earlier availability of the tunnel were an adequate offset to the extra cost can not be stated.

The estimated cost of construction of the entire line was therefore as follows:

Open country work, 327 miles at $90,000	$29,430,000
Tunnel, 32.25 miles at $1,056,000	34,056,000
	$63,486,000

To cover the cost of electrification, as far as it had been planned at the time, this sum was increased to $75,000,000 which was considered the minimum that must be in sight in financing the project before work should be commenced.

Although not strictly within the scope of this paper, a brief reference may be made to the means by which this sum of money was raised. As a simple business proposition at that early date, it would not command the necessary capital. The time might come when it would be a paying investment but that time had not yet arrived. Any immediate undertaking of the work must therefore be contingent upon substantial public assistance.

There were indeed many strong reasons why such assistance should be given. The State of Washington had a vital interest in the matter. It would profit immensely by a line of communication such as was proposed, not only in the general welfare of its people and the harmonizing of their interests, but in the enhancement of value of much of its own property. For example, the State forests, then considered to be worth about forty million dollars and now worth five times that sum, would certainly be increased in value by the removal of so great a barrier between the property and a large part of its market. So far as this timber might find a market in the eastern part of the State that portion of its people would benefit by the cheaper haul. The same argument applied to the far greater quantities of

privately-owned timber, and to the vast holdings of the Government amounting in all to upward of 250 billion feet. Again, the Puget Sound country stood in intimate need of the products from over the mountains. Although some of the finest agricultural land in the world is to be found on the shores of Puget Sound, its limited area and the large percentage of urban population make it necessary to rely upon the interior country which must always continue to be the garden and granary for the seaboard section. The forests of the West Side thus found their counterpart in the grain and fruit of the East Side. In 1907 the wheat product of Eastern Washington was 40 million bushels; now it exceeds 100 millions annually. The value of this product to the farmers, and thus indirectly to the State, would certainly be enhanced by close and cheap transportation to the harbors of Puget Sound.

Then there was the important highway problem. New York, Massachusetts and other eastern states were expending many millions for trunk roads through those commonwealths. Colorado and California were devoting large sums to carry roads through their mountainous districts. But where was there another State in the Union in which closer highway intercourse between sections separated by natural obstacles was so imperative and important as in the State of Washington?

All these considerations led the several counties most directly interested to vote bonds on their own account, and the State added to these enough to bring the total up to $15,000,000. The bonds were to be delivered only upon completion of the tunnel and upon condition that the road should be open to common use, upon equitable terms, by all railroads desiring to use it, and that provision should be made for efficient highway traffic through the tunnel. The bonds are now soon to be delivered to the Company and the State and county indebtedness has in reality only just begun.*

*In 1817 the State of New York (population about one million) commenced, and in 1825 finished, the Erie Canal at a cost of $7,600,000. At the date of the completion of the recent enlargement,

Although the Government had long since abandoned the policy of aid in railroad construction, the extraordinary magnitude and cost of this work and its evident public utility and close relation to Government business led it to make an exception in this case. To and from no other ports of the United States are Government shipments of all sorts greater than they have become at Tacoma and Seattle. The timber holdings of the Government tributary to the Sound were of enormous extent and would be a perpetual source of revenue. Their value, both to the Government and to the people who use the lumber, would be enhanced by any reduction in the cost of transportation. The same considerations that led the Government to open the Columbia River to navigation at an outlay of many millions (the State of Washington also aiding) applied with even greater force to opening a route through these mountains whereby the ports of Puget Sound might be made as accessible from the interior as are those at the mouth of the Columbia. The Government therefore agreed to duplicate the State contribution, its appropriation to be payable upon the opening of the entire line to traffic and subject to the perpetual requirement of common user. The Government also gave the Company the free use of such timber on the reserves as was needed in the construction of the tunnel and liberal water power concessions on the public domain and the Columbia River for the electrification of the system and its branches.

