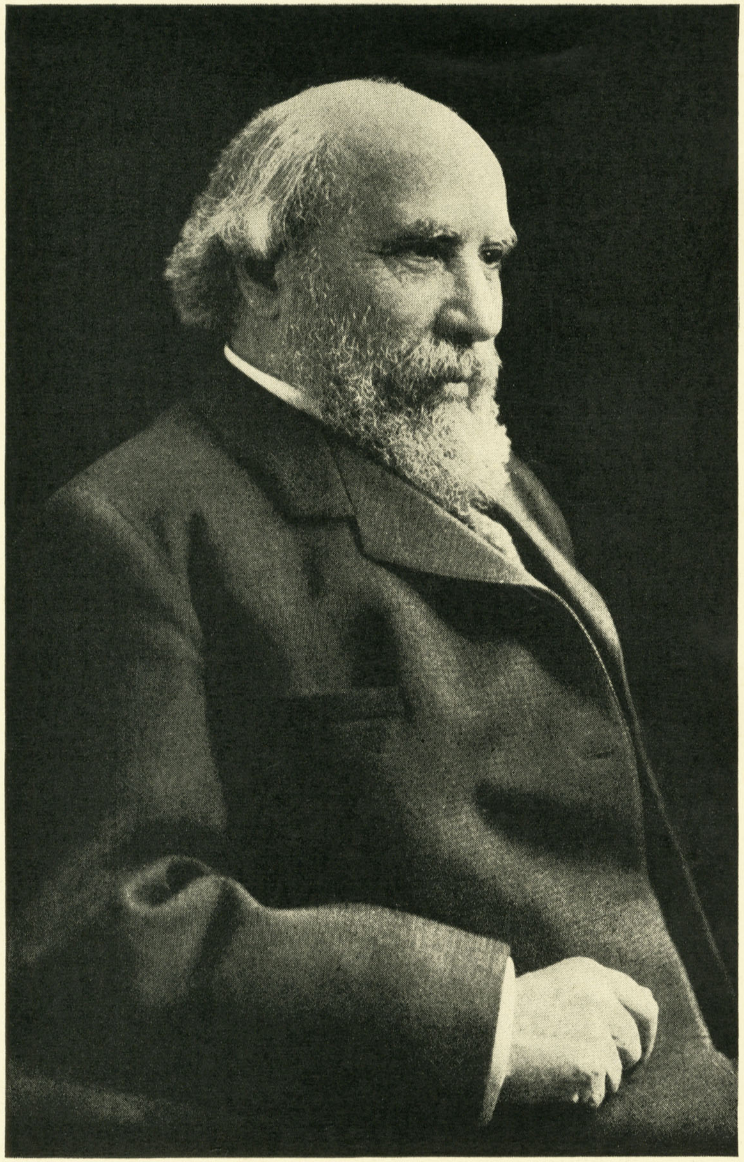
New Cascade Tunnel

Great Northern Railway



THE EMPIRE BUILDER

The Cascade Mountain Crossing *of the* Great Northern Railway

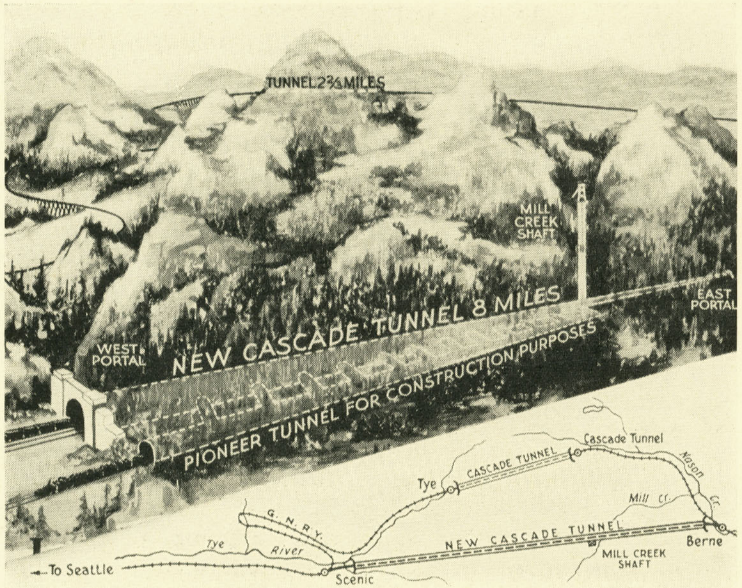
"When the Pacific extension has been completed, your company will have a continuous rail line from Lake Superior, St. Paul and Minneapolis to the Pacific Coast, shorter than any existing transcontinental railway and with lower grades and less curvatures. . . . The policy of improving the property, which has given such good results in the past, is still being followed."

