Pole Lines of C. M. & St. P. Electrification

A Description of the Montana Power Company's Transmission-Line Construction and the Chicago, Milwaukee & St. Paul Railway Company's Trolley-Line Construction, With Comparative Costs on the Use of Wood Poles and Steel Towers

AMONG the many features of the electrification of the Rocky Mountain and Missoula divisions of the Chicago, Milwaukee & St. Paul Railroad and the power distribution system of the Montana Power Company, which furnishes energy for the operation of the trains, one of the most interesting is the pole-line construction. The magnitude of this work can be shown by the statement that in the electrification of 440 miles of main line, from Harlowton, Mont., to Avery, Idaho, approximately 38,000 poles were used in the construction of the power transmission system. This system includes the high-tension transmission line, the positive or outgoing feeder system, the overhead contact system and the negative or return system.

High-Tension Transmission Line.

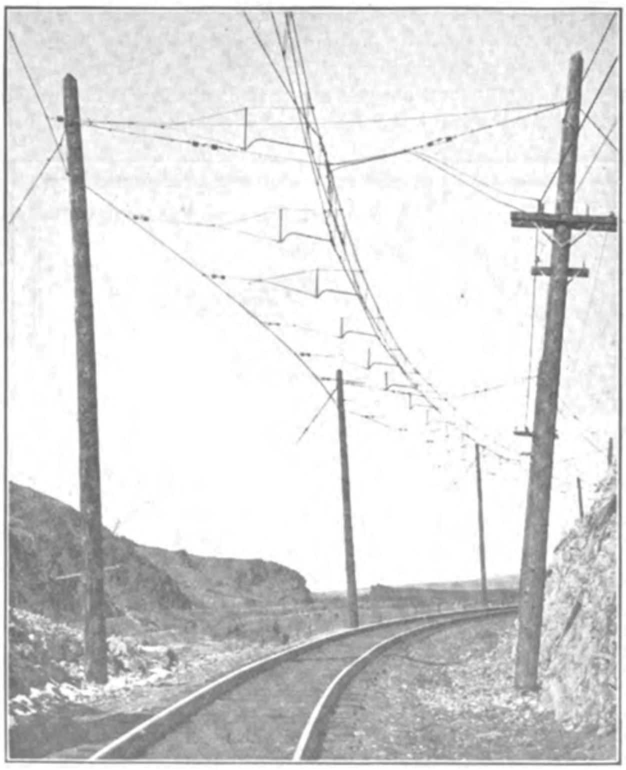
The Montana Power Company's transmission line transmits three-phase alternating current at a pressure of 100,000 volts. For the major part of the distance the line is located on the railroad company's right of way, and while this is convenient for inspection from trains and economical distribution of materials for construction and repairs, it was necessary and desirable in certain localities to erect the pole line outside of the right of way in order to effect a saving in distance or to avoid physical obstructions.

Poles of the best quality Western Red Cedar, purchased under usual specifications and inspected before being shipped, were used throughout. The standard sizes for the transmission line are 45 and 50 feet in length with eight-inch tops. Lengths between 45 and 80 feet were used to take care of grading the line and local conditions. The standard pole spacing for tanget work on level ground is 440 feet. This distance is varied to suit conditions as regards to curvature or topography of the country, in some sections it being necessary to make the spacing from 1,200 to 1,400 feet.

