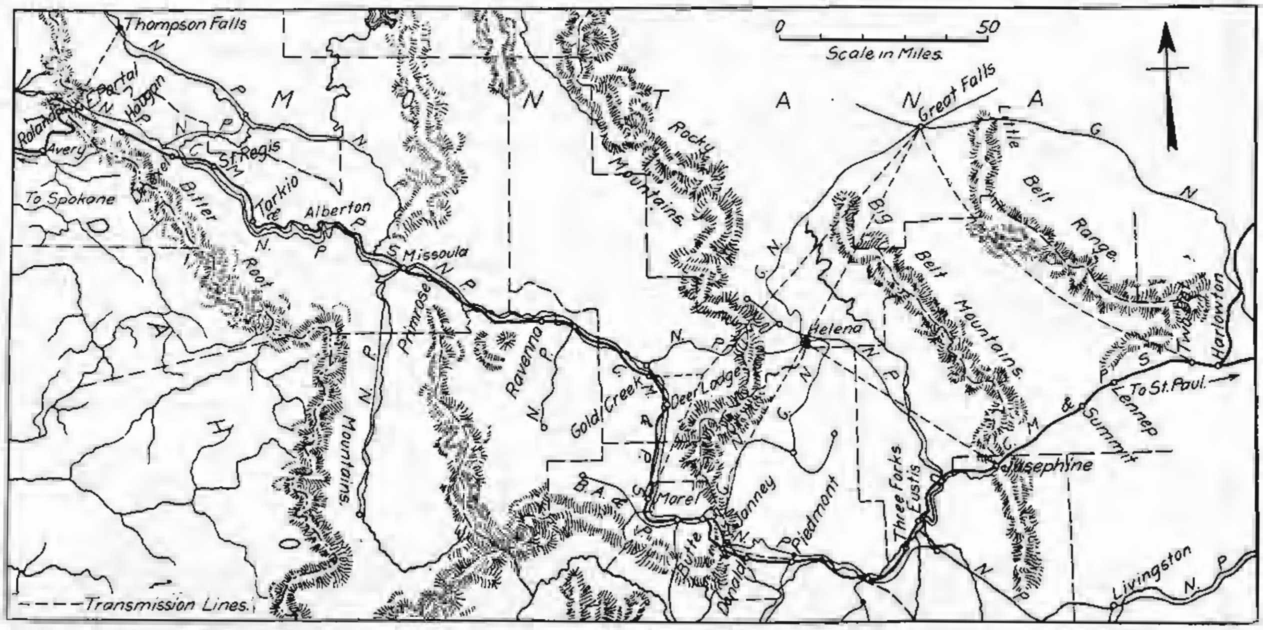
Electrification of 440.5 Miles of the St. Paul

A Description of the New Construction Work on Four Entire Engine Districts with Heavy Mountain Grade

The Chicago, Milwaukee & St. Paul is now actively engaged in the electrification of 440.5 miles of main line and 141 miles of side and yard tracks on its Puget Sound extension between Harlowton, Mont., and Avery, Idaho. This includes the Rocky Mountain and Missoula divisions with four engine districts and intermediate terminals at Three Forks, Deer Lodge and Alberton, Mont. Work on the district between Three Forks and Deer Lodge, inclnding 113 miles of line and 168 miles of all tracks, is now practically completed and it is expected that this section will be ready for electric operation shortly after November 1. The electrification of the eastern district between Three Forks and Harlowton is also nearing completion and it will be plaeed in service soon after January 1, 1916. Work is also under way on the two western districts comprising the Missoula division and it is expected that this division will be operated electrically by January 1, 1917. This entire project involves an expenditure estimated at $15,000,000.

This project is of special interest to railway men for a number of reasons. With only one or two exceptions, all previous electrification installations have been made to relieve local smoke conditions in cities or tunnels or to reduce congestion at certain specific points, and not primarily to effect economies of operation. This projeet of the St. Paul is being developed to reduce the cost of operation, the smoke problem being negligible, and there being no traffic congestion as this line is single track with only a moderate traffic. Also, while other installations have been of limited mileage and have only served to create constructive mileage for train crews in most cases, this supersedes steam operation on four entire engine districts, affording opportunity for the full development of economies in yard as well as line operation, and for the working out of methods for electrical operation on a much larger scale than heretofore possible.



Map of the Electrified Line and Sources of Power Supply

PHYSICAL AND TRAFFIC CONDITIONS

Between Harlowton and Avery this line crosses the Belt, Rocky and Bitter Root mountains. The Belt mountains are crossed at Summit, 45 miles west of Harlowton, at an elevation of 5,795 ft., with a one per cent grade 14 miles long on the east slope and a one per cent grade 44 miles long on the west slope. The length of this latter grade presents one of the most serious problems encountered in this installation. The Rocky Mountains are crossed at Donald, 124 miles west of Summit and 18 miles east of Butte, at an elevation of 6,350 ft. The eastern slope includes 20.8 miles of two per cent grade and the western slope 10 miles of 1.66 per cent grade. The third district between Deer Lodge and Alberton descends continuously westward on a maximum grade of 0.4 per cent. The crossing of the Bitter Root mountains is made at Roland, Idaho, at an elevation of 4,200 ft. The summit is reached by 12 miles of 1.7 per cent grade on the east slope and 24 miles of 1.7 per cent grade on the west side. Over 6,250 ft. of rise and fall is overcome between Harlowton and Avery.