James J. Hill in Great Northern Railway annual report for 1890

The physical advantages mentioned above still prevail and the completion of the longest railway tunnel in the Americas is proof that the policy of improving the property is still being followed.

On Thanksgiving Day, 1925, the Directors authorized the most extensive improvement project ever undertaken on the Great Northern. It involved the construction of a long tunnel piercing the backbone of the Cascade Range, the relocation of all but 7 miles of the old 50-mile line between Peshastin and Scenic, the elimination of nearly 12 miles of tunnels and snow-sheds and the electrification of 75 miles of road between Appleyard (near Wenatchee) and Skykomish. This program is now completed at a cost of $25,000,000.

When the Pacific extension was begun at Havre in 1890, the outstanding engineering problem consisted of finding the best route across the Cascade Mountains. John F. Stevens, in December, 1889, had discovered Marias Pass, which gave the Great Northern by far the best Rocky Mountain crossing in the United States north of New Mexico, and immediately thereafter James J. Hill assigned the Cascade problem to him. Mr. Hill's instructions were to choose a location far enough north to serve a territory not already reached by any railway and to get as direct a line to Puget Sound as possible with favorable distance, grades, and curvature. At the end of the season of 1890 Mr. Stevens recommended a route through the pass now used and called in his honor Stevens Pass. The line in 1892 was carried over the summit on a series of switch-backs, but a tunnel 2⅝ miles long was soon after-



The new Cascade Tunnel and the old line abandoned January 12, 1929.

wards built and has been in use since 1900. A notable feature of the Stevens Pass route was the fact that by building a longer tunnel the line could be greatly improved in the future, and attention was called to several possible tunnel sites which could be connected up with the original line. Such an improvement was being thought of in 1916 and 1917 when studies were made of the various possible tunnels and four ranging from 6 to 17 miles in length were seriously considered. The World War intervened at that time and the plan was put aside. In 1921 the subject was revived, location surveys were begun, and the matter received more or less continuous attention until the line just completed was tentatively adopted in the spring of 1925. The tunnel as built is 7.79 miles long; it is absolutely straight from end to end and is on a grade of 1.56 per cent descending from east to west. It cost $14,000,000.

BUILDING THE LONG TUNNEL

A contract covering the work was entered into with A. Guthrie & Company on November 27, 1925, and two weeks later actual tunneling operations began. The construction program was developed by J. C. Baxter, while the men who carried out the plans were R. F. Hoffmark and W. E. Conroy. The desire of the Railway Company to complete the project in three years made it necessary to attack the excavation at several different places for, obviously, only a limited amount of man-power and machinery could be brought into action through the east and west portals alone. The long tunnel crosses under the deep valley of Mill Creek at a point about 2½ miles west of the east portal. This crossing lent itself to the purpose of opening two additional working faces. From Mill Creek, directly above the projected tunnel line, a shaft was sunk 622 feet to the level of the proposed tunnel, affording an additional face for attack eastward, and another westward, making in all four primary faces from three main camps.

