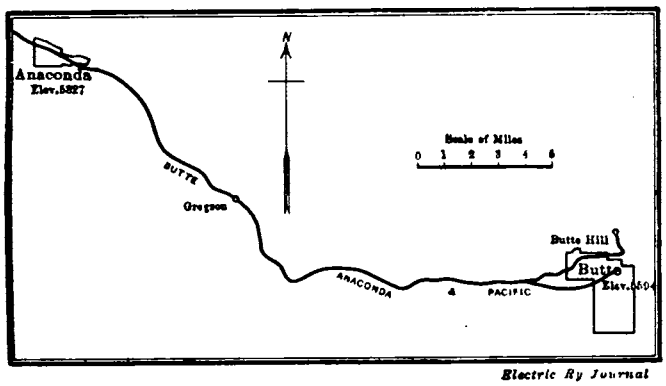
# Butte, Anaconda & Pacific Railway Electrification

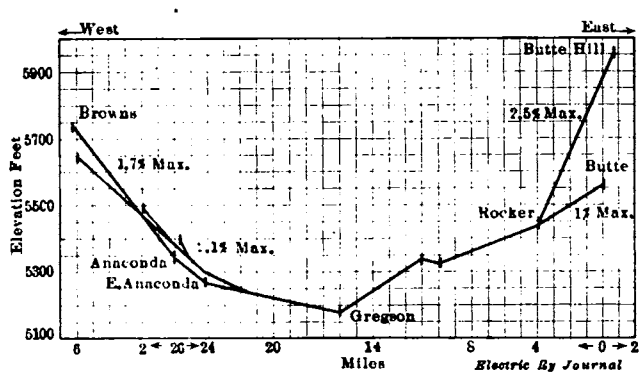
This Ore-Carrying Road Is the Largest 2400-Volt D. C. Electrification—Seventeen 80-Ton Locomotives Are in Use—Current Is Furnished from Great Falls, Mont.

The Butte, Anaconda & Pacific Railway electrification has attracted unusual attention on account of the use of 2400 volts, direct current, on a large scale. Out of a total of 114 miles of single track, 75 have been electrically equipped and full electrical operation commenced about five months ago. A preliminary account of this project was printed in the issue of the ELECTRIC RAILWAY JOURNAL for Feb. 10, 1912. Details of the overhead construction were given in the issue for Aug. 31, 1912, and a full account of the type of locomotive selected appeared in the issue of Jan. 7, 1913. A brief review of the essential features of the equipment will suffice as an introduction to some of the operating details.

There are seventeen 80-ton locomotives in use, two for passenger and fifteen for freight service. The freight locomotives are geared for a free running speed of 35 m.p.h. The passenger locomotives are able to draw three loaded passenger coaches at 45 m.p.h., and the freight locomotives produce a tractive effort of




Butte Electrification—Map of Electrified Line




Butte Electrification—Profile of Electrified Line

25,000 lb. at 15 m.p.h. The maximum tractive effort for five minutes is 48,000 lb., based on a tractive coefficient of 30 per cent.

The locomotives are of the articulated double-truck type with all of the weight on the drivers. Four 1200-volt motors of the GE-229-A type are used. They are commutating-pole motors with supplementary forced ventilation, the blower for this purpose forming part of the dynamotor equipment used for lowering the voltage to 600 for the auxiliary apparatus. The blower on each unit has a capacity of 7200 cu. ft. per minute at 4-in. pressure. The motors are connected in two series groups which are operated like single motors in the usual series-parallel control. Nine steps are provided in the series connection and ten in the parallel. Overhead roller pantographs, pneumatically controlled, are used.

## OVERHEAD CONSTRUCTION

The overhead contact wire is No. 0000 grooved wire, supported by an eleven-point catenary suspension, hung from steel messenger cable. Both side bracket and cross-span supports are used as required. In one case twelve yard-tracks are spanned, requiring an intermediate pole support for the span cable. A rolled-steel strap hanger looped loosely on the messenger wire is used to hang the contact wire with the necessary flexibility.