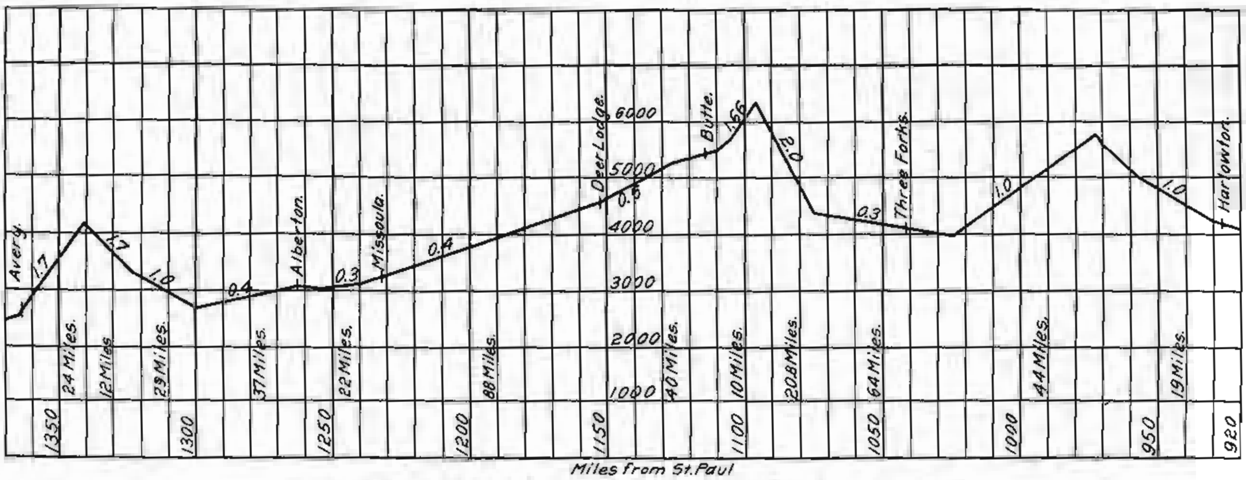
As would be expected in such mountainous country, the curvature is heavy, the maximum degree of curve being 10 deg. There are 36 tunnels between Harlowton and Avery, 16 of which are on the western slope of the Bitter Root mountains. The longest is the St. Paul Pass tunnel at the summit of the Bitter Root mountains, 8,751 ft. in length.

The traffic consists of two heavy transcontinental passenger trains with a third local passenger train between Harlowton and Butte, and an average of four tonnage freight trains each way daily, with a local freight every second day. The freight traffic amounts to about 15,000 gross tonnage daily. Under ordinary conditions the prevailing tonnage is eastbound and consists largely of grain, lumber and other dead freight. Normally one-time freight is able to handle all eastbound expedite business. Westbound, nearly all the traffic consists of merchandise and other time freight.

The local traffic originating within the limits of the electrified zone is relatively small, Butte and Missoula being the only cities of any importance. While the St. Paul brings considerable freight into Butte, it is the latest road into the city and reaches many industries only through connecting lines.

At the present time a 2,000-ton train is hanled up one per cent grade with one Mallet road engine. Helpers are added on the heavier grades, 7 engines being held in this service on the Rocky Mountain division, as compared with an average of 23 road engines.

Only three short branches connect with the main line between Harlowton and Avery and these will not be electrified at present. A considerable amount of business originates along the Great Falls line, which connects with the main line at Harlowton, but practically all this goes east. Almost all the traffic handled



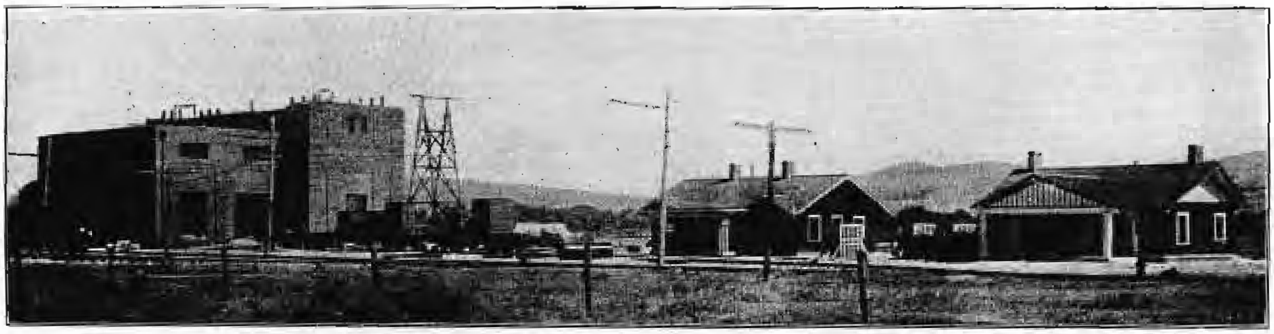
Profile of the Electrified Portion of the Chicago, Milwaukee & St. Paul

therefore, comes from points west of Avery. This traffic is growing regularly and the electrical equipment now being installed is capable of handling a tounage train in each direction every two hours, or nearly double the present business.

SPECIAL CONSIDERATIONS

One of the considerations leading to the decision to electrify this portion of the St. Paul was the favorable results secured from the electrification of the Butte, Anaconda & Pacific, which parallels the St. Paul west from Butte for a short distance. As described by J. B. Cox in the *Railway Age Gazette* of December 25, 1914, the first year's electric operation of this line showed an increase of 33 per cent in the average train load and a saving in operating expenses equal to 20 per cent return on the investment.

Such savings are brought abont in large measure by the high cost of coal and the cheapness of electric power. The St. Paul secures the coal used in this district from company mines located



The Piedmont Substation and Bungalows

on its line at Roundup, Mont., 70 miles east of Harlowton, giving an average haul over this zone of 300 miles. This coal costs an average of $2.75 per ton at the point of use. It also provides about 1,000 tons of westbound traffic daily, although this is not as serious as might be supposed, as it is in the direction of light tonnage. Power is secured by contract with the Montana Power Company at the unusually low price of 0.536 cents per kw. hour, based on a 60 per cent load factor.