A pioneer tunnel 8 feet high by 9 feet wide, located 52½ feet south of the main tunnel, was driven eastward from the west portal and westward from the Mill Creek shaft. The crews engaged on this work met on May 1, 1928, the final blast being fired by President Coolidge from Washington. The com-

Cross-cut from Pioneer Heading

The Mucking Machine

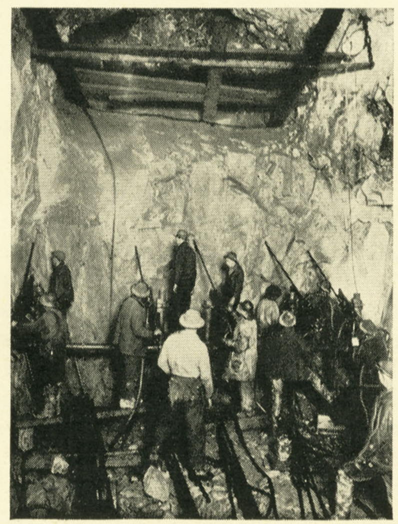
paratively small pioneer tunnel could be driven much more rapidly than the main tunnel. As it advanced, cross-cuts were driven to connect with the route of the main tunnel at intervals of about 1500 feet. This made accessible as many as eleven working faces simultaneously, and made possible the employment at one time of 1793 men on the tunneling operations.

Through the pioneer tunnel also were operated the trains carrying workmen and supplies and the rock excavated from the faces reached through the cross-cuts. Through it were run pipes which furnished compressed air for driving the drills and shovels, and the electric power lines which operated other machinery and lighted the workings, and through it was forced the air for ventilation. The pioneer tunnel not only served to drain the water from the main tunnel during construction, but will continue to do so permanently.

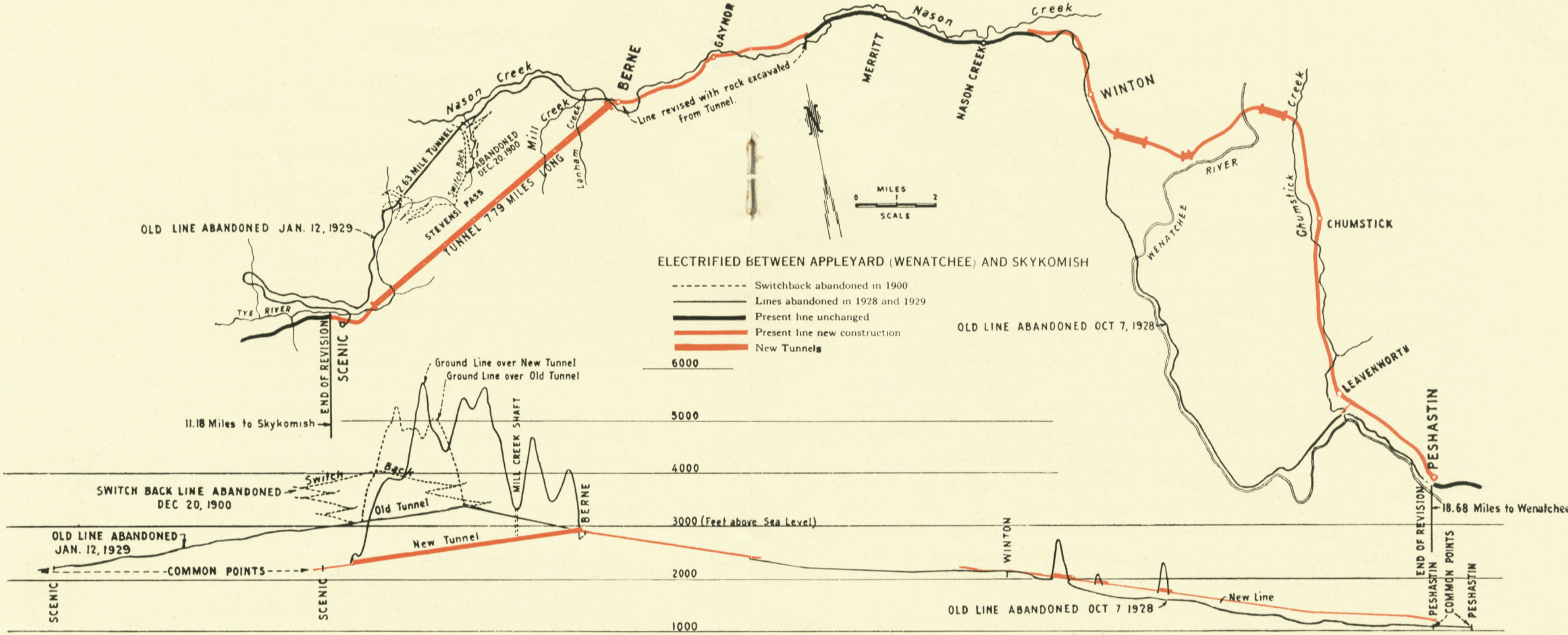
Practically all of the work was done by machinery and skilled workmen. Electricity, compressed air, and dynamite applied with the utmost skill through the most modern machinery characterized the whole project. Several world records for speed in tunneling were made, the tunnel having been completed in about half the length of time previously required for a job of such magnitude. Solid granite was encountered practically throughout, but the tunnel is entirely lined with concrete for positive protection against falling rock.

