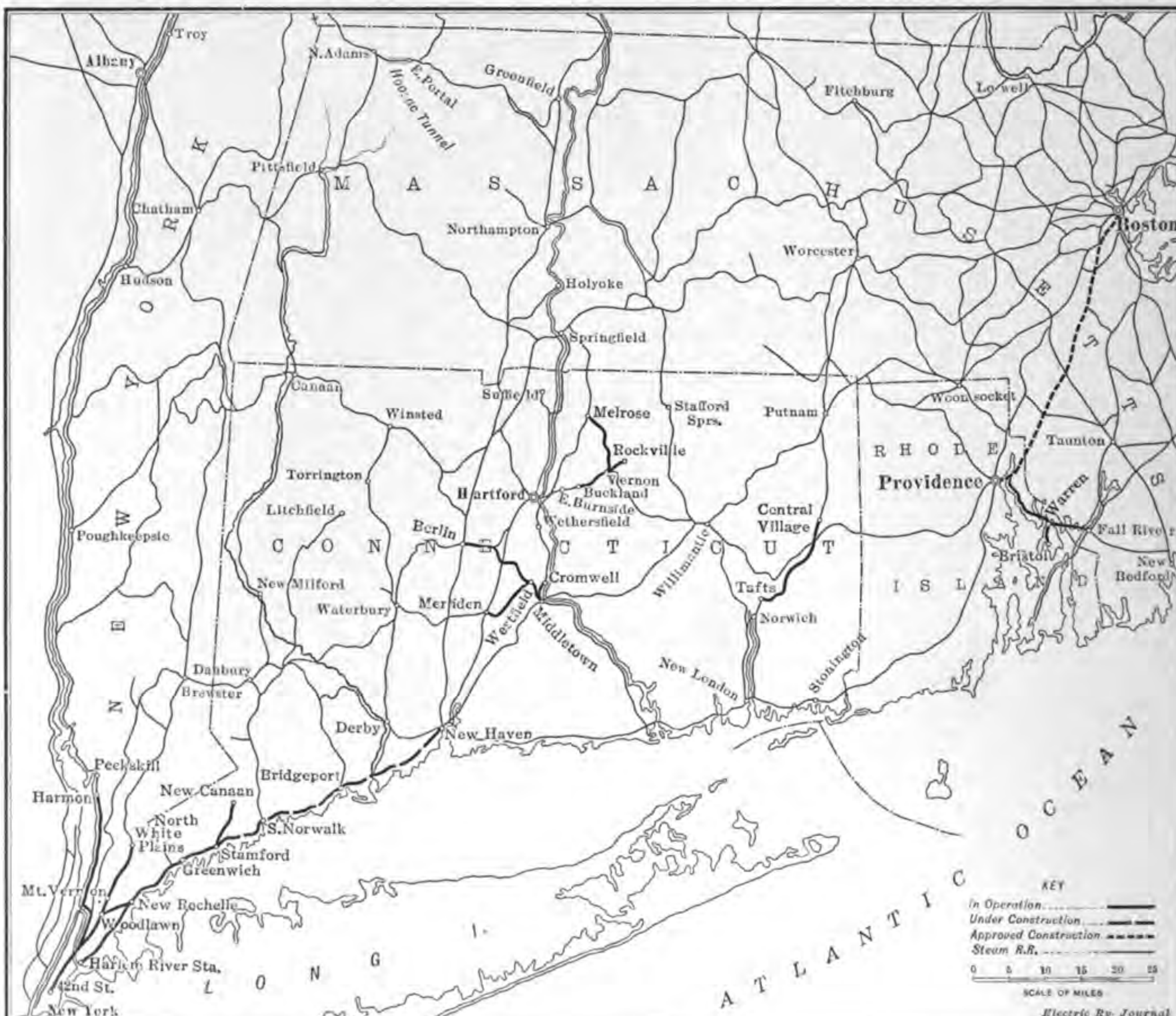
Electrification Progress in the United States

This Article Reviews the Progress in Steam Railroad Electrification from the Earlier Tunnel and Terminal Work to the Long Distance and Mountain Railway Projects Now in Hand

Steam railroad electrification, in one sense, is almost as old as the electric railway itself, for among the first lines to be electrified were the dummy roads in the suburbs of the larger cities and the shorter steam railroad branches which had become part of urban traction systems. However, as all of these installations were independent of trunk-line service they will be omitted in the following review. An earlier table and bibliography of all classes of steam records of the original equipment were presented by J. E. Muhlfeld, general superintendent of motive power Baltimore & Ohio Railroad, on Feb. 16, 1906, before the New York Railroad Club and published in the Street Railway Journal for Feb. 24, 1906. Two electric locomotives, as described in the Electric Railway Journal for Nov. 26, 1910, were added in the latter year to the original four machines named by Mr. Muhlfeld.



American Electrifications—Lines of the New York Central, New Haven and Boston & Maine Railroads

railroad electrifications will be found on page 539 of the Street Railway Journal for Oct. 12, 1907.