Important operating economies are expected from this development, but because of the numerous new problems to be solved, many of the proposed methods of operation are only tentative and subject to wide variations as they are put in practice. One of the important innovations which will be introduced is that of running freight and passenger engines over two districts, changing crews at the intermediate terminals. While trains will be inspected at Three Forks and Alberton and bad-order cars set out, the delays at these points will be small compared with present methods of operation, while it will be necessary to maintain only a few men at these points. At Harlowton, Deer Lodge and Avery, the engines will be inspected, but they will be sent throngh the shop only after they have made about 2,000 miles.

Another feature of special interest is the regenerative system of operation of the electric locomotives by which the surplus energy not required to hold the trains on the descending grades will be returned to the line for further use. By this means not only will there he added safety on the heavy grades, as the regular air brake equipment will be held in reserve for emergency use, but the excessive wear on wheels and brake shoes will be eliminated. Of secondary importance is the returning of the surplus power to the line, affording a material saving in power consumption, the arrangement with the power company providing that the railroad is given credit for all energy returned. While the amount of power so returned can only be estimated within wide limits and will depend on the distribution of trains and other conditions, it has been estimated that 15 per cent to 18 per cent should be recovered in this way. The speeds of trains descending grades will not be fixed arbitrarily, but will instead be left in the control of the engineer within broad limits.

Another original and interesting feature is the power limiting and indicating system which is being installed, by which the speeds of trains and the amount of power consumed will be fixed by the load despatcher. In this way, to avoid excessive peak loads, the despatcher can limit the amount of power taken by any train, assisting passenger and other preferred trains and holding back secondary trains. As far as practicable trains will also be so spaced that a descending train will be returning power to the line when others are ascending.

THE POWER SUPPLY

Power is secured from the Montana Power Company and is delivered by this company at the right of way at substations located at Two Dot, Josephine, Piedmont, Janney, Morel, Gold Creek and East Portal. With the exception of that delivered at East Portal, all power comes from the hydro-electric developments at Great Falls, the road lying roughly in the arc of a circle of a radius of about 100 miles, with Great Falls as the center. The power delivered at East Portal is generated at Thompson Falls, a relatively recent development. The power plants developed and proposed by this company have a total capacity of 244,000 hp., while large storage reservoirs are in service, insuring an ample continuous supply of power. By this arrangement, the railroad secures power without the necessity of making the large initial investment which would otherwise be required, while, by combining this with its large commercial load, the power company is able to sell the power cheaper than if it all went to the railroad.

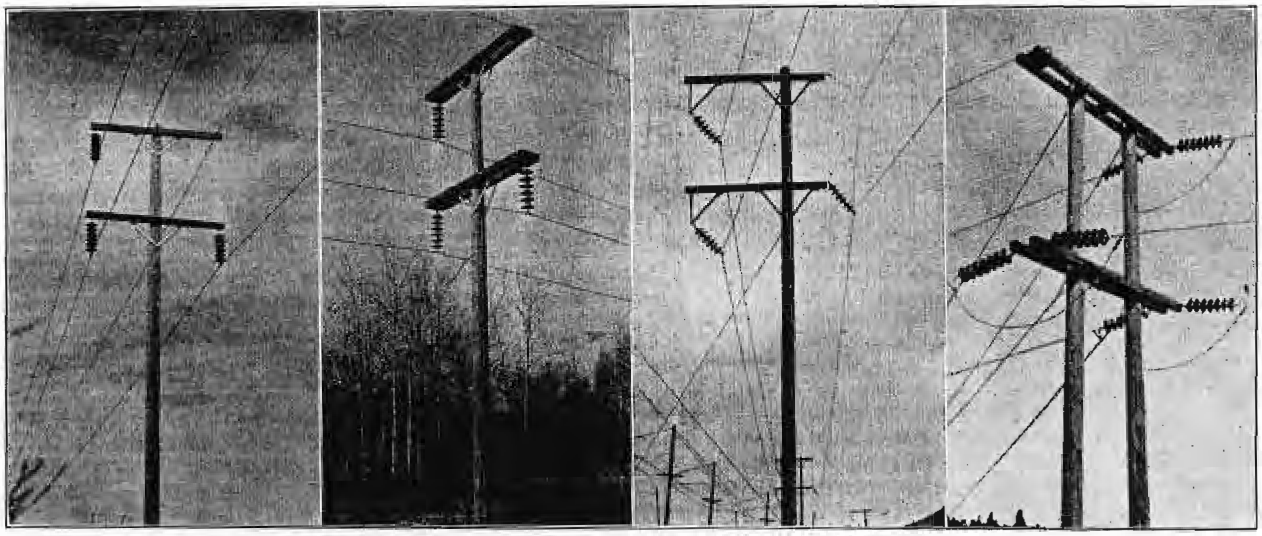
This power is brought to the right of way as 100,000-volt, 3-phase, 60-cycle alternating current. To deliver it at the required places it was necessary to construct 100 miles of transmission line to reach Two Dot, 54 miles to reach Josephine, and 135 miles to reach Morel. In the vicinity of Butte, power was secured by tapping existing lines. These new lines consist of two 45-ft. wooden poles spaced 10 ft. 6 in. apart, and supporting a wooden cross arm 22 ft. long. Three transmission wires are supported from this cross arm by suspension insulators, one between the two poles and one near each end. Twelve of these supports were built per mile.