Typical Round at Pioneer Tunnel Face

What took place in one pioneer heading is typical of the activity at all of the many faces. The cycle of the various operations which followed in regular sequence from the moment that the drills were started against a new face of rock until they were again ready to drill the succeeding face constituted a round, each round accomplishing an advance of 8 feet. Five rounds in twenty-four hours was the objective which was considered a perfect score. This would be a total progress of 1240 feet in a month. A loss of one minute per round in the pioneer would mean a delay of 40 hours in the completion of the tunnel, so the great problem was to cut down delays. In October, 1926, the drillers progressed 1157 feet, or 93.3 per cent of a perfect score. A typical cycle for one round in the pioneer tunnel consumed about 4 hours and 40 minutes in its various parts. For instance, on August 25, 1926, at 7:10 in the morning the shifter threw in the firing switch detonating 195 pounds of 60 per cent gelatin. For 27 minutes approximately 6000 cubic feet of air per minute were discharged at the face to clear away the gases so men could return to work. During the following 38 minutes the shift of 16 men brought up the mucking machine, cleaned up the fly-rock and replaced electric light and compressed air lines. Then for 1 hour and 22 minutes



Drilling on last barrier in main bore.



Map and Profile of Old and New Lines between Peshastin and Scenic

the mucking machine loaded out the round in 50 cubic feet capacity cars at the rate of 3 minutes per car. After the blasted rock was removed, 38 minutes were occupied in taking the mucking machine back to a place of safety and bringing up the drill carriage on which were mounted 4 drills each manned by a driller and his helper. The drilling time for 28 holes, which averaged 8½ feet in depth, occupied the next hour and 17 minutes. During the drilling time a wooden body insulated powder car was brought to the face with the exact amount of dynamite and primers required for one round. While part of the drill crew removed the drill carriage the balance of them loaded the holes, this operation requiring 13 minutes. When the holes had been loaded and the leads of the electric blasting caps connected up the electrician who was a member of the drifting crew tested the exploder circuit and the firing circuit separately, after which the shifter who was the last man to leave the face connected the exploder circuit to the firing line. As he retreated in the tunnel he closed a safety switch in the firing line about 300 feet from the face and when he had reached the next cross-cut where the locked firing switch was located he unlocked it and fired the blast at 11:50 A. M. a total elapsed time of 4 hours and 40 minutes.

Following this same general plan of close synchronization all the other operations at the tunnel went on continuously day and night, including Sundays and holidays, and in spite of