But the main feature in financing the project has been the co-operation of the several great railway systems affected by it. Such co-operation had in fact become the fashion to some extent in this part of the country before the project began. The Great Northern and the Northern Pacific had jointly built the North Bank

the Canal had cost the State nearly $200,000,000, an expenditure greater in proportion to population than would be the entire cost of the Cascade Tunnel to the present population of the State of Washington. And yet it is certain that the enlarged Erie Canal can never be as beneficial, relatively, to the people of New York as will be this new railway system, organized and controlled as it is, to the people of our own State.

road. These railroads and the Milwaukee and Union Pacific had likewise co-operated extensively in the building of their systems betwen Seattle and Portland. It was therefore by no means an innovation when the Great Northern, Northern Pacific, Burlington, Canadian Pacific, Milwaukee, Union Pacific and North Coast jointly guaranteed the $45,000,000 required in addition to the State and Government aid. The arrangement found something of a precedent in the Terminal Railway Company of St. Louis which owns and controls the terminal facilities of that great city. The use of these facilities is open under definite conditions to all railroads entering St. Louis, and the stock of the Company is largely owned by the co-operating roads. In like manner, the P. S. & I. E. is a great terminal system to all eastern lines seeking access to Puget Sound and was organized to overcome natural obstacles to such access which were too great for any one company to overcome singly. In fact, the name, Puget Sound Terminal Railway, would have been more strictly appropriate than the name adopted.

It is scarcely necessary to remind you that every alternative proposition was considered which might secure the advantages desired without so large an outlay of money. In particular it was urged that electricity afforded a better solution of the problem, by building on very steep grades in a comparatively direct line over the mountains, using gravity on the down-bound traffic to generate electricity for use in up-bound traffic instead of wasting the energy in brake friction. The effect of such a system would be to balance up-grade traffic against down-grade, much the same as a cable balances an up-going against a down-going car, leaving only friction and similar resistances to be overcome, and practically reducing grades, however steep, to a dead level. For several years a line built on this principle, with grades as steep as 4 per cent, had been in operation in the Alps. But while theoretically very attractive, there were many reasons why it would fall short of the desired results in the Cascades. The topography is such that no open air line could

be found which would be much of an improvement over those now existing. By the use of very steep grades the existing lines might be shortened from five to fifteen miles; but this would be practically all. Moreover such excessive grades would require the division of trains into small sections and the necessity of making and breaking the regular trains at the two ends of the portage. A degree of danger would always be involved in such steep grades. Then there were the serious winter conditions to be met. It was remembered that on one occasion traffic had been effectually blocked for a period of three weeks during which Puget Sound was almost isolated from the East. Electric operation of such a line at such a time would be possible only by a continuous snow-shed from one side of the range to the other. All these drawbacks robbed the proposed system of many of the advantages which were apparent upon superficial survey.

It was also urged that the interest on the cost of the work would more than pay the extra expense of lifting freight over the range, as compared with the costly low-grade routes, and that it would be a better proposition financially to use sufficient extra motive power on the existing lines than to construct a new line at such great cost. But it was pointed out that, even if the argument itself were sound, it was certain never to be applied. With lines from the whole Inland Empire leading down the Columbia to the seaboard, it would be the veriest folly to add enormously and unnecessarily to the cost of the hauling of freight by taking it over the mountains. Building upon the expectation that the railroads would show any such generosity towards Puget Sound would evidently be building upon a foundation of sand.

In short, all these measures were mere paliatives, —solutions that did not solve. What the people wanted was not some improved method of SCALING *the wall; they wanted the wall—with its steep grades, sharp curves, deep snows, torrents, landslides and avalanches—* GOTTEN RID OF ALTOGETHER.

Would it pay? If the North Bank road, planned by the most astute railroad genius of the time, was a paying

proposition at $40,000,000, would not this proposed road, open to use by every railroad seeking access to Puget Sound, be a better paying proposition even at a cost of $60,000,000? Every consideration that makes the Columbia gateway through the Cascade Mountains of importance in the transportation problems of the Northwest, would apply with greater force to an equally good opening through the mountains to Puget Sound. In the form which this enterprise has taken, all parties thereto have unquestionably made profitable investments. The State and Government will be fully reimbursed for their outlay by the direct enhancement in value of their own property and by the general benefit accruing to the people, to say nothing of the important considerations of public policy involved. To the several co-operating railroads the new line is virtually a low-grade alternative route relieving each of the mountain climb for much of its heavy freight traffic, and in most cases materially reducing mileage. By means of this co-operation the new road will have business enough from the start to place it on a paying basis, whereas it might not be justified for years to come by even the entire business of any one road alone. On the other hand the contribution of each road is so small that it will of itself prove a paying investment by eliminating the costly haul over the mountains, and in other important respects.

