Electrical Equipment for the Chicago, Milwaukee & St. Paul

Motive Power, Substations, and Transmission-Line Construction for 2400-Volt Direct-Current Electrification in Rocky Mountains

AFTER careful consideration the Chicago, Milwaukee & St. Paul Railway has decided to use 2400-volt direct current catenary system for the proposed electrification of its Rocky Mountain division between Three Forks and Deer Lodge, Mont., a distance of 113 miles, corresponding to approximately 168 miles of single track. This covers one freight division.

The trolley will be fed from five substations containing synchronous motor-generator sets, step-down transformers and necessary switching apparatus located at the following proposed sites: Morel, 17 miles east of Deer Lodge; Newcomb, 46 miles east of Deer Lodge; Grace, 63 miles east of Deer Lodge; Piedmont, 78 miles east of Deer Lodge, and one at Three Forks. The sites of these substations may be varied slightly if later investigation shows such changes desirable. These stations will receive energy from the 100,000-volt transmission line of the Great Falls (Mont.) Power Company. No decision has been reached with regard to the type of either the passenger or the freight locomotives. It is probable that twelve locomotives will be required for freight service. The freight locomotives will be required to haul a trailing load of 2500 tons up a 1-per cent grade at a speed of approximately 15 miles per hour. The passenger locomotives will be required to handle a trailing load of 800 tons on level track at approximately 50 miles per hour, and on a 2-per cent grade at approximately 24 miles per hour. The current will be taken by means of roller pantograph collectors. Trains will be heated by means of oil-burning steam boilers.

All the locomotives, both freight and passenger, will be provided with regenerative control. The air brakes will be used only for stops and in emergencies.

SUBSTATIONS

Based upon the investigation of the locomotive performance on the ruling grades in the electrified zone, it has been decided to install in each substation supplying gradients of over 1 per cent a capacity of three 1500-kw units, two being in operation and the third held in reserve. Although the starting of a train calls for practically 100 per cent overload upon the two units in operation, a 200-per cent overload for five minutes' guarantee will furnish ample capacity to start a train of maximum tonnage on a maximum grade.

For gradients up to 1 per cent energy will be furnished from a two-unit substation containing two 1500-kw motor-generator sets, each having a maximum load capacity of 4500 kw for a period of five minutes. It is the intention to use one 1500-kw unit in operation with the second as reserve, to be used in emergencies such as disablement of the operating unit or a congestion of trains requiring them to be operated in fleets.

Basing the substation capacity and location on the foregoing limitations, it is proposed to install three three-unit and two two-unit substations on the 113-mile division between Deer Lodge and Three Forks, Mont. In each case the substation building will be designed to accommodate an additional unit which may be installed when future traffic conditions make it desirable. All substation units are to be of the same size and will comprise a sixty-cycle synchronous motor direct-connected to two 750-kw 1200-volt direct current generators connected in series for 2400 volts. Each motor-generator set will be fed from three single-phase step-down transformers reducing from a transmission potential of 100,000 volts to 2300 volts at the synchronous-motor terminals. Each motor-generator set will be equipped with two exciters, one for the synchronous motor and the other for the fields of the generators, thus making the motor-generator set, step-down transformer and exciting generators, together with the controlling switchboard, a complete unit in itself.

It is proposed to erect the substation buildings of brick on concrete foundations with a concrete roof supported on steel girders which provide a foundation for the overhead high-voltage bus bars. Each building will be equipped with a crane of sufficient capacity to move the heaviest part of the substation apparatus. Transformers will be of the self-oil-cooled type, placed in a roofed transformer room with tracks to facilitate installation and repairs. The accompanying table presents the equipment and capacity of each substation.