The Mucking Machine

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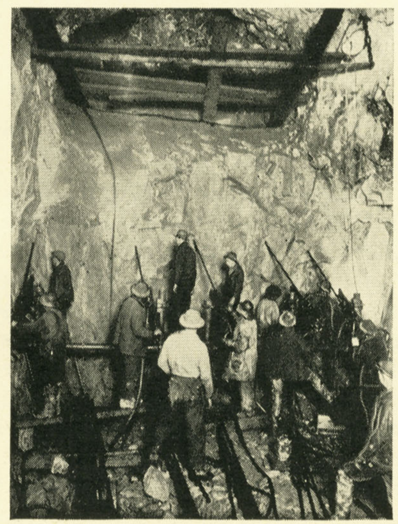
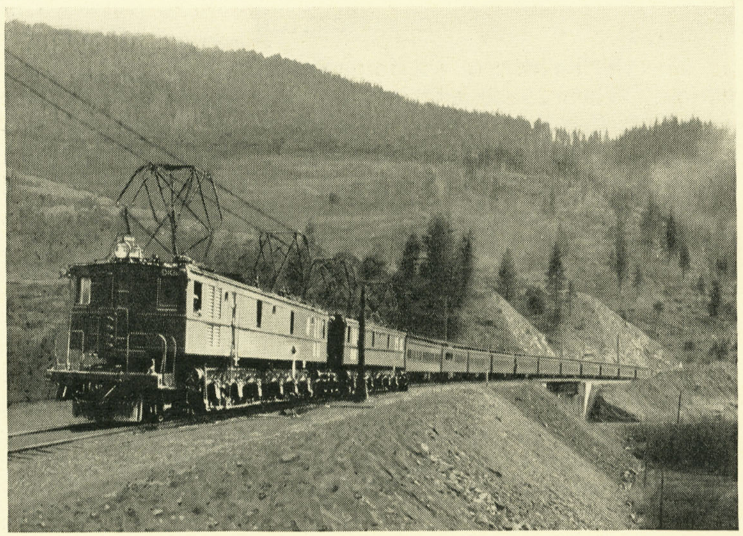


Drilling on last barrier in main bore.

nating current and direct current systems. Alternating current is used for transmission from the source of power to the locomotives and direct current is used in the traction motors. The alternating current transmission system has the advantage of minimum power losses, minimum copper requirements, and strong overhead construction at moderate cost. The locomotives themselves carry the transformers and motor-generator sets which change the high tension alternating current to low tension direct current. The type of traction motor which is most rugged in construction, most economical to maintain, and most flexible to operate is thus made available. The combination gives a self-contained locomotive with an unlimited range of speed capable of developing full capacity at any speed without waste of power.

Power is obtained from the Puget Sound Power & Light Company and comes from three general sources: first, the Power Company's system on the West Coast, second, Lake



Electrical operation on the Chumstick Line.

Chelan, and third, Tumwater Canyon. These sources are all connected up and give unusual assurance of continuity of supply. Two transmission lines are used to protect against interruption of power supply through accident to one of the lines.

SIGNIFICANCE OF IMPROVEMENTS

Completion of the new tunnel and 34 miles of easy, high speed track replacing 43 miles of steep and winding mountain line, together with electrification of 75 miles of road, mark a great step forward in bringing the West Coast closer to the East. These improvements eliminate from operation the problems incident to crossing a mountain barrier, and will expedite the flow of commerce and contribute to the comfort of travelers, as well as save time. Trains will cover the distance between Seattle and Spokane on shorter schedules than ever before.

While these savings and advantages over a period of years will repay the cost and carrying charges of the improvements, the public as well has a vital and immediate interest in these and all similar improvements in the Nation's transportation facilities. Such improvements constitute an elemental achievement that fixes shorter distances and lower grades, and these in turn set up new standards of performance, resulting in benefit to all who are affected by the advancement of transcontinental transportation.

Completion of this magnificent three-fold improvement project is a source of the greatest satisfaction to the Directors and Officers of the Railway Company, because it brings the Cascade Mountain District up to the standard of operating efficiency on the other divisions and realizes a cherished ideal of James J. Hill, in whose mind the Great Northern Railway, as it is to-day, was conceived.

Interesting Facts Concerning the New Cascade Tunnel

Comparison of old and new lines between Peshastin and Scenic

	Old Line	*New Line*	*Favorable to New Line*
Length of Line	49.98 mi.	41.10 mi.	8.88 mi.
Degrees of Curvature	5683	2009	3674
Summit Elevation	3383 ft.	2881 ft.	502 ft.
Grade in Tunnel	1.69%	1.56%	0.13%
Length of Maximum Grade	24.63 mi.	6.37 mi.	18.26 mi.
Rise Westbound	2410 ft.	1889 ft.	521 ft.
Fall Westbound	1402 ft.	881 ft.	521 ft.

Tunnels and Snow-Sheds Eliminated

Tunnels.........19,332 ft. Snow-Sheds.....39,870 ft.