Returning from this brief digression into the financial aspect of the project, I will now take up its great distinguishing engineering features—the tunnel under the Cascades and the electrification of the system. The tunnel, as already stated, is a trifle over thirty-two miles long. The very mention of this figure caused the project to be scouted and ridiculed when first brought to public attention, and yet it was by no means so extraordinary or unprecedented as many were inclined to believe. While actually the longest tunnel at that time or since undertaken, it was not so much greater as to make it appear impracticable on that account. Already three tunnels had been built in the Alps aggregating thirty miles in length. Another was at that time proposed and

has since been built over sixteen miles long. The aggregate length of the large tunnels under the Alps and neighboring ranges already built or under construction is more than 100 miles. There were no very long railroad tunnels at that time in this country (the Hoosack tunnel nearly 5 miles and D. N. W. & P. tunnel under James Peak, Colorado, 6 miles, being the longest), but the aggregate length of the railroad tunnels of the United States and Canada ran up into the hundreds of miles. It may also be mentioned that a tunnel had already been built of greater length than the one here considered, viz: the Croton water supply tunnel for the City of New York, which is thirty-three miles long, though of course very much smaller in section (14x14 feet) than a railroad tunnel. The many tunnels in and around the City of New York exceed in length and vastly exceed in cost the Cascade Tunnel. Among projected works of this character the proposed tunnel under the English channel involves far greater difficulties and cost; yet it has been seriously considered and work was actually begun but was stopped by the British government for military reasons.

The Cascade Tunnel presented no unusual problem except that of the magnitude of the work. Its two portals were perfectly accessible by an established railroad. The excavation of intermediate sections by means of shafts sunk from the surface was only applying mining methods which are in use the world over. The whole project was simply that of a vast amount of tunnel excavation involving no difficulties with which engineering experience was not entirely prepared to cope.

The electrification of the system likewise presented few features with which engineers were not already familiar on other works. The magnitude of the work alone entitled it to especial distinction, unless we include the novel feature of utilizing the tunnel itself and the several shafts leading to it for power development.

The numerous papers already submitted to the Society upon various phases of the work, make the subject tolerably familiar even to those members who have not

been personally connected with it. I will, however, for completeness of this record, go into the matter somewhat *in extenso.*

* * * * * * * * *

Summarizing the foregoing description, the main features of interest connected with this work and its execution are as follows:

(1.) Owing to the great magnitude of the work and the difficulty of covering it satisfactorily in the terms of a contract, it has been carried out by the Company direct. The outcome has shown that it has been done quite as expeditiously and economically as it could have been done by contract and with the avoidance of all contract complications.

(2.) Work was prosecuted from the two ends and two intermediate shafts, located in the valleys of Icicle and Deception Creeks as shown on the profile. The bore was thus at first driven simultaneously from six separate headings. The longest section, that between the two shafts (13 miles), required a little less than six years for completion. The other sections were finished more than a year in advance of this, and the full completion of the work, including lining, roadbed, lighting, power, ventilation, etc., followed closely upon the final opening of the last section.

(3.) Railroads were built up the valleys of Icicle and Deception Creeks to the working shafts for use in construction, but the cost of these roads, as already stated, has been fully offset by their use as logging roads, apart from their purpose in construction work.

(4.) The ventilation of the tunnel is accomplished by means of the two working shafts and a small shaft sunk approximately midway between them. Powerful fans force the air down through the main shafts and up through the central shaft expelling it from the tunnel at the center and the two ends. The relatively high temperature of the tunnel due to natural warmth and the heat from lighting, as compared with the mountain temperature at the supply shafts, tends to desicate the incoming air and absorb the moisture which in some places

percolates through the lining. Owing to the electrical operation of trains and the consequent absence of smoke, a moderate change of air keeps the tunnel entirely pure.

(5.) The tunnel is lighted by a vast number of incandescent lights whose effect is strengthened by the light color given the walls. An elaborate system of switches is provided. Working parties can light up any section desired, and trains, by means of automatic running contacts, carry with them a zone of light extending one-half mile in advance of the locomotive and one-fourth mile in rear. The tunnel is really a large, well-ventilated, warm and brilliantly-lighted gallery and there will be no necessity for lighting passenger cars or closing windows as in passing ordinary tunnels.

(6.) Commodious side tracks have been provided in the vicinity of the two main shafts.

(7.) Provision has been made in the form of permanent cement-lined channels between and under the tracks to carry 50 cubic feet per second of water eastward from a shaft to be opened at the crossing of the Wenatchee River, 20 cubic feet westward from the Icicle Creek shaft, 30 from the Deception Creek shaft and 50 from a shaft to be sunk at Foss Creek near Skykomish. These shafts will admit to power plants in the tunnel the water from the creeks above and will develop altogether more than sufficient power for the operation, lighting and ventilation of the tunnel.