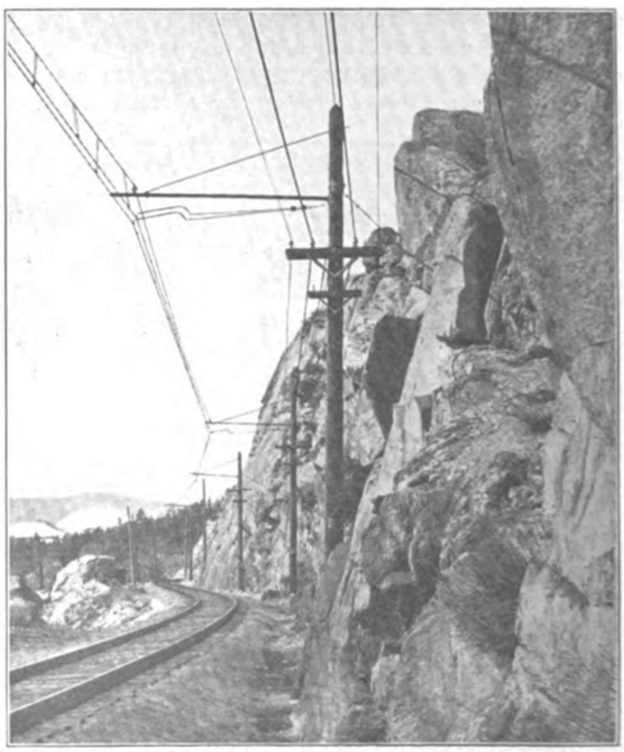
The crossarms used are Washington fir, with a cross section of 4.75 by 5.75 inches, and on tangent work they are braced by galvanized steel flats, 0.25 by 2 inches, fastened to crossarms with 0.625-inch carriage bolts and to poles with 0.625-inch lag screws. The crossarms are fastened to the poles with 0.75-inch bolts. On curve and angle work, including angles up to 10 degrees, the crossarms are offset to provide clearance between the wires and the poles, the amount of offset being dependent upon the degree of the angle or curvature. The crossarms are braced with angle irons. Drop brackets made of angle irons are used for insulator suspension on the ends of the arms protruding the most, while on the shorter side suspension is by means of crucible-steel castings with eyes. On angles between 10 and 30 degrees two poles are used with double crossarms and are heavily guyed. On angles greater than 30 degrees two poles are used, spaced far enough apart to maintain the proper distance between wires. One pole carries insulator suspensions for two wires and the other pole one insulator suspension. Both poles are heavily guyed, there being four separate guys for each pole.

Where the transmission line crosses the tracks or over telephone, telegraph or other power circuits, it is strengthened both mechanically and electrically as a matter of safety. The line is dead-ended and the type of construction shown in the accompanying illustration is used.

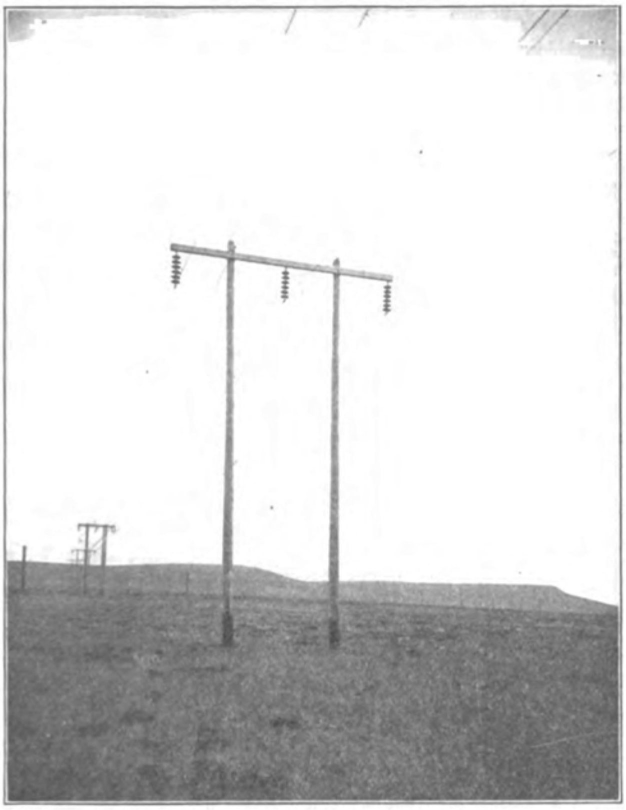
Where the spacing between poles is 450 feet or more, double crossarms are used and the poles are side-guyed. In marshy ground, or where poles are exposed to wash, standard poles are side-guyed and banked with rock.