BALTIMORE & OHIO RAILROAD

It is an interesting coincidence that the Baltimore & Ohio Railroad which in 1828 placed in service the first American-built steam locomotive on its initial 3 miles out of Baltimore should also have been the pioneer user of heavy electric locomotives. Its Belt Line tunnel at Baltimore, comprising 7.4 miles of single track, was electrified on the third-rail system in 1895 to eliminate ferriage and give this railroad direct entrance to Baltimore. Performance

NEW YORK, NEW HAVEN & HARTFORD RAILROAD

The New York, New Haven & Hartford Railroad, which holds the lead in length of electrified track, entered the electrification field in 1895, when it equipped with electric power for d.c. overhead operation a total of 16.8 miles of single track between Nantasket Beach and Pemberton, Mass., on a peninsula about 10 miles southeast of Boston, as described in the Street Railway Journal for July, 1895. This line is operated with electricity now only in summer.

The company's first heavy interurban electrification, and

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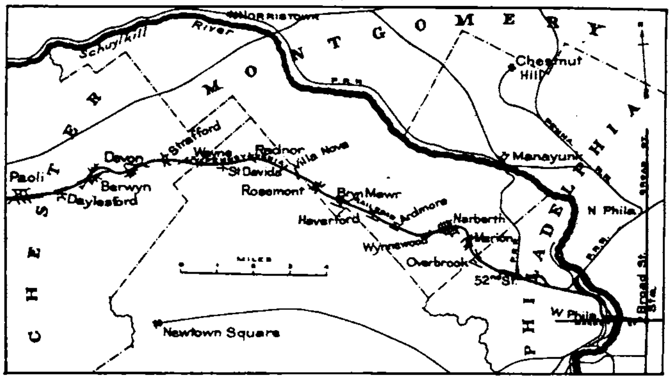
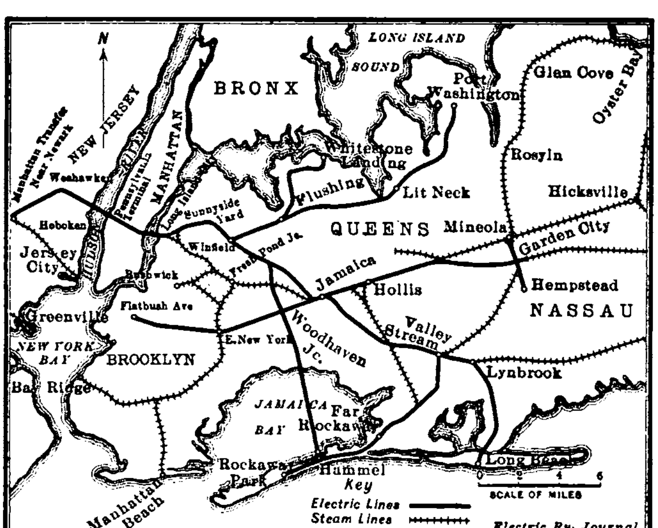
the first undertaken by any trunk line in the United States, was the equipment in 1902 of the Providence-Warren-Bristol-Fall River branch with the 550-volt d.c. simple overhead system. This Rhode Island line was described in the STREET RAILWAY JOURNAL for March 1, 1902, and its location and route are also shown in the accompanying general map of the New Haven company's electrifications.



American Electrifications—Approved Paoli Suburban Line, Pennsylvania Railroad, Out of Philadelphia

It is 38.5 miles in length, measured as single track, and consists of a double track from Providence to Warren, a single track from Warren to Bristol and Fall River respectively, sidings at Providence, etc. The service is of standard interurban character and includes the handling of baggage. Electrification of this line made it possible to give a faster schedule despite an increase in the number of stops made by local trains.

During 1907 the New Haven company added to its branch electrifications the Middletown-Berlin-Meriden and Hartford-Vernon-Melrose lines in Connecticut. The Middletown-Berlin section, 10.4 miles long, and the Middletown-Meriden section, 7.2 miles long, are of 600-volt d.c. plain overhead construction. They were electrified to give more profitable feeders for the trunk lines and to build up

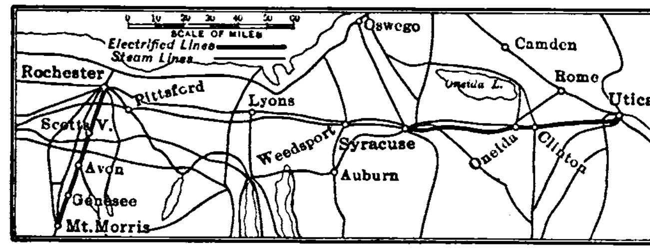


American Electrifications—Long Island Railroad and Pennsylvania Terminals

the towns served by providing connections with the local street cars. A description of the Middletown electrification was printed in the STREET RAILWAY JOURNAL for Sept. 21, 1907.

The Vernon and Melrose lines follow the tracks of the Hartford street railway system of the Connecticut Company for 2.5 miles to East Burnside, where the cars are deflected to the steam railroad right-of-way from Buckland, Manchester and Talcottville to Vernon Junction, a distance of about 16.8 miles single track. At Vernon Junction the line swings to the north and passes to Rockville and Melrose over single-track branches totaling 14.7 miles of single track. The electrification of these lines made it possible to bring passengers into the business section of Hartford and to improve the headway through the operation of single cars. This line, which is of the d.c. catenary type, was described in the issue of the STREET RAILWAY JOURNAL for Dec. 7, 1907.

