Chicago, Milwaukee & St. Paul Electrification in Washington

Good Progress Being Made on Cascade Mountain Electrification—Principal Features of Power, Feeder and Trolley Lines, Substation and Locomotive Equipment

By W. A. SCOTT

ELECTRIFICATION of 218 miles of Chicago, Milwaukee & St. Paul Railway line from Othello, Wash., to Seattle and Tacoma, has progressed to the point where the poles and fixtures for supporting the power-transmission wires, and those for the trolley, feeder and other wires, are nearly all in position. The substation buildings between Othello and Tacoma are completed and a portion of the substation equipment is on the ground and installed.

As mentioned in earlier issues of the ELECTRICAL REVIEW, the present electrification is the largest and most important development of this kind now under way. Added to the 441 miles of previously electrified line from Harlowton, Mont., to Avery, Idaho, it will give this progressive railroad about 660 miles of electrified trunk line through the Rocky and Cascade Mountains and neighboring ranges.

SUBSTATIONS.

The eight substations, which are situated at an average distance of 28 miles apart, are of brick construction with flat roofs covered with tar and gravel, except that two of them in the regions of heavy snow have sloping roofs covered with a special roofing composition. Each substation will have two or three bungalows adjoining it for the operators.

Beginning at Othello and proceeding westward, the substations are named in the following order: Taunton, Doris, Kittitas, Cle Elum, Hyak, Cedar Falls, Renton and Tacoma. The substation location in each case corresponds to that of the regular railroad station at the respective towns.

POWER LINE CONSTRUCTION.

At Taunton substation, which is 9.2 miles west of Othello, a connection is made with the Long Lake hydroelectric station of the Washington Water Power Co., by a 110,000-volt transmission line 170 miles in length; and at Cedar Falls substation with the Snoqualmie plant of the Puget Sound Traction, Light & Power Co. by a transmission line about 10 miles in length. The latter company is building a new substation at its Snoqualmie plant in which to step up the generator voltage to 110,000 for transmission to the Milwaukee railway company. The Puget Sound Traction company's new substation will contain three 4500-kv-a. transformers, of General Electric type, and one in reserve, all to be outdoor installations, to be completed by July 1. It will also include a special type of large disconnecting switches being furnished by the Electrical Engineers' Equipment Co., of Chicago. The Milwaukee company, as in its previous electrification work, is constructing its own transmission tie lines.

In this power-line construction the Milwaukee company will have between Taunton and Cedar Falls a 6-strand No. 00 copper cable with a hemp center, making a 133,000-circular mil cable having a diameter of 0.446 in. The line from Cedar Falls to Renton and Tacoma, via Snoqualmie Falls, has six strands and a hemp center, with a cable diameter of 0.938 in. The Long Lake-Taunton line consists of seven No. 8 wires, giving a cable diameter of 0.3855 in. and 115,000 circular mil area.

SUBSTATION EQUIPMENT.

The Milwaukee company erected its own substation buildings, which are T-shaped, providing for a 50 by 84-ft. high-tension room in the rear, and a 30 by 60-ft. room in front for motor-generator set. Taunton, Doris and Kittitas substations are being equipped by the Westinghouse Electric & Manufacturing Co. and those at Cle Elum, Hyak, Cedar Falls, Renton and Tacoma are being equipped by the General Electric Co. Those at Taunton and Tacoma are 2-unit stations, with the two units to be installed. Doris, Hyak and Cedar Falls are 3-unit stations, with two units installed in each case. Cle Elum and Renton are 2-unit stations with one unit installed in each one. These are all 2000-kw. units.

The purpose herein is to describe the equipment in one of the substations installed by the Westinghouse Company and that in one of the substations installed by the General Electric Co. as typical of the two types of installations.

TAUNTON SUBSTATION.

The Taunton substation, which is supplied with Westinghouse apparatus, contains two oil-insulated, self-cooling tubular type transformers for indoor service. These are shell-type transformers rated at 2500 kv-a., 3 phase, 60 cycles, with high-voltage winding for 102,000 volts, and low-voltage winding for 2300 volts. Additional taps are provided on the high-tension winding to give 97,200 and 92,400 volts at full capacity. Taps for 1150 volts are provided on the low-tension winding to afford the starting voltage for synchronous motor of the motor-generator sets. The transformers are connected in star on the high-voltage side and in delta on the low-voltage side. Each transformer is connected to and has the corresponding capacity for supplying one motor-generator set.

The high-tension windings are made up of flat coils to keep the voltage stresses between coils low. Each coil is wound with layers of thin copper ribbon, which is bare, but as the coil is wound the conductor is automatically insulated with layers of paper and cloth applied through a folding tool.