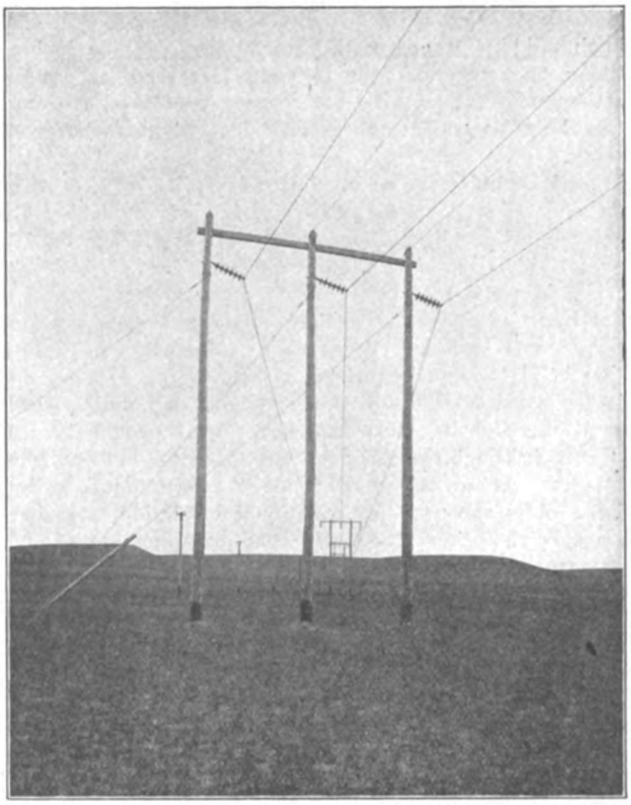
A 10-Degree Curve on the Chicago, Milwaukee & Paul Electrified Line.



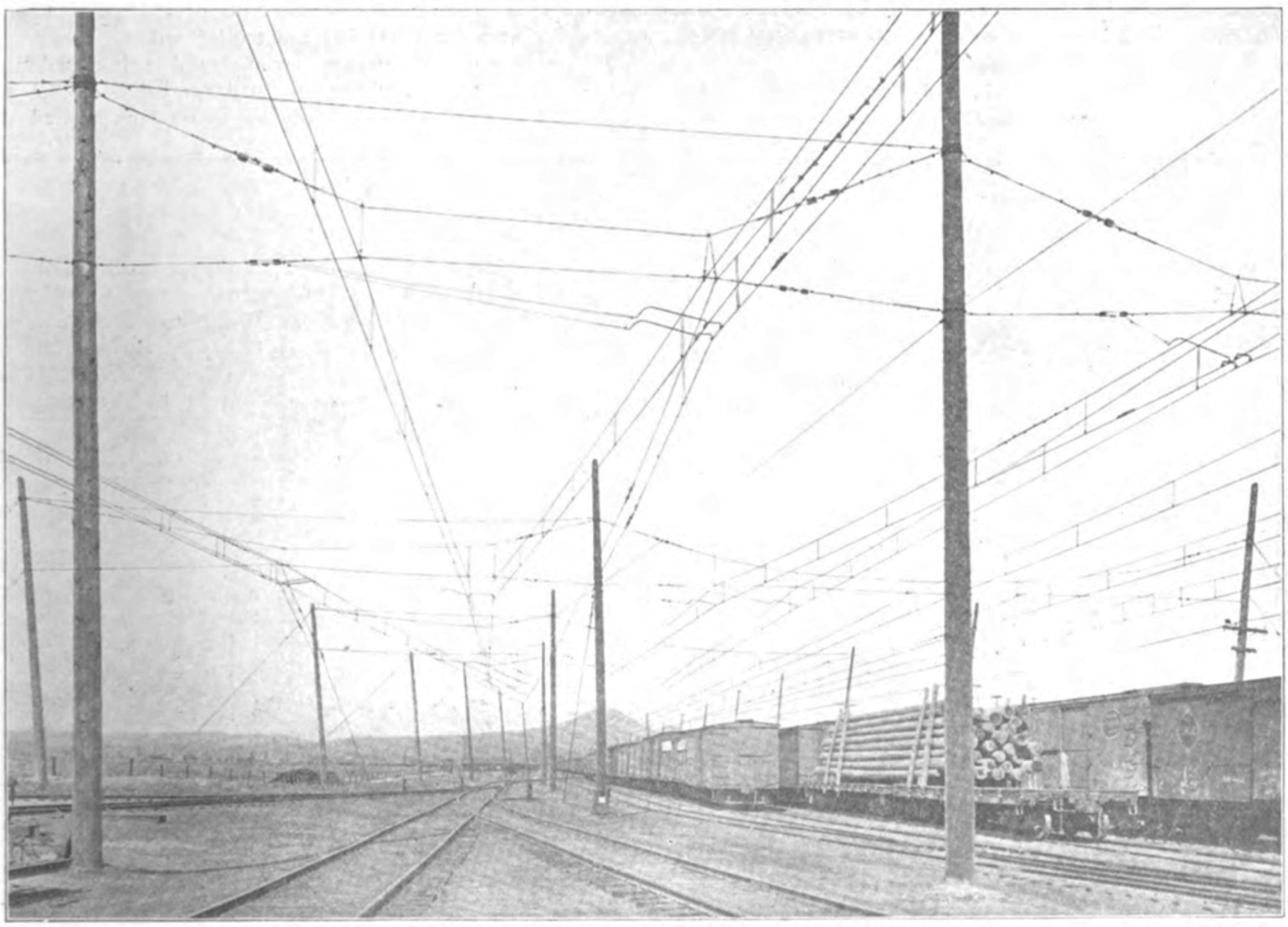
Pole-Line Construction on Curve on a Two-Per-Cent Grade.