(8.) The entire route is to be operated by electricity, the power, in addition to that just specified, being derived from the Wenatchee River, Chelan River and Kettle Falls on the Columbia. The Company has acquired exclusive right to the development of the first two powers and partial right to the second. The Wenatchee River has been regulated by a high dam about six miles below Wenatchee Lake to a uniform flow of 2500 cubic feet per second and an effective head of 400 feet has been developed in the Tumwater Canon a short distance below. The new plant absorbs the Great Northern plant completed in the spring of 1909 for moving trains through the old Cascade tunnel. Lake Chelan, by controlling

works giving it a maximum fluctuation of 30 feet, has its flow regulated to a uniform output of 2500 cubic feet per second, and an effective head to the Columbia of 400 feet. Altogether the Company's power rights, developed and undeveloped, amount to over 300,000 horse power. They will be used not only to operate the main system but the extensive network of branch lines ramifying in all directions, particularly through the grain belt. The net annual value of these powers to the Company will be not less than $5,000,000.

Some reference should be made to the means of fulfilling one of the conditions of the local contribution of fifteen millions dollars—viz: That the tunnel should offer a means of highway communication across the range. The scheme worked out has already received the popular name of the "Mountain Ferry" and, briefly, consists in transporting vehicles and equestrians through the tunnel by train. The Company has so far provided a special service for this work consisting of a light locomotive and ten cars especially equipped for the purpose. Each car is long enough to receive one six-horse team and wagon or two single teams and wagons or two large automobiles. Ingress and egress are through doors in the ends of the cars. The brakes and coupling devices are operated by electricity under control from the locomotive. Broad capacious loading platforms have been built with the ground in rear graded up to an easy approach. For each car of the train there is provided in front of the platform a turn table, electrically operated, for the purpose of swinging the ends of the cars to the platform. Unloading and loading can take place simultaneously with all the cars and the operation is simpler and more expeditious than with the most perfectly equipped ferryboat. A few experimental trips thus far made show that this process can easily be accomplished in five minutes. As the trip through the tunnel can be made with the greatest ease in not to exceed 45 minutes, and if necessary in 30 minutes, it is anticipated that a round trip every two hours will prove a perfectly practicable service. It is probable that two or three such trips daily will meet

present requirements.

This transfer of 32 miles carries vehicles beyond all danger of snow blockades on either side and makes travel practicable in winter as well as summer. It accomplishes in one hour without effort what would otherwise take at least two days of heavy work over the mountains, even when the season permits the trip to be made at all. The charge for this service, which must be approved by the Railroad Commission of the State, is based upon the actual cost of operation, including a proper proportion of maintenance and fixed charges, and must not exceed such cost by more than 10 per cent. It is only a small fraction of the expense involved in loss of time, forage and wear and tear of a trip over the range, even if made under the most favorable conditions.

Great interest is felt in the influence of the new route upon the movement of freight, and some of the results can be predicted with a good deal of certainty. To illustrate the subject more fully the following tables have been prepared. Some of the figures are approximate only, being made up from general information and not from official profiles, but all are accurate enough for purposes of comparison. The figures for adverse gradients on the Milwaukee in Table I have been reduced to the Spokane datum, although the eastern terminal point on this line is taken at Tekoa, both in the tables and in Plate II of profiles. Tekoa is 33 miles southeast of and 727 feet higher than Spokane.

These tables indicate the following traffic arrangements which seem pretty sure to come to pass.

Through freight to and from the east over the Great Northern, Northern Pacific and Burlington will largely be routed over the new line.

Practically all business of the Great Northern will use the new line between Leavenworth and Skykomish. The old distances from Leavenworth and points east on that line will be shortened 25 miles to Everett, Bellingham and Vancouver, 39 miles to Seattle and 50 miles to Tacoma. The saving in gradient will be 2166 feet.

The advantage to Puget Sound traffic of the Canad-

TABLE 1

SPOKANE TO PUGET SOUND BY DIFFERENT RAIL ROUTES

Names of Railroads	Distances in Miles from Spokane to				Total adverse gradient (Seattle)	
	Seattle	Tacoma	Everett	Bellingham	West Bound	East Bouud
Northern Pacific	400	396	433	497	3520 ft.	5400 ft.
Great Northern	339	379	306	370	3543 "	5406 "
Chicago, Milwaukee & St. Paul	325	345	358	422	3655 "	5518 "
Union Pacific (via Portland)	610	572	643	707	1850 "	3730 "
Spokane, Portland & Seattle ("North Bank") (via Vancouver, Wash.)	548	508	581	645	1108 "	3058 "
Puget Sound & Inland Empire	359	388	340	404	375 "	2238 "