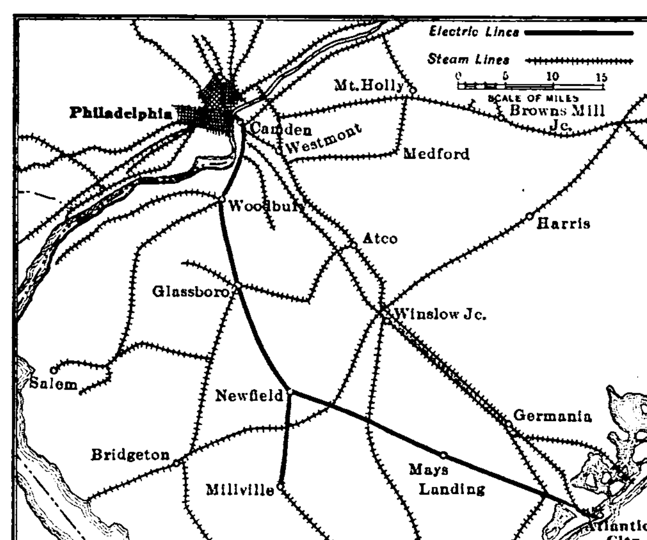
In addition to these d.c. electrifications, the New Haven



American Electrifications—Erie and West Shore Railroads, Central New York

company's tracks between Middletown and Cromwell, Tafts and Central Village, etc., carry trolley cars of its subsidiary, the Connecticut Company, besides the regular steam service.

The 11,000-volt, single-phase, twenty-five-cycle main-line electrification of the New York, New Haven & Hartford Railroad is too well known to require any description, numerous articles on this subject having been published in the STREET RAILWAY JOURNAL and the ELECTRIC RAILWAY JOURNAL since 1905. A general review of the locomotive development on this system was published in the issue of Feb. 17, 1912. The section now in operation comprises 21.5 miles of route, or 109.3 miles of single track, between Woodlawn at the New York City line and Stamford, and the Harlem River branch as shown has just been completed



American Electrifications—West Jersey and Seashore Division, Pennsylvania Railroad

with 63.4 miles of main line and 78 miles of yard track, a total of 141.4 miles of single track. The main line electrification for the 41 miles between Stamford and New Haven now nearing completion will comprise 170 miles of main-line track and 40 miles of yards and sidings, or 210 miles in all. Furthermore, the board of directors has approved the electrification of the four-track main line

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between Providence and Boston, a distance of approximately 50 miles. This work will call for 196 miles of main-line track and 20 miles of yards and sidings, a total of 216 miles. The figures for the Providence-Boston electrification are subject to change as the plans are not yet matured, but the single-phase mileages of the Harlem River and Stamford-New Haven divisions are approximately correct. The total single-phase electrification of this character with the completion of the Providence-Boston line will be about 700 miles of single track.

This company also operates a single-phase cross-country line of light catenary type between Stamford and New Canaan, comprising 7.7 miles of single track. This road carries electric passenger cars and steam freight, the latter being handled at night.

On May 27, 1911, the Boston & Maine Railroad placed in service the Hoosac Tunnel, which had been electrified for 11,000 volts, twenty-five cycles, single-phase, in conformity with the practice of the New York, New Haven & Hartford Railroad. This line, comprising 22 miles of track, was described in the Electric Railway Journal for July 1, 1911.

NEW YORK CENTRAL & HUDSON RIVER RAILROAD

As is well known, the New York Central and New Haven electrifications were accelerated by the compulsory conversion of the joint viaduct and tunnel entrance to the Grand Central Station via Park Avenue, New York. Unlike the a.c.-d.c. electrification of the New Haven company, the New York Central equipment is direct-current, third-rail throughout. The latter electrification comprises two lines out of New York City, the Harlem division to North White Plains, 24.4 miles northeast, and the Hudson (main-line) division to Harmon, 34 miles north of New York, a total of 234.4 miles of single track. The New York Central & Hudson River Railroad has no immediate plans for additional main-line work, but a plan to electrify its freight entrance along the Hudson River in New York City is now being jointly considered by the railway company and a committee of the Board of Estimate and Apportionment of New York. The latest data on the operations of the electric zone of the New York Central company will be found on pages 586 and 587 of the Electric Railway Journal for March 29, 1913.