Straight-Line Construction of Montana Power Company, Serving Chicago, Milwaukee & St. Paul Line.



Curve Construction Used by Montana Power Company, Serving Chicago, Milwaukee & St. Paul Line.



Overhead Construction in Butte Yards, Chicago, Milwaukee & St. Paul, 3,000-Volt Direct-Current Electrification.

The pole guys used are of three-eighths and three-fourths-inch steel strand wrapped around poles and secured with Crosby clips. Anchors are three-fourths or one-inch mild-steel rods, with timber slugs of nine inches minimum diameter and four to eight feet long, as conditions demand. Where solid rock was encountered a heavy steel eyebolt, securely set, was used instead of anchor rod and slug.

The disk or unit type of insulation is utilized. The single top type consists of a glazed porcelain disk, 10 inches in diameter, with annular ridges on the under side cemented to a malleable iron cap and pin with ball end. The hook is locked into the cap by means of a cotter pin and cannot be removed from the eyebolt or other attachment to pole without removing the cotter. The standard suspension insulator consists of six disks.

The suspension clamp is nine inches long and curved down at the ends to clear the wire. It is provided with two five-eighth-inch clamping bolts with a shim between the wire bolts. At anchorage and heavy strain points seven insulator disks are used for additional insulation, together with a special anchor clamp and four clamping bolts.

The three conductors each consist of six strands of No. 6 B. & S. gauge copper wires with a hemp core, the latter being saturated with perservative compound to make it impervious to moisture. The sag in conductors was carefully calculated for various lengths of spans and temperatures. The wire was strung with the aid of horses and was pulled to specified tension, the tension being checked by use of a spring balance.

Feeder and Contact Systems.

A single line of poles carries the positive or outgoing feeder system, the overhead contact system and the negative or return leads. The rails are also used as part of the return system.