Pioneer Tunnel

Work begun at Scenic December 14, 1925
Completed May 1, 1928
Length......28,292 ft. Size......8 ft. high x 9 ft. wide
Cubic yards excavated 94,900

MAIN TUNNEL

Excavation

Work begun at Scenic March 6, 1926
Completed December 8, 1928
Length......41,152 ft. Size......18 ft. wide x 25 ft. high
Cubic yards excavated 839,700

Concrete Lining

Work begun at Scenic October 12, 1926
Completed December 24, 1928
Finished size...............16 ft. wide x 21 ft. 5 in. high from top of tie
Length......41,152 ft. Average thickness....2 ft. 9 in.
Cubic yards concrete placed..........262,564

Accuracy of Instrument Work

Error of closure between East Portal and Mill Creek:
Alignment..........0.23 ft. Elevation........0.20 ft.
Distance..........0.90 ft.

Error of closure between Mill Creek and West Portal:
Alignment..........0.64 ft. Elevation..........0.78 ft.
Distance..............1.00 ft.

Tracklaying and Ballasting

Tracklaying began December 25, and was completed December 30, 1928.
Ballasting of track began December 29, 1928, and was completed January 6, 1929.

BEST RECORDS

Excavation

Great Northern Railway CASCADE		*Canadian Pacific Railway* CONNAUGHT	
Pioneer Tunnel—8 x 9 ft.		*Pioneer Tunnel—6½ x 8 ft.*	
1 day	52 ft.	1 day	37 ft.
2 days	90 ft.	2 days	68 ft.
3 days	140 ft.	3 days	98 ft.
1 month	1157 ft.	1 month	932 ft.
Main Tunnel		*Main Tunnel*	
Enlargement from Center Heading		Enlargement from Center Heading	
1 month	1220 ft.	1 month	1030 ft.

COMPARISON OF LONG RAILWAY TUNNELS

Name of Tunnel	*Length*		*Width*		*Height above Top of Tie*
*Simplon No. 1	65,734 ft.	12.45 mi.	16.40 ft.	Single Track	18.05 ft.
St. Gothard	48,983 ft.	9.28 mi.	26.24 ft.	Double Track	19.68 ft.
Loetschberg	47,685 ft.	9.03 mi.	26.24 ft.	Double Track	19.68 ft.
Mt. Cenis	42,150 ft.	7.98 mi.	26.24 ft.	Double Track	19.68 ft.
New Cascade	41,152 ft.	7.79 mi.	16.00 ft.	Single Track	21.43 ft.
Moffatt, Colorado	32,253 ft.	6.11 mi.	16.00 ft.	Single Track	22.50 ft.
Connaught, B. C.	26,512 ft.	5.02 mi.	29.00 ft.	Double Track	21.54 ft.

*A second bore (Simplon No. 2) parallel to No. 1 and of similar dimensions was completed in 1921.

All of the tunnels which are longer than the Great Northern's Cascade Tunnel are located in the Alpine region of Southern Europe.

ELECTRIC LOCOMOTIVES

The locomotive dimensions and electrical characteristics are shown in the following table:

	Single Cab LOCOMOTIVE	*Double Cab* LOCOMOTIVE
Classification	1-C+C-1	1-D-1+1-D-1
Total weight each locomotive	527,200 lb.	715,400 lb.
Weight on drivers	420,600 lb.	550,000 lb.
Weight per driving axle	70,100 lb.	68,750 lb.
Maximum rigid wheel base	15 ft. 4 in.	16 ft. 9 in.
Total wheel base	58 ft. 8 in.	78 ft. 11 in.
Total length	73 ft. 9 in.	94 ft. 4 in.
Height over pantograph, locked down	15 ft. 3 in.	15 ft. 10 in.
Number of motors	6	8
Tractive effort cont. rating	60,500 lb.	88,500 lb.
Tractive effort—starting—30% adhesion	126,180 lb.	165,000 lb.
Power at traction motors	750 Volts D. C.	600 Volts D. C.
Power at trolley	11,500 Volts, 25 cycle A. C.	


5010