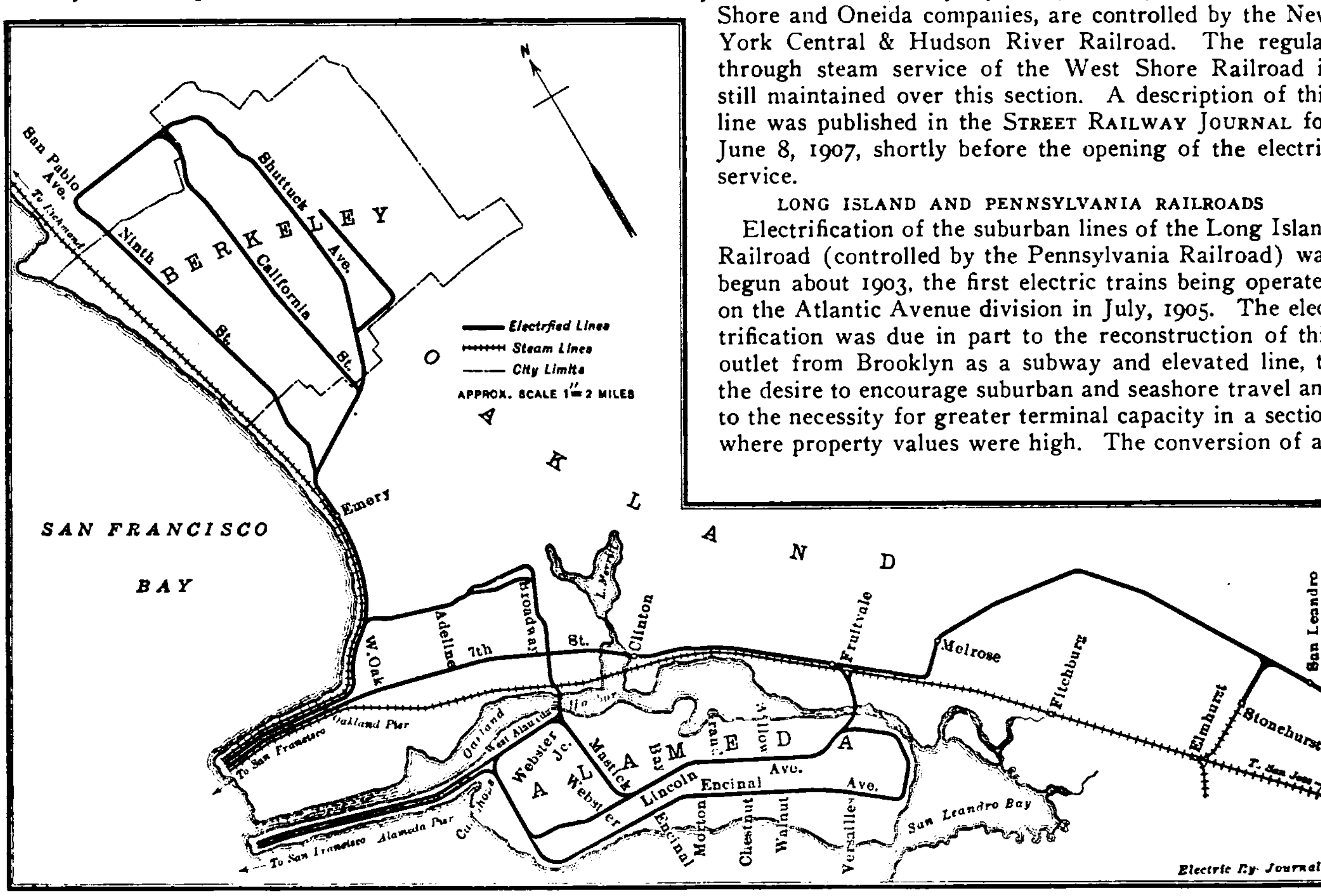
The electrification of the Detroit River tunnel, 19.2 miles of single track, was completed in October, 1910, by the Michigan Central Railroad, a subsidiary of the New York Central & Hudson River Railroad. This is a 650-volt direct-current third-rail line, as described in the Electric Railway Journal for Jan. 14 and 21, 1911.

The Oneida Railway is a 600-volt direct-current third-rail line, comprising 44 miles of route or 118 miles of single track. It is an electrification of the main line of the West Shore Railroad between Utica and Syracuse, New York. The passenger cars operated by the Oneida Railway over this section also are run over the tracks of the Utica and Syracuse street railway systems, which, like the West Shore and Oneida companies, are controlled by the New York Central & Hudson River Railroad. The regular through steam service of the West Shore Railroad is still maintained over this section. A description of this line was published in the Street Railway Journal for June 8, 1907, shortly before the opening of the electric service.

LONG ISLAND AND PENNSYLVANIA RAILROADS

Electrification of the suburban lines of the Long Island Railroad (controlled by the Pennsylvania Railroad) was begun about 1903, the first electric trains being operated on the Atlantic Avenue division in July, 1905. The electrification was due in part to the reconstruction of this outlet from Brooklyn as a subway and elevated line, to the desire to encourage suburban and seashore travel and to the necessity for greater terminal capacity in a section where property values were high. The conversion of all parts of the suburban system for third-rail, 600-volt operation has not yet been completed, but the electric lines, as indicated on the map, now total 1868 miles of single track. Articles on this electrification appeared in the Street Railway Journal for Nov. 4, 1905, April 7 and June 9, 1906, and in the Electric Railway Journal for March 26, 1910, and June 10 and 17, 1911.

During 1910 the Pennsylvania Railroad completed its New York terminal, comprising 98.4 miles of d.c. third-rail construction from Manhattan Transfer station opposite Newark to Long Island City, via a new route to Bergen Hill and through tunnels under the Hudson River, Manhattan Island and East River. The principal articles on this installation appeared in the Electric Railway Journal for June 3 and June 10, 1910, and an article on the maintenance of these locomotives in the issue of March 15, 1913. It may be added that by arrangement made in 1911 with the Hudson & Manhattan Railroad cars of the



American Electrifications—Southern Pacific Railway's Suburban Lines at Berkeley, Oakland and Alameda, Cal.