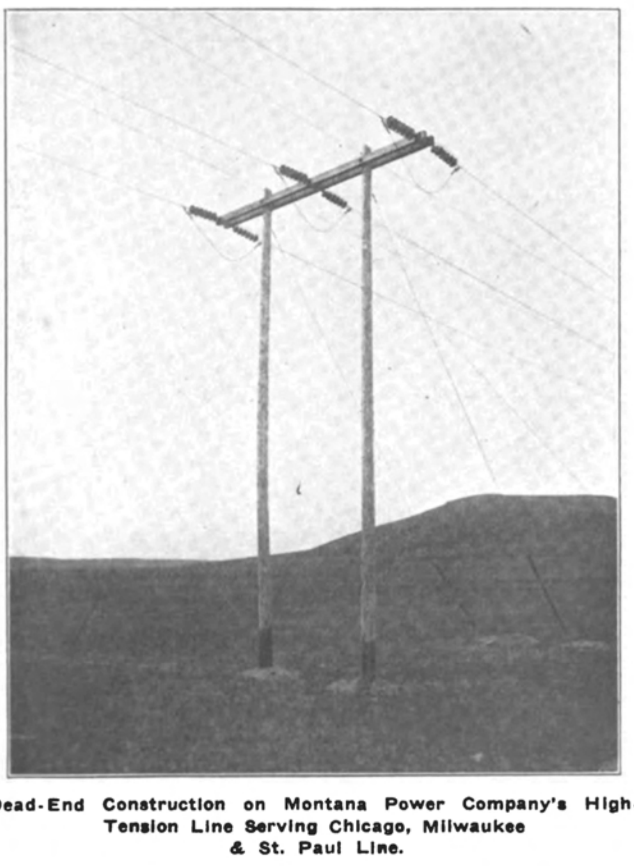
Like those used in the erection of the transmission system, the poles are of Western Red Cedar, the standard length being 40 feet with eight-inch top. For the trolley work, lengths ran as high as 55 feet for spans in yards where a number of tracks are included. The standard spacing on tangent track for the trolley system is 150 feet. This spacing varies with the track curvature and special installations near switches, there being some spacings of 70 feet, but comparatively few below 90 feet. Spacing changes were made in multiples of 15 feet.

The crossarms are Washington fir, with a cross-section of 3.75 by 4.75 inches, and are fastened to the poles by means of 0.75-inch bolts and standard braces, 1.25 by 0.25 by 28 inches, the later being attached to the crossarms with 0.375-inch carriage bolts and to the poles with lag screws 0.5 by 5 inches. Crossarm pins are strenght-grained second-growth locust.

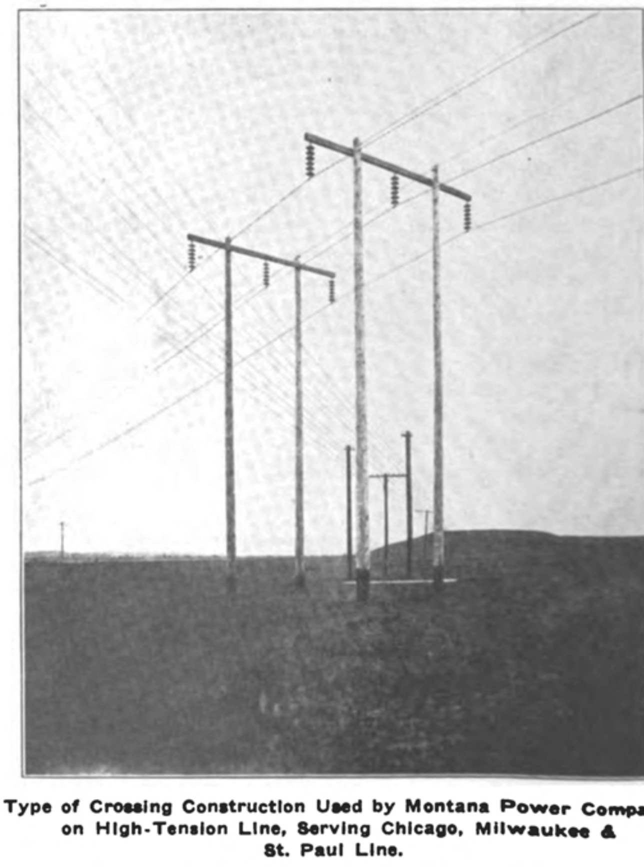
Wherever conditions permitted the bracket type of trolley-wire support was used, this type being preferable because of its appearance, of its offering the least obstruction to view from the locomotive, to its cheapness, and to the fact that it occupies the least space of any of the types used. On some curves and at points where there is more than one track, span construction is used. Where there are more than two tracks, two cross spans are used. The upper span carries practically the entire load, the lower span serving the messenger or trolley supporting wires and sustaining a part of the weight.