THE SUBSTATIONS

Fourteen substations are being built between Harlowton and Avery. They are spaced an average distance of 33 miles apart, the exact locations depending on the grades and the power consumption. They are located at Two Dot, Summit, Josephine, Eustis, Piedmont, Janney, Morel, Gold Creek, Ravenna, Primrose, Tarkio, Drexel, East Portal and Avery. In all cases the points of delivery of energy by the power company are at substations to permit one attendant to operate the switches on both lines.

The substation buildings are of permanent construction throughout, with concrete foundations, brick walls and concrete roofs carried on steel purlins and roof trusses. To provide proper ventilation for the motor generator sets, the foundations for this equipment are arched with a basement underneath and openings in the exterior walls for air inlets. The supply of air is controlled by steel sash operated as butterfly valves. All sash in the main buildings are also of steel and are controlled by chains or rods.

The floors are of concrete and contain conduits carrying power transmission lines to the various equipment units. The only conduits exposed to view are those for building lighting and those leading to the outside feeder system. A standard gage track is built in the floor on which will be operated a steel car or truck to transfer heavy equipment from one part of the building to another. A steel turntable is also being installed.



Standard Transmission Line Construction (1) on Tangent with 300-ft. Spans. (2) On Tangent with Spans of 450 Feet. (3) On Curves up to 10 Degrees. (4) On Curves Between 10 Degrees and 30 Degrees

The roof consists of reinforced concrete slabs 3 in. thick supported on steel trusses and covered with a five-ply tar and gravel roof. All substations are built with flat roofs except those at Drexel, East Portal and Avery, which are provided with pitched roofs because of the very heavy snowfall in the Bitter Root mountains. Otherwise they are of the same construction as the other stations except that the horn gaps for the lightning arresters are placed indoors, increasing the size of the buildings somewhat.

The substations are divided into two rooms, the motor generator or low tension room, and the transformer or high tension room. The partition is of brick, with two tin-clad doors for protection. One corner of the motor generator room is partitioned off and, with a bay built onto the building, forms the office. The interior walls are painted white above a green wainscot five feet high. All doors, sash and other exposed steel, conduits and substation equipment are painted black.

At the substations the 100,000-volt, 60-cycle, 3-phase alternating current is converted to 3,000-volt direct current. On delivery at the substations this 100,000-volt current passes through oil switches to the high tension bus, from which it is conducted through further oil switches to the transformers, emerging at 2,300 volts a.c. The current is then led through suitable switches to the motor generator sets, leaving at 3,000 volts d.c., and passing through control switches on the switchboard to the feeder system at this potential.

The transformers are rated 1,900 and 2,500 k.v.a. and are provided with four 2½ per cent voltage taps and 50 per cent motor starting taps.

In the standard station the motor generator sets comprise a 60-cycle synchronous motor, driving two 1,500-volt d.c. generators connected permanently in series for 3,000 volts. The fields of both the synchronous motors and the direct current generators are separately excited by small generators direct-connected to each end of the motor generator shaft. The direct current

Erecting the Overhead Work

generators are compound wound and will maintain constant potential up to 150 per cent overload with a capacity for momentary overloads up to three times their normal rating. To insure good commutation on these overloads, the generators are equipped with commutation poles and compensating pole face windings. The synchronous motors will also be used as synchronous condensers and it is expected that the transmission line voltage can be regulated in this way so as to eliminate any effect of the fluctuating load.

The transformers weigh 28 tons and the motor generator sets 66 tons. They are assembled in nnits of a maximum weight of 10 tons each to permit handling readily. A hand-operated traveling crane in the motor generator room and a triple chain block hoist in the transformer room, each with a capacity of 10 tons, are installed to handle the equipment.

The substation at East Portal has a transformer room 30 ft. by 170 ft. and a motor generator room 40 ft. by 77 ft., with the ridge of roof 55 ft. above the ground. The two-unit substations have transformer rooms 30 ft. by 87 ft., and motor generator rooms 40 ft. by 60 ft., while the three-unit substations have transformer rooms 30 ft. by 101 ft., and motor generator rooms 40 ft. by 77 ft. The height of roof of the flat top buildings is about 45 ft.

The source of water supply at the substations varies with the local conditions and includes deep wells, springs and streams. To insure adequate pressure, underground steel pneumatic tanks are installed, with electrically-driven pumps equipped with auxiliary air pumps. These pumps are automatic, starting and stopping at given pressures.

Special attention has been given to the provision of attractive bungalows and surroundings at the more or less isolated locations of the substations to make the living conditions of the operators as good as possible. To this end one four-room and one five-room bungalow of attractive design have been built at each substation as homes for the operators. These buildings are equipped with electric lights and running water. Each station layout is designed and painted differently to give it individuality.

THE TRANSMISSION LINE

The power distribution system includes the transmission line, the positive or outgoing feeder system, the overhead contact system and the negative or return system. A 100,000-volt transmission line, entirely independent of the power company's line, extends from Two Dot to Morel and from Gold Creek to Avery. In general, this line is located on the right of way, although it leaves it at numerous places where distance can be saved, and it passes over the summits of all tnnnels. Disconnecting switches are placed in the line on each side of each substation, permitting power to be taken from either direction and providing relief from break-ins or trouble on any individual seetion of the line.