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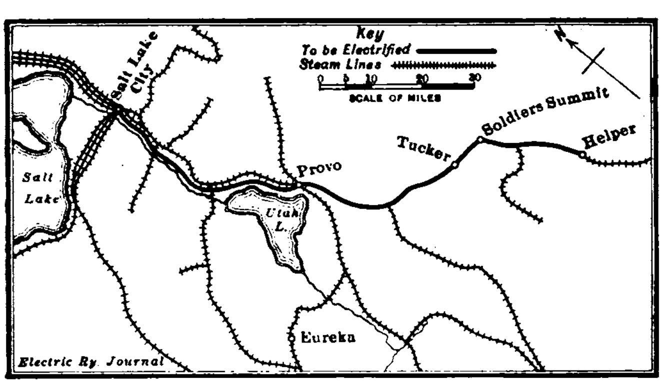
latter company are operated electrically over the right-of-way of the Pennsylvania Railroad between Newark and Jersey City.

The West Jersey & Seashore division of the Pennsylvania Railroad between Camden (opposite Philadelphia) and Atlantic City comprises 150.3 miles of 700-volt d.c. third-rail construction. This electrification was due chiefly to the desire to encourage seashore travel on high-speed trains. The electric service was opened Sept. 18, 1906. Articles describing this line or presenting operating data were published in the following issues: Nov. 10, 1906; Oct. 12, 1907; March 26, 1910; July 1, 1911.

Another map shows the route of the approved Philadelphia-Paoli electrification, a distance of 20 miles. As noted on page 515 of the Electric Railway Journal for March 15, 1913, this line is to form the beginning on a general electrification of the Pennsylvania's lines in and about Philadelphia. The length of the electrification, measured as single track, will be approximately 90 miles, according to the number of sidings converted.

ERIE RAILROAD

In June, 1907, the Erie Railroad completed the electrification of its Mount Morris division between Rochester, Avon, Geneseo and Mount Morris, N. Y., a route distance of 34 miles, equivalent to 40 miles of single track. This line, which is of interurban passenger character, is operated at 11,000 volts, twenty-five cycles, single-phase, with Niagara power. Two articles on this line appeared in the Street Railway Journal for Oct. 12, 1907. Operating results were presented in the Electric Railway Journal for June 19, 1909, and the most recent data will be found elsewhere in the current issue.



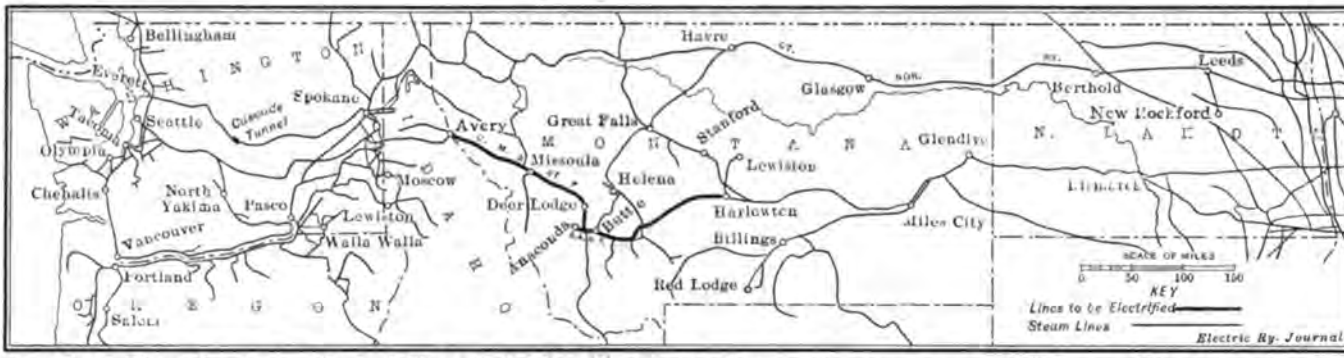
American Electrifications—Denver & Rio Grande Company's Line in Utah

SOUTHERN PACIFIC RAILROAD

During 1911 the Southern Pacific Railroad converted 96 miles of suburban steam track in and about Oakland, Alameda and Berkeley, Cal., to overhead 1200-volt d.c. overhead operation. Descriptions of this work appeared in the Electric Railway Journal for Oct. 21 and 28, 1911, and Oct. 5, 1912. The last article describes the electric locomotives, which are to be used chiefly for freight service.

GRAND TRUNK RAILWAY

The electrification of the Grand Trunk Railway, as carried out in 1908 under the name of the St. Clair Tunnel Company, comprises 4 miles of tunnel track at Port Huron, Mich., operated at 3300 volts, twenty-five cycles, single-phase. This work was described in the Electric Railway Journal for Nov. 4, 1908.



American Electrifications—Map of Electrified Lines in the Northwest, Showing Route of Chicago, Milwaukee & Puget Sound Railway

GREAT NORTHERN RAILROAD

The electrification of the Great Northern Railway's Cascade tunnel, between Leavenworth and Skykomish, about 100 miles east of Seattle, was completed in July, 1909, for three-phase, twenty-five cycle, 10,000-volt operation. This is the only three-phase line in the United States. It has 6 miles of single track, including the approaches. The distance between Leavenworth and Skykomish, the proposed completed three-phase electrification, is 57 miles. The line was electrified to eliminate smoke troubles and increase the capacity. A description of this installation was published in the Electric Railway Journal for Nov. 20, 1909.