Trolley bracket arms are made up of 2.5 by 2.5 by 0.3125-inch "T" iron with a 0.6125-inch oversupport or truss rod and malleable castings for the attachment of truss rod to the arm and the arm to the pole. The latter casting is fastened to the pole by means of two lag screws. The truss rod passes through the pole and is secured by a nut and washer, the latter being large enough to give the full diameter of the pole for support. The pin for supporting the messenger insulator is malleable iron and clamped on the arm with a hook bolt. This method of attachment is cheap and effective and provides adjustment along the arm for centering the trolley wires.

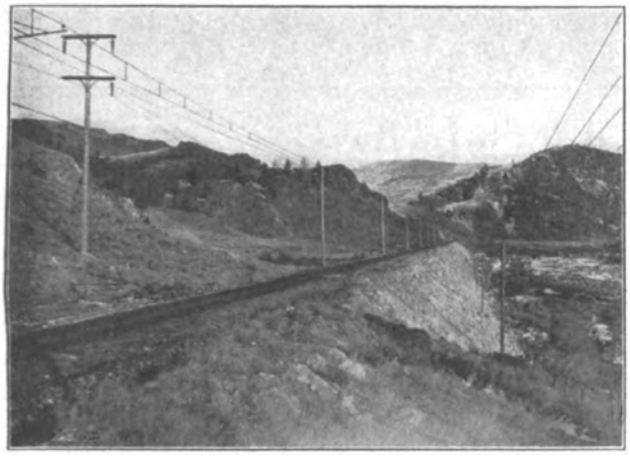
In the span construction seven-strand galvanized-steel cable of a size suitable for the load carried is used. Attachment to the pole was made by two wraps around the



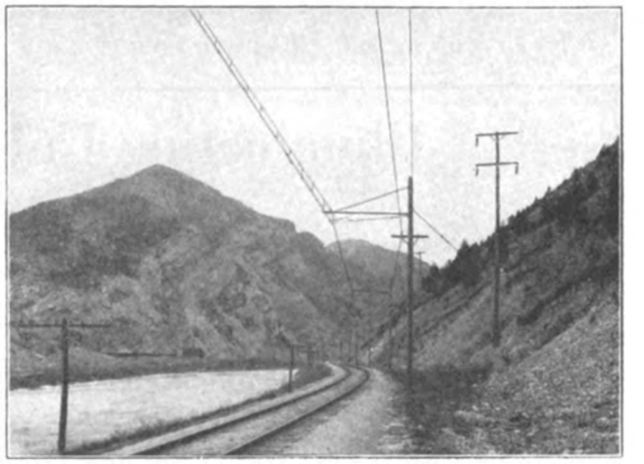
Dead-End Construction on Montana Power Company's High-Tension Line Serving Chicago, Milwaukee & St. Paul Line.



Type of Crossing Construction Used by Montana Power Company on High-Tension Line, Serving Chicago, Milwaukee & St. Paul Line.



Overhead Construction and Transmission Line Near Durant, Mont.



Overhead Construction and Transmission Line in Jefferson River Canon, Montana.

pole with shims between the strand. As in the transmission-line construction guys are seven-strand galvanized-steel cable and anchors are three-fourths and one-inch diameter, slugs being used for anchoring.

The positive feeders are of stranded bare copper cable, two sizes being used, one 500,000 circular mils and the other 750,000 circular mils. For the greater part of the distance a single cable of the smaller size is used, but on the heavier grades two feeders are required. The feeder is connected with the trolley wires at intervals of about 1,000 feet with bare copper stranded 250,000-circular-mil cables.