The construction of a 100,000-volt line along a right of way on which there are telegraph and telephone lines involves special problems in itself, the telephone being used for despatching purposes and the telegraph for commercial business. To reduce the interference as much as possible, the transmission line is

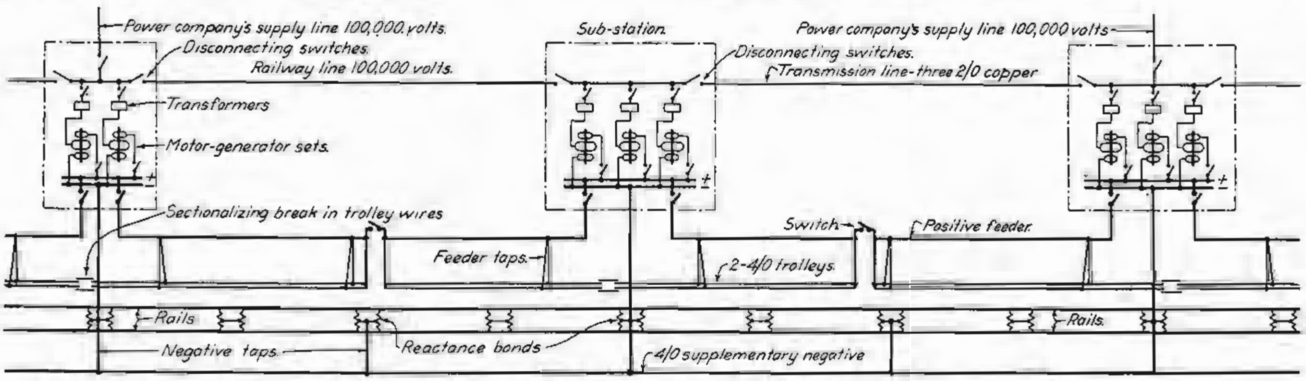


Diagram Showing the Transmission and Distribution System

Because of the difference in power demands, the generating equipment varies somewhat. At Piedmont and Janney three 1,500 kw. motor generator sets have been installed, while at all other stations between Harlowton and Deer Lodge two 2,000 kw. motor generator sets are being installed. At East Portal, near the western end, the largest substation will be built, containing three 2,000 kw. motor generator sets. This station will also receive two taps from the power company's transmission line, while provision will be made for a future second transmission line belonging to the railway company westward as a precautionary measure, because of the heavy snowfall in this vicinity.

located on the side of the track opposite the other lines and near the right of way fence. At points where the telegraph lines formerly crossed over the track, they are placed underground to prevent physical contact with the transmission line under any conditions. Where the transmission line crosses the telegraph line, it is strengthened to give it a greater factor of safety.

The transmission line is built with Idaho cedar poles 45 ft. and 50 ft. long, with a minimum diameter at the top of 8 in. The cross-arms are of Washington fir and are 4¾ in. by 5¾ in. in cross section. For tangent work braecs of ¼ in. by 2 in. galvanized steel are added. Three conductor wires are carried, each consisting of six strands of copper with a hemp core. The copper is 0.15 in. in diameter and the completed condnctor 0.45 in. The hemp core is saturated with a preservative compound, making it impervious to moisture, and is used to increase the size of the conductor. The standard distance between poles on tangents on level ground is 300 ft. Where the length of the individual wires supported by a pole is 450 ft. and over, double cross-arms are used as shown in one of the photographs. In marshy ground or where the poles are exposed to side wash, they are guyed and banked with rock.

For curve and angle work where the angle does not exceed 10 deg., the cross-arms are offset to provide the desired clearance between the wire and the pole and they are more heavily braced. For angles between 10 deg. and 30 deg. a two-pole structure heavily guyed and fitted with double arms and insulators is used, supporting the transmission wires at the level of the cross-arms.

The standard suspension insulator with six discs is employed, this type requiring 340,000 volts to arc over it when dry and 250,000 volts when wet. At anchorage and heavy strain points an insulator with seven additional discs is used for further protection.

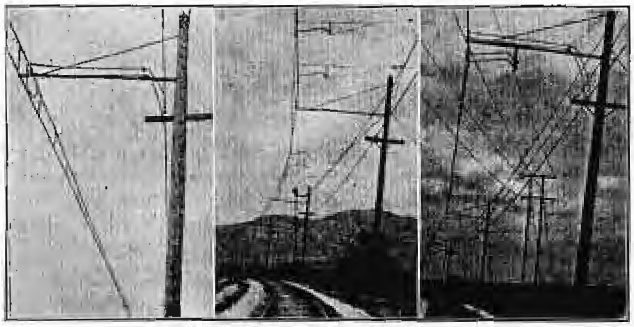
In addition to the one conductor wire the upper cross-arm carries an uninsulated ground wire of 3/8-in. Siemens Martin steel strand, grounded at every pole with a wire of the same size. This is provided as additional protection from lightning, both for the line insulators and the substation equipment.

THE FEEDER AND TROLLEY CONSTRUCTION

The outgoing feeder system consists of one or two lines of standard bare copper cable of either 13/16 in. or 1 in. diameter. For the greater part of the distance a single line of the smaller cable is used, but on the heavier grades two feeders are required. The feeder is connected with the trolley wire at intervals of 1,000 ft. by bare 9/16 in. copper strand cable, as shown in one of the photographs.