Electrified Steam Railroads in the United States in Operation or Under Construction

Railway	Miles of Single Track	System of Electrification	Total Mileage
Baltimore & Ohio	7.4	Low voltage d.c.	....
N. Y., N. H. & H. and B. & M.	104.4	Low voltage d.c.	....
New York Central lines	371.6	Low voltage d.c.	....
Pennsylvania system	435.5	Low voltage d.c.	....
Total of low voltage direct current			918.9
Butte, Anaconda & Pacific	90.0	High voltage d.c.	....
Southern Pacific	96.0	High voltage d.c.	....
Total of high voltage direct current			186.0
Grand Trunk	4.0	Single-phase	....
Erie	40.0	Single-phase	....
N. Y., N. H. & H.	490.4	Single-phase	....
Total of single-phase			534.4
Great Northern	6.0	Three-phase	....
Total of three-phase			6.0
Grand total			1645.3

Lines Approved for Electrification.

Pennsylvania	90*	Not decided	....
Norfolk & Western	75	Not decided	....
Denver, Rio Grande & Western	114	Not decided	....
Chicago, Milwaukee & Puget Sound	440	Not decided	....
Great Northern	530	Not decided	....
Grand total			1249

* Paoli electrification, mileage approximate.

This company is also said to be considering the electrification of a 530-mile line between New Rockford, N. D., and Lewistown, Mont., for which roadbed and other construction contracts have been awarded. In this case electrification is said to be favored owing to the poor coal and water conditions for locomotives. A discussion of this subject was published on pages 117 and 118 of the Electric Railway Journal for Jan. 18, 1913.

CHICAGO, MILWAUKEE & PUGET SOUND RAILWAY

The Chicago, Milwaukee & Puget Sound Railway has already contracted for hydroelectric power to operate its line from Harlowton, Mont., to Avery, Idaho, a distance of 440 miles. It is probable that a 2400-volt d.c. system will

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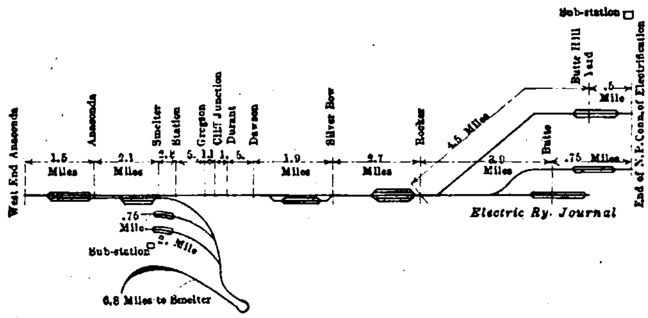
be used. Avery is 2495 ft., Harlowton 4163 ft. and the intermediate town of Deer Lodge 4520 ft. above sea level. The distance between Avery and Deer Lodge, the proposed initial electrification, is 211.5 miles and between Avery and Harlowton 439.3 miles, all single track. Articles on this mountain project were published in the ELECTRIC RAILWAY JOURNAL for Jan. 11, 1913, and Feb. 15, 1913.



American Electrifications—Diagrammatic Map of Butte, Anaconda & Pacific

DENVER, RIO GRANDE & WESTERN RAILWAY

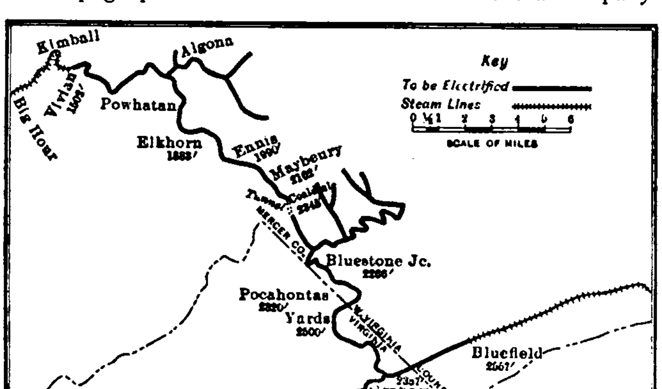
The Denver, Rio Grande & Western Railway has decided to electrify one 114-mile mountain division. The distance from Helper to Soldier Summit, which is to be the initial electrification, is 29 miles and from Helper to Salt Lake City, 114 miles. Helper is 5840 ft., Soldier Summit 7454 ft. and Salt Lake City 4224 ft. above sea level. Preliminary articles on this electrification appeared in the ELECTRIC RAILWAY JOURNAL for Nov. 23 and Nov. 30, 1912.

BUTTE, ANACONDA & PACIFIC RAILROAD

The Butte, Anaconda & Pacific Railroad is an ore-carrying mountain line comprising 114 miles of single track, 90 miles of which are being electrified for 2400-volt d.c. operation. Articles on this installation have appeared in the ELECTRIC RAILWAY JOURNAL for Feb. 10 and Aug. 31, 1912, and on page 20, Jan. 4, 1913. A description of the locomotives appears in this issue.

NORFOLK & WESTERN RAILWAY

The latest mountain electrification is that of the Norfolk & Western Railway for the heavy coal-carrying line between Vivian and Bluefield, W. Va., comprising 30 miles of route or 75 miles of single track. The operating conditions on this line were described in the ELECTRIC RAILWAY JOURNAL for May 3, 1913, and the general course of the line and topographical conditions are shown in the accompanying map. The system of electrification has not yet been selected.