TABLE 2

TRAFFIC RELATIONS OF NEW ROUTE NOT SHOWN IN TABLE 1

Names of Roads and of Initial Points Considered	Old and New Routings	Distances From Points in Column 1				Saving in gradient via P. S. & I. E. to Seattle
		Seattle	Tacoma	Everett	Bellingham	
Canadian Pacific (Dunmore Junction)	Via old line thru Vancouver, B.C.	995	1033	962	898	
	Via new line thru Spokane	863	892	844	908	5200 ft.
Great Northern (Leavenworth)	Via old line	142	182	109	173	
	Via new line	103	132	84	148	2166 "
Chicago, Milwaukee and St. P. (Beverly)	Via old line	156	176	189	253	
	Via Columbia River and new line	184	222	163	227	2695 "
Union Pacific (Mouth Snake River)	Via old line thru Portland	403	365	436	500	
	Via Columbia River and new line	267	296	248	312	170 "

ian Pacific may be seen from the fact that the distance from Dunmore Junction (where the Spokane branch leaves the main line) to Seattle is 132 miles shorter than via the old line through Vancouver, B. C., and that the saving in vertical ascent is about one mile, while at the same time the tremendously steep gradients on some portions of the main line will be eliminated. Even to and from Vancouver itself, in spite of the shorter distance by the old line, freight traffic largely and passenger traffic to some extent can be advantageously routed by the new line.

The principal benefit to the Milwaukee will be from Beverly (Columbia River) west. East of that point the gradients are under 0.4 per cent, but from Beverly west the advantage of using the new line will be considerable. The Milwaukee and Union Pacific have jointly built a line up the Columbia Valley from the mouth of Snake River to the P. S. & I. E. above Wenatchee. From Beverly to Everett by this route as compared with the Milwaukee main line, the gain is 26 miles in distance and 2700 feet in grade.

Perhaps the most important change is that affecting the Union Pacific and the traffic to its vast tributary territory in the southeast. From Pendleton (see map), which is the starting point over the Blue Mountains, to Everett on Puget Sound, the distance via the new route is 141 miles shorter than via Portland, while the adverse gradient is actually less. The Union Pacific is now constructing a line through the Snake River canon above Lewiston whereby the climb over the Blue Mountains will be eliminated, with a saving of gradient of about 3600 feet. A bridge has been built across the Columbia, just below the mouth of the Snake, and the distance from this point to Everett is 188 miles less than via Portland.*

It was in the year 1909 that the agitation for this

*Draw on the map a straight line from Everett to the mouth of Snake River and note how little this new route departs from it. The distance to tide-water at Everett or Lake Washington is only 18 miles farther than to Portland and is 62 miles less than to Willapa Bay at the mouth of Nasel River.

important work began—the year in which the North Bank and Milwaukee roads were completed and Seattle's great Fair made the world better acquainted than ever before with the resources of the Northwest Country. Since that date the development of this region has been so rapid that today, on the eve of opening this splendid new route, it is estimated that, in spite of the heavy diversion of traffic from the old lines, the latter will still have more business to handle than before the project began. In fact, certain of them are about to commence very extensive and costly improvements. The Northern Pacific will lower its tunnel under the Cascades sufficiently to eliminate all gradients in excess of about 1 per cent, and the Milwaukee will build its long-contemplated tunnel under the Snoqualmie Pass, reducing the gradients on either side, and will alter its location near Ellensburg so as to cut out a large part of the sag at that point with gradients under 0.4 per cent.

As the situation is now shaping itself, Puget Sound will hereafter enjoy every advantage in railroad transportation that the Lower Columbia has, while her spendid harbors and her stragetic position commercially give her vastly superior maritime advantages. The agricultural and seaboard sections of the State of Washington are as effectively united, in regard to rail and highway communication, as if the Columbia River flowed through the range where the tunnel now is. The completion of the work will mark an era in the industrial development of the State. One of the most satisfactory features of the enterprise is its joint organization among the several railway systems terminating on the Northwest Coast, whereby competition is tempered by co-operation, and immense advantages are secured to each without any unreasonable sacrifice. Not less a subject for congratulation is the fact that the promoters of the project were not frightened by its magnitude nor led by timid counsels to adopt some less effective plan. They now have the best that the situation admits of, for it will be physically impossible ever to find a better than the Cascade Tunnel Route.