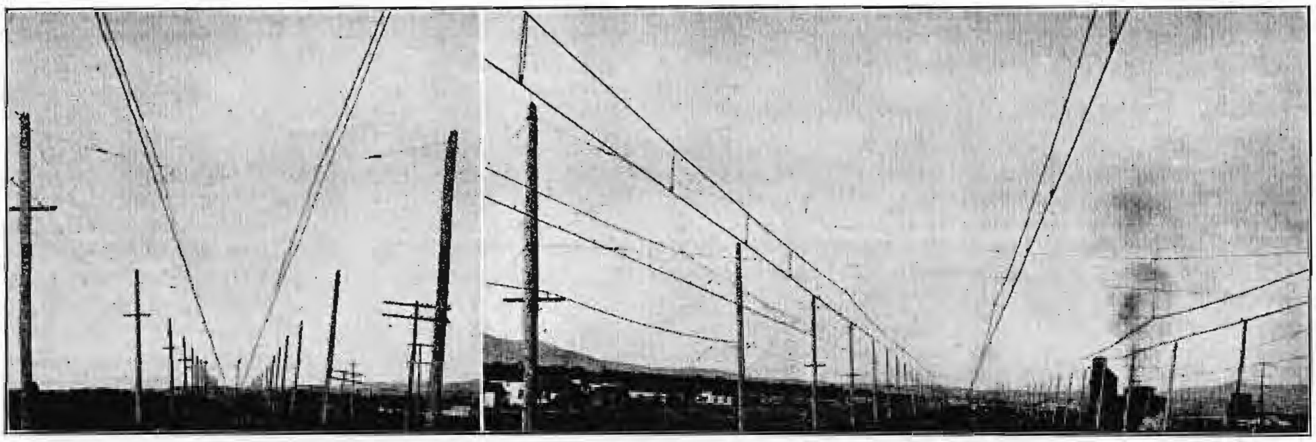
Disconnecting switches are inserted in the feeder line on each side of each substation. Sectionalizing switches are also installed beyond the outlying switches at each yard and passing track, and at each end of all long tunnels, enabling any section of the line to be cut out at the time of a derailment, or for any other reason, without disturbing operation beyond the adjacent stations. Likewise, in case of an accident damaging both the track and trolley line, any section of the line can be "killed" and repair work conducted simultaneous with that on the track. These sectionalizing switches are mounted high on the trolley pole, removing all "live" parts from the operator, while the operating handle is placed about five feet above the ground and is locked with a switchlock, making it accessible to any properly authorized employee. Shortly before a district is placed in operation complete instructions will be issued to all employees concerned, instructing them regarding the purpose and manner of using these switches.

The feeder system is carried on the common pole line with the trolley system. The poles are of Idaho cedar 40 ft. long and 8 in. minimum diameter at the top. They are spaced 150 ft. apart on tangents, the spacing decreasing in multiples of 15 ft. on curves to a minimum of 90 ft. They are set on an outward batter of 1/2 in. to 1 ft. on tangents and slightly more on curves. Special forms of pole construction were adopted on the numerous bridges on this line as shown in the accompanying photographs. On through girder structures, the poles rest on



Standard Trolley Construction—Trolley Construction on Tangents with Feeder Tap (left); "Pull Overs" on a Heavy Curve (center); Steady Braces and Feed Tap on Light Curve (right)

two angles placed back to back outside the girder. The base is held in place by a U-bolt passing around it and bolted to a short angle which is in turn riveted to the other angles. Another U-bolt near the top of the girder holds the pole in position. On deck girders the poles are supported by brackets framed of angle irons with U-bolt connections at the top and bottom. On pile trestles two 3-in. by 12-in. timbers are bolted to the two piles at one side of a bent, projecting beyond the bent and supported at the outer end by knee braces. The pole rests on this and is held in place by a second set of 3-in. by 12-in. timbers projecting beyond the pile cap and bolted through the pole.

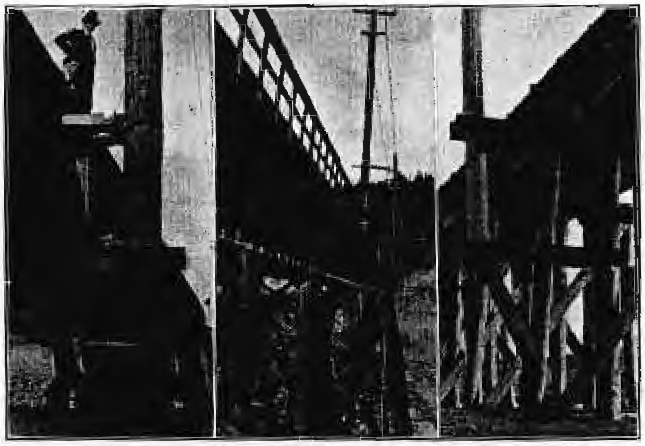


Overhead Construction for Two Tracks (left); Overhead Construction in Three Forks Yard (right)

A cross-arm of Washington fir 3 3/4 in. by 4 3/4 in. in cross section carries the feeder wires. The messenger and trolley wires are supported by a bracket arm consisting of a 2 1/2-in. by 2 1/2-in. by 5/16-in. tee iron with a 5/8-in. truss rod extending from a connection near the outer end to the top of the pole.

The overhead contact system consists of the messenger and trolley wires, both of which are anchored at intervals of a mile. The messenger wire is a seven-strand galvanized steel cable ½ in. in diameter, supported directly from the bracket arms. The trolley system is unusual in that two 4/0 copper contact wires are provided, both of which are supported at intervals of 15 ft. from the messenger wire by hangers, spaced 7½ ft. apart and supporting the two trolley wires alternately at an elevation of 24 ft. 2 in. above the top of rail. This form of construction with two wires, one of which is always flexible, permits the collection of heavy current with the current collector without sparking or excessive heating under the two extremes of heavy current consumption and high speed. Only one trolley wire is provided for yard and side tracks.

On curves up to six degrees and on curve easements steady braces are placed on each bracket arm to pull the trolley wires over, as shown in one of the photographs. On curves sharper than this a "backbone" consisting of a galvanized steel strand extends from pole to pole with "pull-offs" connecting with the messenger and trolley wires. The number of "pull-offs" depends on the degree of curve.



Special Construction on Through Girder Bridges (left); Steel Viaducts (center); Pile Trestles (right)

A special form of construction is provided in tunnels. Two suspension insulators attached to the roof of the tunnel 28 in. apart support a 3-in. 4-lb. inverted channel which carries the messenger wire and the two feeder wires spaced 6 in. at each side.