American Electrifications—Norfolk & Western Railway

Plans have been prepared for a proposed narrow-gage electric railway in Switzerland between Arzier and St. Cergue and to La Cure and Morez. The line would be about 25 miles long, about 8 miles of which would be in French territory.

LOCOMOTIVES FOR THE BUTTE, ANACONDA & PACIFIC

The electrification of the Butte, Anaconda & Pacific Railway is of exceptional interest because it is the first in this country where direct-current locomotives operating on as high a potential as 2400 volts will be employed. Construction work necessary to effect the change from steam to electric equipment is now practically completed, and the road is at present being operated to some extent by electric power.

The section of line that has been electrified lies between Butte and Anaconda, Mont. It comprises 30 miles of main-line single track and numerous sidings, yards and smelter tracks, aggregating a total of about 90 miles on a single-track basis. The haulage of copper ore from the Butte mines to the smelters at Anaconda, which is the principal traffic, together with all mine supplies, lumber, etc., moving in both directions, amounts to practically 5,000,000 tons of freight per year. The freight trains, weighing 3400 tons and made up of fifty loaded ore cars, will be handled against a ruling grade of 0.3 per cent by locomotives consisting of two of the units illustrated. Single units will be used for making up trains in the yards and for spotting cars.

The initial equipment consists of seventeen units, fifteen for freight and two for passenger service. Each unit weighs approximately 80 tons. The two units forming the freight locomotive in each case will be coupled together and operated in multiple, and combination locomotives will haul the 3400-ton train at a maximum speed of 15 m.p.h. against the ruling grade and at 21 m.p.h. on level tangent track.

The passenger locomotives are the same design as the freight locomotives, except that they are geared for a maximum speed of 45 miles per hour on level tangent track. A schedule of eight passenger trains per day, four each way, is maintained, the average train being composed of a locomotive and three standard passenger coaches. All the locomotive equipment, as well as the substation apparatus and overhead line material, was designed and built by the General Electric Company. One of the locomotives will be exhibited at the Master Mechanics' and Master Car Builders' conventions at Atlantic City.

The general design is of the articulated double-truck type, all weight being on the drivers. The cab, containing an engineer's compartment in each end and a central compartment for the control apparatus, is carried by the two truck frames on center pins. It is of the box type, extending the entire length of the locomotive, and is provided with end and side doors. Friction draft gear mounted on the outer end frame of each truck transmits the hauling and buffing stresses directly through the truck frame, diverting these strains from the center pins and underframe.

The trucks are built of heavy steel castings. The side frames are of a truss pattern with heavy top and bottom members and pedestal tie bars. They are connected by end frames and a cast-steel center transom. The entire weight is carried on semi-elliptic springs suitably equalized. On each axle is mounted a motor of the twin-geared type.

The cab underframe consists of two 12-in. longitudinal steel channels on either side of the center and two 6-in. x 6-in. steel angles along the outer edge. The central channels are inclosed and form a distributing air duct for forced ventilation. Air is conducted through the center pins, which are hollow, into the truck transoms and thence to the motors. The engineer's compartment, at either end of the cab, contains the operator's seat, controller, air-brake valves, bell and whistle ropes, ammeter, air gages, sanders and other control apparatus that should be within immediate reach of the engineer.

In the central section is grouped the control apparatus. The contactors, reverser and rheostats are mounted in two banks running lengthwise of the compartment and are arranged with ample space between them to afford con-

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venient access for cleaning, inspection and repair. All parts and circuits carrying 2400 volts are thoroughly protected from accidental contact. A dynamotor is employed to furnish 600 volts for the operation of the contactors, lights and air compressor.

The principal data and dimensions applying to the locomotives are the following:

Length inside of knuckles	37 ft. 4 in.
Height with trolley down	15 ft. 6 in.
Width over all	10 ft. 0 in.
Total wheelbase	26 ft. 0 in.
Rigid wheelbase	8 ft. 8 in.
Total weight	160,000 lb.
Wheels, diameter	46 in.
Tractive effort at 30 per cent coefficient	48,000 lb.
Tractive effort at one hour rating	30,000 lb.
Tractive effort at continuous rating	25,000 lb.

The motors are of the GE-229-A commutating-pole type, wound for 1200 volts and insulated for 2400 volts. A forged pinion is mounted on each end of the armature shaft and meshes into a corresponding gear mounted on the wheel hub, providing a gear reduction of 4.84 on the freight locomotives and 3.2 on the passenger locomotives. The motor is designed especially for locomotive service, is inclosed and provided with forced ventilation. Air is circulated over the armature and field coils and over and through the commutator, through longitudinal holes in the armature core, and thence exhausted through openings in the bearing head. The continuous capacity of each motor is 190 amp on 1200 volts under forced ventilation, and the input is 225 amp on 1200 volts for the one-hour rating. For the double unit the continuous rating is equivalent to an output of 2100 hp.

The operating equipment on the locomotives includes the Sprague-General Electric Type M multiple-unit control, and it is designed to operate the four motors in series and series-parallel. The pairs of motors with their respective resistances are all connected in series on the first point of the controller. The resistance is varied through nine points on the controller and finally short-circuited on the tenth or running point. The pairs of motors are then operated similarly in series-parallel and all resistance is cut out on the nineteenth point, which is the full-speed running point. This provides a control with ten steps in series and nine steps in series-parallel.