SUBSTATIONS AND THEIR EQUIPMENT

Location	Equipment	Total Capacity
Morel	2-1500-kw	3000 kw
Newcomb	3-1500-kw	4500 kw
Grace	3-1500-kw	4500 kw
Piedmont	3-1500-kw	4500 kw
Three Forks	2-1500-kw	3000 kw

Energy will be supplied to the locomotives by means of roller contact with an overhead copper trolley wire located at least 24 ft. above the rail. The trolley wire will be of No. 0000 copper and suspended from a steel catenary cable. This catenary construction will be supported by bracket arms extending from wooden poles, except on the sharper curves, where two poles and span wire construction will be employed. The single pole bracket construction is to be followed wherever possible, because it affords less obstruction to view and is also less expensive than span construction. Where two or more tracks are to be spanned span construction with wooden poles will be employed. Where the number of tracks exceed four, steel construction will be used.

The overhead trolley will be supplemented by feeder copper in order to restrict the energy losses in the 2400-volt conducting circuit to a reasonable amount. However, only a portion of the complete feeder system will be installed until such time as the maximum tonnage of trains has been reached and the frequency of train service more definitely determined. For immediate installation the feeder copper will be as follows: Deer Lodge to Colorado Junction, 750,000 circ. mil.; Colorado Junction to Piedmont, 1,000,000 circ. mil.; Piedmont to Three Forks, 500,000 circ. mil. The details of track bonding have not yet been decided.

The Great Falls (Mont.) Power Company proposes to construct new transmission lines where necessary to deliver electricity to the Chicago, Milwaukee & St. Paul Railway electrified zone. This power will be supplied in about the following capacities: Deer Lodge, 20,000 kw; Butte, 10,000 kw; Three Forks, 3000 kw. This arrangement necessitates building a new duplicate transmission line from Great Falls to Deer Lodge. As the proposed feeding-in points of the Great Falls Power Company do not coincide in all cases with the location of the substations, the railway will install a transmission line to tie in these feeding points to each of the several substation sites. This transmission line will follow the railway company's right-of-way, except at some points where it is possible to cut across the country and save distance.

Owing to the great distance from the right-of-way of the railway company to the source of power at Great Falls, it was found necessary to adopt a transmission potential of 100,000 volts, both for the Great Falls transmission lines and for the single-circuit transmission line on the railway company's right-of-way. This high potential permits a shift in loads to different parts of the system without excessive loss. The transmission line built along the railway company's right-of-way and connecting the several substations will include the 100,000-volt line suspended upon 45-ft. wooden poles by a six-unit suspension-type insulator.

Draining Retaining Walls

IN the extensive retaining-wall construction through the Watsessing depression on the Montclair branch of the Delaware, Lackawanna & Western Railroad, described in the issue of Dec. 20, 1913, page 687, special care was taken to secure ample drainage. The walls were built in 20-ft. sections, without horizontal joints, and with tongue-and-groove vertical joints to impede the flow of water as much as possible. The joints were waterproofed for the full height of wall and for a width of 18 in. on either side of the joint. Burlap and asphalt were the waterproofing materials used, the burlap being placed two ply, with coats of asphalt placed alternately. Gasoline was burned on the concrete surfaces to remove any moisture. Just above the top footing at each joint a 4-in. drain was carried through the wall in the customary manner, but at the inner end of each pipe was set a right-angle elbow, turned upward. Loose rock was then piled around the elbow and up to the full height of the wall in a column about 3 ft. longitudinally and 2½ ft. transversely.

With the use of the elbow for each drain it was thought that the water, trickling down through the rock drain, would come to rest at the bottom, and would gradually deposit its suspended matter around the pipe. When this sedimentation reached the rim of the open pipe it was believed that the water washing over the rim of the pipe would carry the sediment in small amounts entirely through the pipe, thus keeping the drain open longer than if the elbow had been omitted. Eventually, it was figured, the sediment would form a natural funnel at the mouth of the drain.

The arrangement was carried out by Mr. W. H. Speirs, resident engineer, under the direct supervision of Mr. G. T. Hand, division engineer, and the more general direction of Mr. G. J. Ray, chief engineer.