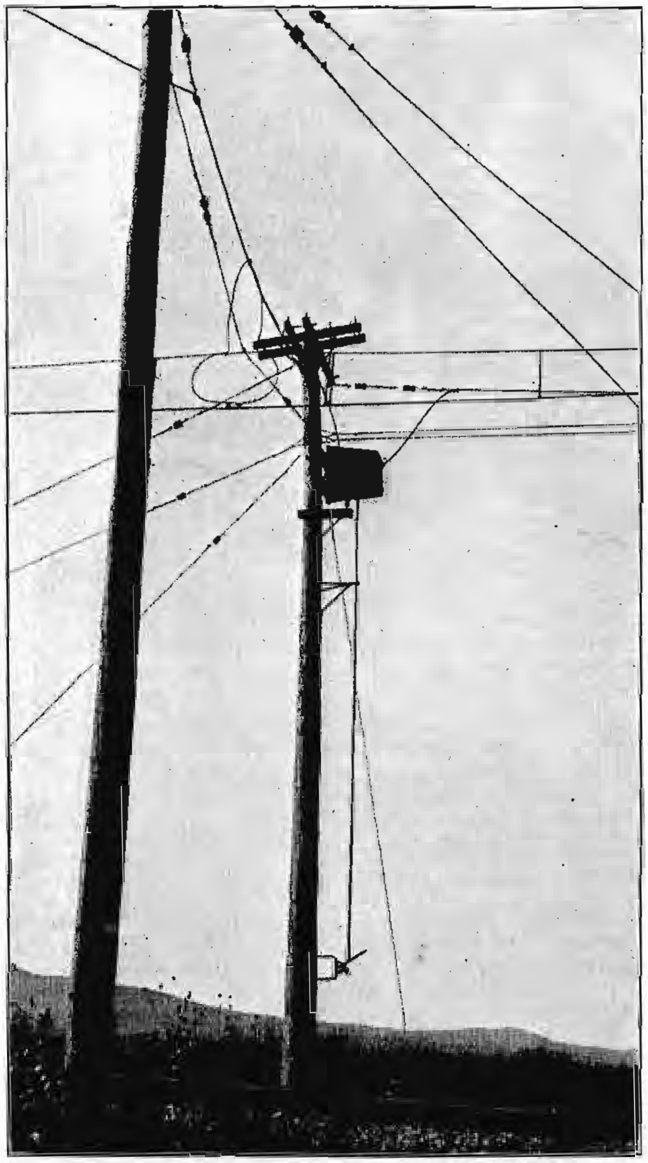
Where there is more than one track two-pole span construction is used. The maximum number of tracks spanned is nine in Deer Lodge yard. In yards the cross catenary span supports an intermediate or "steady" span which in turn supports the messenger wire. It is not designed to relieve the cross catenary of any load but is adopted simply to steady the messenger wire.

The negative or return system consists of the track rails and an auxiliary ground wire. The track rails are bonded with ⅝-in. copper bonds placed either under or outside the angle bars, depending on the type of joint in use. The return ground wire consists of a ½-in. copper cable carried on the top of the trolley poles without insulators. It is connected to the rails at every second signal station. In addition to providing protection for trackmen, this ground wire, located above the trolley, feeder and signal wires, affords effective protection from lightning for all these circuits and eliminates the necessity for lightning arresters for the first two. At tunnels the ground wire is hung from the side wall about six feet above the track.

THE LOCOMOTIVES

At the present time 43 locomotives have been ordered, the first of which are now being delivered. These locomotives are the first to be built for so high a potential as 3,000 volts d. c. The passenger and freight locomotives are similar in all respects except that the former have a gear ratio permitting the hauling of a trailing load of 800 tons at 60 miles per hour. The passenger locomotives are also provided with oil-fired steam-heating outfits for the heating of the trains. The interchangeability of parts for these freight and passenger locomotives will be of material assistance in the maintenance of this equipment.

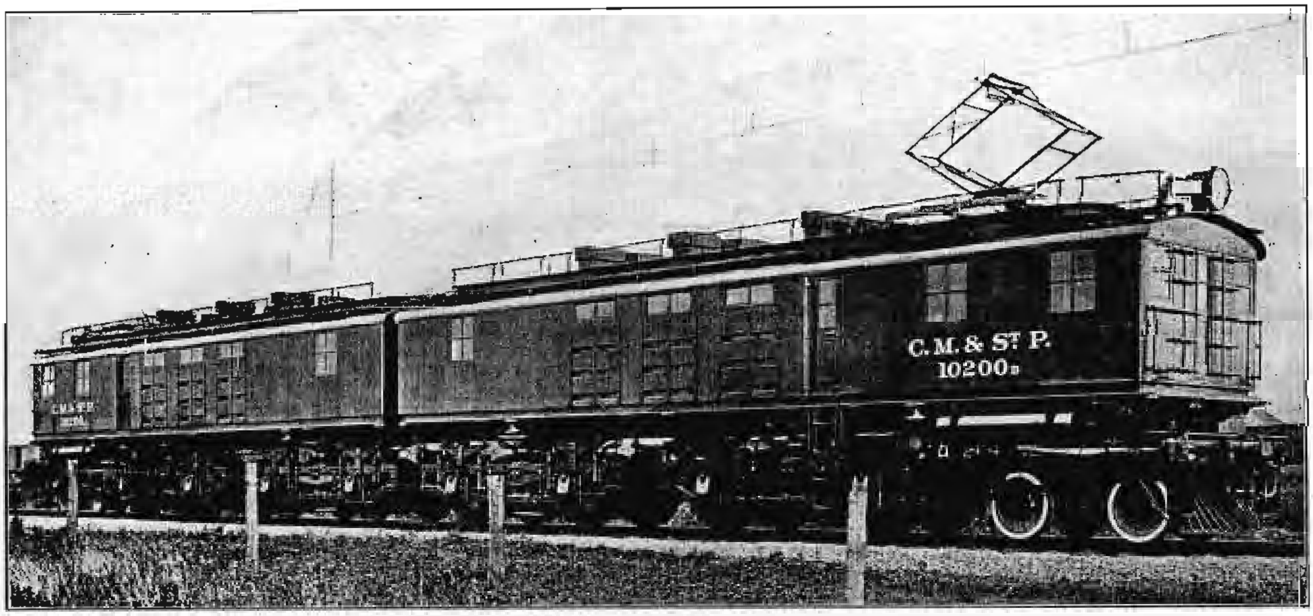
The cab consists of two sections each approximately 52 ft. long. The outer end of each section contains a compartment for the engineer and helper and the remainder is occupied by the equipment. The engineer's compartment is double lined, with hair felt insulation, while a 3,000-volt heater driven by a small motor removes the cold air from the floor. Each locomotive carries eight motors, each with a normal one-hour rating of 430 hp. and a continuous rating of 375 hp. or a total continuous rating of 3,000 hp. With a 30-per cent co-efficient of friction the tractive effort available for starting trains is approximately 135,600 lb. Each motor is twin-geared to its driving axle, a pinion being mounted on each end of the armature shaft. The rim of the gear is mounted in such a way that its relation with the spider is fixed by springs, allowing flexibility between the two. The motor is of the commutating pole type with openings for forced ventilation provided by a motor-driven