The contact wire is made up of the usual sections connected by circuit-breakers, but the interruption of power supply is prevented by overlapping the contact wires at breaking points. They are separated by the distance necessary for insulation, which is easily bridged by the roller. Lightning arresters are installed on poles every third of a mile.

The contact wire is reinforced by two 500,000-circ. mil bare copper cables, tapped in every 1000 ft. These normally connect the substations, permitting an interchange of power.

## CAR HEATING AND LIGHTING

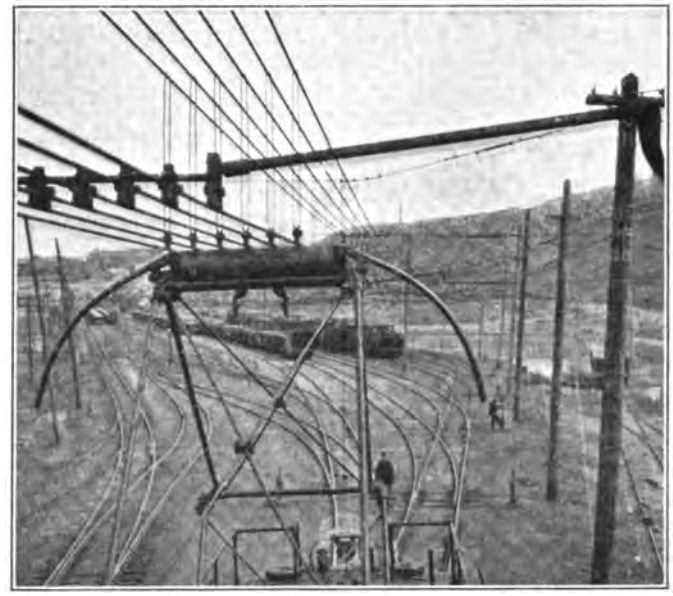
Current for car lighting is drawn from the dynamotor at 600 volts, each passenger and baggage coach being wired for five groups of five series lamps each. The electric heating is furnished in each coach from a 25-kw heating unit from which warm air is distributed by means of a motor-driven blower having a capacity of 500 ft. to 1000 ft. per minute. Cool air is drawn into the heater from a point on the car roof and distributed through ducts under the floor to radiators placed between alternate seats. The heating unit is in sections for the purpose of graduating the power consumption. The temperature is controlled by means of the usual thermostats.

## POWER SUPPLY

The energy needed for the operation of the electrified zone is obtained from the Great Falls Power Company's plant at Great Falls, about 125 miles distant in an air line. The capacity of the six generating units in the plant is 21,000 kw, and they produce electric power at 6600 volts, three-phase. The voltage is stepped up for the 130-mile transmission to Butte to 102,000, while power is from this point supplied to Anaconda, 26 miles farther on, at 60,000 volts. The Butte substation forms the center of the extensive power system operated by the Montana Power Company, which has several power plants to draw upon.

The only substations in use are at Butte and Anaconda. Here 2400-volt, sixty-cycle synchronous motor-generator sets, three in each substation, transform 2400-volt, three-phase power to the 2400-volt d.c. form. Each set contains one motor and two 500-kw, 1200-volt, commutating-pole generators, operating in series. These generators are compound-wound and have compensating pole-face windings. The series fields are connected on the grounded sides of the armatures, and the main fields are separately excited from 125-volt exciters.