Taps in the high-tension winding are placed in the body of the winding instead of at the ends where they would be exposed to the effects of line surges. The low-tension coils are made up of rectangular copper conductors in multiple, each one being covered with two layers of cotton insulation. The transformer

tanks are of boiler plate, having a cover bolted to the top, with a gasket between tank and cover, making them air tight.

The leads and taps from the high-tension coils are connected to the terminals, the latter being carried by insulating supports mounted upon the barriers between the coils, forming a terminal arrangement free from grounded supports. The three high-tension leads are carried through the cover by bushings of the condenser type. The five low-tension terminals are brought through suitable bushings in the cover, the terminal boards being mounted inside the transformer case.

This substation contains two motor-generator sets, each consisting of two 1000-kw., 6-pole, 1500-volt, direct-current generators connected in series and driven by a 3-phase, 60-cycle synchronous motor. The motor and two generators are on the same shaft and bedplate. There is an exciter at each end of the shaft, one for the generators and one for the synchronous motor. The normal full-load output of each set is 2000 kw., at 514 r.p.m., 3000 volts, 667 amp. The exciter for the generators is rated at 10 kw., 125 volts; the exciter for the synchronous motor is rated 30 kw., 125 volts. It has a special winding, arranged to automatically hold the power-factor on the motor at 95% leading when delivering maximum load, with provisions for adjusting the power-factor setting to give unity or leading power-factor between one-half and full load.

The power company's feeders are controlled by 110,000-volt, 200-ampere, remote-controlled, hand-operated oil circuit-breakers, having a very high ultimate rupturing capacity at the arc. These are provided with bushing-type current transformers operating the protective relays. Each oil circuit-breaker is controlled from a panel located in the middle wall and on which is mounted the controlling, operating and indicating mechanism and disconnecting switch. The incoming power line and railroad 3000-volt feeder lines are equipped with static voltage detectors. The main switchboard contains nine panels. There is one resonant shunt to be connected across the 3000-volt direct-current busbars, to be so proportioned as to shunt out the harmonics set up in the machines by slot action.

A unique feature is the Westinghouse flash suppressor, which device consists of a combination of electrically operated switches that function to create a short-circuit across the collector rings provided on the armatures of the direct-current generators, immediately upon any sudden rush of current beyond that for which the combination is set. The effect is to kill the direct-current voltage instantly and suppress any tendency to flash or "buck" over at the generator commutators.

Cedar Falls Substation.

The following is a brief outline of the Cedar Falls substation equipped by the General Electric Co. It has two 2000-kw. motor-generator sets, two 2500-kv-a. step-down transformers, and switchboard equipment. This company's oil-cooled transformers have steel plate tubular tanks and the high-voltage winding has approximately 5% taps. The low-voltage winding is provided with approximately 50% starting taps in the same manner as those in the Westinghouse equipment. The oil switches can safely protect the machines and feeders under short-circuit conditions, provided the total rated capacity available on busbars or circuits to which switches are connected does not exceed specified limits. The 110,000-volt circuits of the power company and the railroad transmission lines are controlled by large circuit-breakers, while the transformers are controlled by 100-amp. circuit-breakers. These oil breakers are operated from panels located in the middle wall in a similar manner to those of the Westinghouse substations.

The two motor-generator sets, each consist of one 2300-volt, 2500-kv-a., 3-phase, 60-cycle synchronous motor, started from transformer taps, and direct-connected to two 1500-volt, 1000-kw. generators, connected in series for 3000 volts direct current, and two 125-volt exciters rated at 30 and 10 kw., respectively. The switchboard, as in the Westinghouse stations, consists of a panel for each of the motor-generator sets, panels for two 3000-volt direct-current feeder circuits, storage-battery panel, auxiliary light and power panel for station use, a panel for power-limiting equipment and one for the power company meters.

One of the Baldwin-Westinghouse 240-Ton Electric Passenger Locomotives for the Chicago, Milwaukee & St. Paul Railway.

Direct-Current Feeder Lines.

The 3000-volt direct-current feeder lines are continuous between substations, with taps to the trolley line at intervals of 1000 ft. The return circuits are made up of a No. 4/0 copper cable strung on the feeder-line poles connected to the running rails at intervals of 8000 ft. The purposes of this cable are to prevent interruption of circuit and dangerous voltage at rail joints in case of the breaking of bonds. The running rails also transmit the current necessary for automatic signaling, so that the only cross connections between main-line tracks will be the reactance bonds in connecting with the signals.

Trolley Construction.

The trolley construction is of the catenary type and consists of two standard No. 4/0 grooved copper

wires, hangers for which are alternately spaced and separated for each wire by an average distance of 15 ft., there being no rigid connection between the two wires. This construction provides the flexibility of support, affording the increased trolley contact surface and current-carrying capacity required by high-speed conditions. On passing tracks and yard tracks only one trolley wire is being provided. The normal height of trolley wires above the top of the rail is 24 ft. 2 in.; the minimum height, applying to bridges and tunnels, is 19 ft.