A Sectionalizing Switch Beyond the End of a Passing Track

blower in the cab. Each locomotive is equipped with a speed recorder and with flange oilers provided with an electric heater. The headlight is of the incandescent type with a 30-volt, 150-watt lamp. Each locomotive is also provided with a watt-hour meter showing the amount of power consumed at any time, which will be of value in figuring the cost of moving any particular train or class of traffic. Each half of the locomotive is equipped with an air compressor working against a pressure of 135 lb. in the main reservoir. Each compressor has a capacity sufficient to hold an ordinary train on these grades.

The passenger locomotives are designed to haul 800 tons on all grades up to two per cent and will maintain the present schedule with 650 tons. With trains heavier than this or on grades of two per cent, a second locomotive will be added. They are expected to handle such trains at a minimum speed of 30 miles an hour, while the maximum allowable speed is 60 miles per hour. The speed down the heavy grades is limited to 25 miles an hour by the operating rules of the road. Short local passenger trains will be operated by single units or half locomotives. In descending grades, the passenger locomotives are so arranged that one-half may be returning power to the line while the second unit will provide lights for the train or charge the storage batteries. These functions are interchangeable and under the control of the engineer.



One of the Electric Locomotives

The freight locomotives are designed to haul 2,500 tons trailing on one per cent grades at a speed of 16.8 miles per hour. On all other grades in this line a second locomotive will enable trains of the same weight to be handled. The maximum speed of the freight locomotives is 30 miles per hour, while freight trains are limited to 15 miles per hour descending the heavy grades.

Six electric locomotives will be assigned to helper service on the Rocky Mountain division. With the original installation on this division, switching service will demand one electric locomotive each at Three Forks, Butte and Deer Lodge. With the completion of the work to Avery an additional switching loeomotive will be required at Alberton. Special facilities will be provided at Deer Lodge for the maintenance of the electrical equipment.

The general characteristics of the locomotives are given below:

Total weight	284 tons
Weight on drivers	226 tons
Weight on each guiding truck	58 tons
Number of driving axles	8
Number of motors	8
Total length of locomotive	112 ft.
Rigid wheel base	10 ft. 6 in.
Voltage	3,000 d.c.
Voltage per motor	1,500 d.c.
Horsepower rating, one hour, each motor	430
Horsepower rating, continuous, each motor	375
Horsepower rating, one hour, complete locomotive	3,440
Horsepower rating, continuous, complete locomotive	3,000
Trailing load capacity, 2 per cent grade	1,250 tons
Trailing load capacity, 1 per cent grade	2,500 tons
Approximate speed at these loads and grades	16 m.p.h.

This electrification has necessitated the changing over of the present automatic signals to alternating current. These signals now extend from Three Forks to Lennep, 78 miles, from Piedmont to Butte, 37 miles, and from St. Regis to Haugan, 19 miles. Additional signals are now authorized between Butte and Finlen, 13 miles. These are being built not alone to eliminate electrical interference, but also to improve the view of the signals by placing them lower and in new locations.

This installation is being made under the direction of C. A. Goodnow, assistant to the president, and R. Beeuwkes, eleetrical engineer of the St. Paul. The General Electric Co., Schenectady, N. Y., is building all equipment. The Montana Power Company is the contractor for the construction of the transmission and trolley lines and for the installation of the substation equipment. All building work is being done by company forces. The work on the first district was started in June, 1914, but was suspended nearly all summer by labor disturbances, so that it really began about a year ago.

The English Railwaymen's Wages Question.—The question of a proposed increase of wages in substitution for the war bonus granted to railwaymen in February last has been under discussion by the executive committee of the National Union of Railwaymen, which has forwarded a request to the railway companies to receive a deputation on the matter. The railway companies have now before them the men's request for an advance of wages and also for a joint conference on the questiou, but no definite arrangements in either respect have yet been eoncluded. Meanwhile, the executive committee of the National Union of Railwaymen have strongly deprecated any precipitate ill-advised or sectional strike in this hour of national crisis. A railway conciliation board meeting at Cardiff has satisfactorily settled the dispute of the Taff Vale engine drivers and firemen over reductions in grade and pay, which at one time threatened to give rise to considerable trouble.—*Railway Gazette, London.*