The overhead contact system consists of the messenger, which is attached to the bracket arm and supports the weight of the trolley wire through the hangers, the hangers and two trolley or contact wires, together with the necessary attachments for splicing, trimming and anchorage of both messenger and trolley wires. In some respects the contact system is a departure from former practice. The principle improvement is the use of two contact wires which hang side by side, and since the hangers are staggered there is always a flexible section of wire in contact with the current collector. This provides for the collection of a large amount of power at high speed without sparking. Such a flexible contact system takes care of troubles due to the inequalities in the track, movement in the locomotive body, and inertia of the adjustable contact device. The trolley or contact wires are free to move vertically and horizontally, giving a traveling contact wave in the wires with practically no change in weight or flexibility.

The messenger, which is 0.5-inch, high-strength, seven-strand steel cable, hangs in flat loops between the supports, the lengths of hangers being made to suit the location on the loops so that the trolley wires are practically level when pulled to the proper tension. The hangers are of 0.6125 by 0.125-inch steel looped over the messenger, which leaves the trolley wires free to move in a vertical plane. Clips fastening the hangers on the trolley wires are of malleable iron and fastened with a 0.5-inch bolt with lock washer. The entire hanger is sherardized for protection against rust.

The trolley wires are of hard-drawn copper, No. 0000 B. & S. gauge. At average temperatures the tension is about 1,300 pounds. The trolley wires are grooved so as to permit the use of mechanical clips which will clear the contact surface of the wire.

The negative or return system consists principally of the track rails, which are bonded together with bare copper cable 0.6125 inch in diameter. There is a supplementary negative return circuit which consists of a bare copper cable, No. 0000 B. & S. gauge, and which is attached directly to the tops of the trolley poles with no insulation. This cable is connected to the track rails at a large number of points by taps which are attached to the poles and covered with molding. The supplementary negative wire, being located above the positive feeder trolley and the signal wires, affords effective protection against lightning for these circuits.

On all "live" work in the system, there are two insulators in tandem, so if one should break, insulation will be maintained, under normal conditions, until replacement can be made.

Comparative Costs of Wood-Pole and Steel-Tower Construction.

Data has been prepared on the costs of two transmission lines erected by the Montana Power Company, one being of wood-pole construction and the other of steel-tower construction. The figures give the actual costs of the company's Great Falls-Butte steel-tower line and the East Helena-Josephine wood-pole line, both of which are

UNIT COST PER MILE OF WOOD POLE TRANSMISSION LINE. NO. 0 COPPER WIRE, 100,000 VOLTS.

Supports	$ 203.80
Power wire	955.00
Ground wire	141.95
Telephone system	121.20
Power insulators	239.50
Power crossarms	29.45
Power hardware	28.75
Line switches	21.55
Creosote treatment	60.50
Clearing	30.80
Hauling	149.40
Digging	61.20
Framing	40.20
Setting	43.80
Stringing	87.50
Guying	21.38
Guarding	3.59
Survey	39.80
Camp	67.50
Tools	14.62
Hospital-injuries and damages	6.10
Roads	.13
General expense	55.00
Injuries during construction	.77
Total	$2,423.49

UNIT COST PER MILE OF STEEL TOWER TRANSMISSION LINE NO. 0 COPPER WIRE, 100,000 VOLTS.

Towers	$ 615.38
Copper wire	955.00
Steel wire	141.95
Insulators	108.85
Hauling	181.33
Unloading	14.23
Digging	165.55
Setting	31.90
Assembling	77.17
Erecting	60.25
Stringing	117.52
Survey	20.40
Camp	122.33
Tools	28.71
Switches	115.38
Guying	46.24
Telephone	259.05
General expense	128.52
Total	$3,189.76

similar lines as to carrying capacity and differ only in the supporting structures used. The steel towers are single-circuit towers with horizontal crossarms, and the pole structures consist of two 45-foot Western Red Cedar poles, with eight-inch tops, supporting a single horizontal crossarm. The comparative costs are given in the accompanying table and indicate a considerable saving by the use of wood-pole construction.