Power Indicating and Limiting System.

A power indicating and limiting system, apparatus for which will be furnished by the Westinghouse company, will be installed. The purposes of this system are similar to those of the system already in successful operation for some time on this railroad's electrified Rocky Mountain divisions in Montana, and consist of first, providing a convenient means of measuring and recording at one specified point, the dispatcher's office, the total power required to operate the newly electrified territory; and, second, providing the means, by automatic lowering of the direct-current substation voltage of limiting the maximum demand, or, if desired, the output of a particular substation to a certain predetermined amount. The indicating and limiting apparatus in the substations and the dispatcher's office is connected by a circuit consisting of two No. 8 B. & S. copper wires mounted on the trolley poles. This circuit extends from the most easterly substation, Taunton, through each succeeding substation to the dispatcher's office, and its frequency in any portion is dependent on the load in the substations east of that portion. The final frequency at the dispatcher's office is thus dependent on the total load on all substations and this feature forms the basis of the design of the system, details of which will shortly be completed.

Electric Locomotives.

Fifteen electric locomotives are being built for passenger and freight train service on the electrified line above described. Ten of these are being built by the Westinghouse Electric & Manufacturing Co., and five by the General Electric Co.

The five through passenger locomotives to be delivered by the General Electric Co. will each be equipped with steam heater, train-lighting apparatus, and 12 gearless motors; two 4-axle rigid trucks, and 3-axle guiding trucks. The heating equipment is installed in a separate cab in the center. The portion of the cab extending towards the end of the locomotive from the operating cab will have a rounded form more or less resembling the shape of the present steam locomotive ahead of the engineer's cab. The locomotives will, of course, be capable of operating equally well in either direction.

The Westinghouse passenger locomotives will contain two main running gears, each having a 4-wheel guiding truck, three driving axles in a rigid wheel base and a 2-wheel trailing truck. The whole running gear will thus be composed of two Pacific type running gears coupled together with the 2-wheel trucks on the adjacent ends. A single cab will be mounted upon the running gears. The motors will be of the twin-armature 4-pole type, having two armatures connected permanently in series and carried in a common frame. The two armatures will be geared through a single gear to a quill surrounding the driving axle and carried in bearings in the motor frame. This quill drive is the same in principle as that used on the New York & New Haven locomotives.

No freight locomotives will be purchased, as the present locomotives used for passenger service will have their gears changed so as to adapt them for freight service. The passenger service, both on the present electrified zone and in the district west of Othello, will be handled by the new passenger locomotives above referred to. Each passenger locomotive will have a capacity corresponding to that required to haul a load of 960 tons, or about 12 cars, in a continuous run over any part of the profile between Harlowton, the eastern terminus of the present electrification, and Tacoma and Seattle, the speed varying from about 60 miles per hour on the level to about 25 miles per hour on the heaviest grade. All locomotives will be equipped with control permitting of regeneration on down grades.

The electrification, both with respect to engineering and construction, is being handled by the railroad's electrification department, reporting to General Manager H. B. Earling; R. Beeuwkes is electrical engineer in charge and F. B. Walker is superintendent of construction.

MINIMUM CHARGE ELIMINATED BY NEW YORK COMMISSION.

The Public Service Commission for the First District, New York, has approved an opinion by Chairman Charles Bulkley Hubbell and has decided that the Bronx Gas & Electric Co. is violating the law in exacting from its electric customers a minimum charge of $1 per month when the total consumption of any single consumer during a particular month, multiplied by the rate at which that consumer buys current, does not equal the minimum charge. The maximum price which this company may charge is 12 cents per kw-hr. for electricity. Chairman Hubbell found that the imposition of a maximum charge would have the effect in some instances of raising this rate, and hence would be illegal. The commission, on the chairman's recommendation, directed that the company remove the minimum charge from its tariff schedules and if the company failed to obey this order that counsel to the commission should institute mandamus or injunction proceedings against the company to compel compliance.

ELECTRICALLY ILLUMINATED CHRISTMAS TREE IN WAR ZONE.

Coblenz saw its first electric Christmas tree on Christmas eve. It was set up in the plaza along the Rhine, directly in front of the headquarters of the Third army. The tree, which was 40 ft. high, was decorated with red, white, and blue ribbons and was trimmed by army nurses. It was placed in position by members of the Thirty-seventh engineers.

Red, white, and blue incandescent lights covered the tree, at the base of which in letters 3 ft. high, was the insignia of the Third army. The electricity was furnished by a portable plant taken to the spot by the American troops.

The Seventy-third field artillery gave a concert when darkness fell and the tree was lighted up.

The large building housing the headquarters of the Third army, as well as smaller structures erected by American troops, all bore crosses, which were lighted the evening before Christmas and Christmas evening.