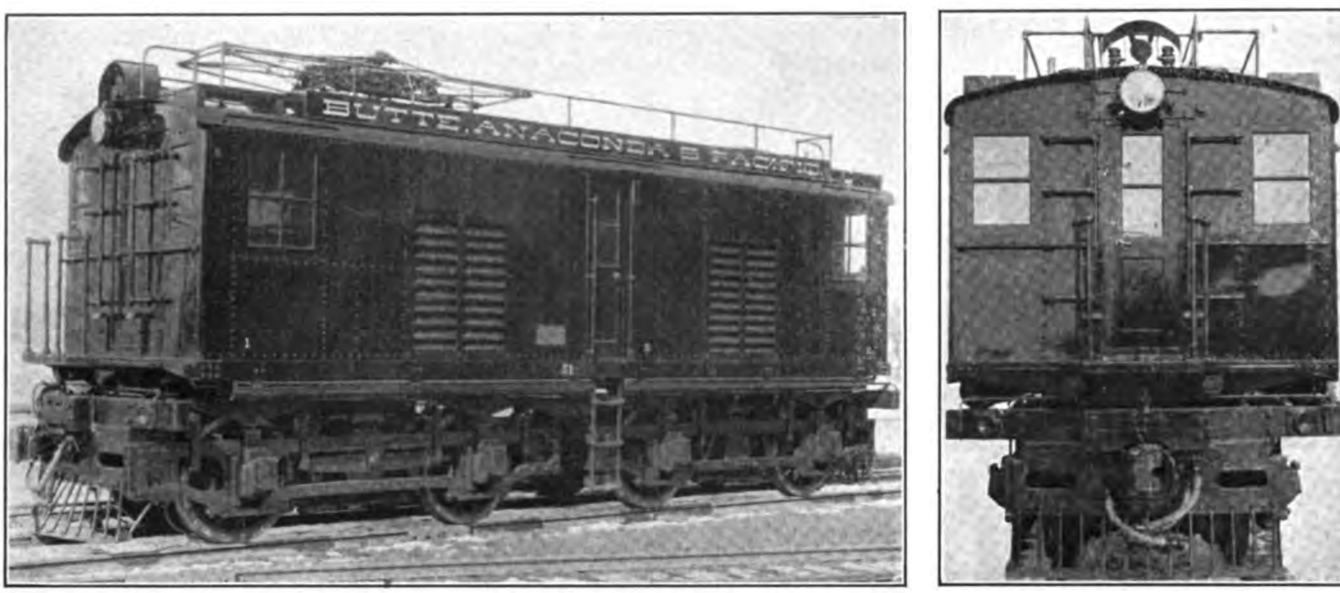
The transition between series and series-parallel is effected without opening the motor circuit, and there is no appreciable reduction in tractive effort during the change, the smooth transition between control points permitting acceleration close to the slipping point of the wheels. A switch having manually operated handles for cutting out either pair of motors is provided so that the locomotive can if necessary be operated with one pair of motors in the usual way. The contactors are actuated by the 600-volt circuit obtained from the dynamotor and are of a design similar to that employed in the standard Type M control.

The main switch is provided with a powerful blow-out so that heavy currents can be opened. The three smaller switches, one for each of the two heaters and one for the dynamotor circuits, are designed specially for 2400 volts. The blades are controlled by levers attached to the grounded part of the locomotive frame and insulated from the live parts of the switch by rods of treated wood.

There are two fuses for the motor circuits and one main fuse for the trolley circuit, all of the copper-ribbon type and fitted with hinged covers to facilitate fuse renewals.

An ammeter is located at each engineer's position and indicates the current in the circuit of one pair of motors. The ammeter and air gages are illuminated by a gage light connected in the headlight circuit, so that the headlight switch turns on simultaneously the headlight and gage light at the same end of the locomotive.

The main motor rheostats are formed of cast-iron grids assembled in a frame and insulated by mica. Twenty resistance units are provided for each passenger locomotive and twenty-six for each freight unit locomotive, the units being mounted in an inclosed compartment above the banks of contactors.



Butte, Anaconda & Pacific Equipment—Side and End Views of 2400-Volt Freight Locomotive

Current is collected by overhead trolleys of the pantograph type. They are pneumatically operated and can be put into service from either engineer's compartment by a hand-operated valve. Each passenger locomotive is equipped with two collectors and each freight unit with one collector. A 2400-volt insulated bus line connected direct to the pantograph is run along the center on the roof of the cab, and the bus lines are connected by couplers between the two units of the freight locomotive, so that current may be obtained from both collectors or from a single collector as desired. The collectors and bus lines are adequately guarded by railings.

The locomotives are equipped with arc headlights and the interior illumination of the cab is provided by ten incandescent lamps arranged in two circuits, one lamp being placed in each engineer's cab and the others in the central compartment. In each lamp circuit is a portable lamp with an extension cord. One lamp switch is located in each engineer's cab, so that one lamp circuit can be controlled from each end of the locomotive. A 600-volt bus line is provided on the passenger locomotives for lighting and a 2400-volt bus line for heating the passenger coaches.

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