Butte Electrification—View of Apparatus on Roof of Locomotive Cab

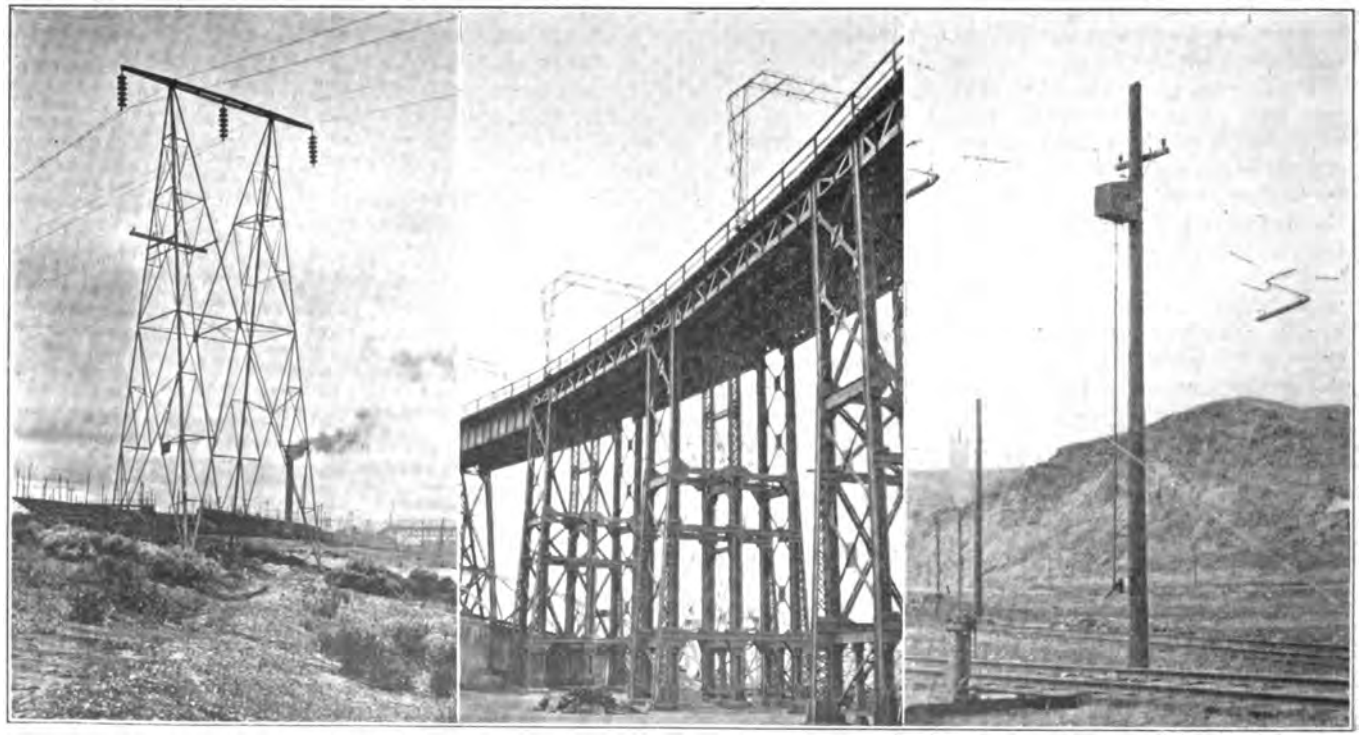


Butte Electrification—Section Where Pantograph Engages Six Trolley Wires

### 2400-VOLT SWITCHING

On account of the use of such a high voltage, special switchboard apparatus had to be designed. The circuit-breakers are provided with arc chutes with magnetic blow-outs of great intensity, the pole faces being so designed as to distribute the magnetic flux uniformly over the whole arc chute, thus insuring that the direct-current arc will be ruptured when the circuit-breaker opens. Low-voltage protection is secured by means of a low-voltage release coil, which, forming a part of the breaker and acting in conjunction with a speed-limiting device installed on the corresponding machine, prevents overspeeding by tripping out the breaker as soon as the speed for which it is set is passed. The low-voltage release and a reverse-current relay are connected in the 2400-volt circuit through high resistance and are insulated from the circuit-breakers so that the speed-limit device on the generator may be kept at ground potential. The low-voltage release must be set before the circuit-breaker will remain closed. This is done by lifting the plunger with a wooden rod connected through a bell-crank mechanism to an operating handle on the front of the switchboard. The breaker may be shifted manually by pulling the operating handle out to the limit of its travel. Lever switches and circuit-breakers are mounted on insulators for the purpose of effectively insulating them against the high voltage of the system.

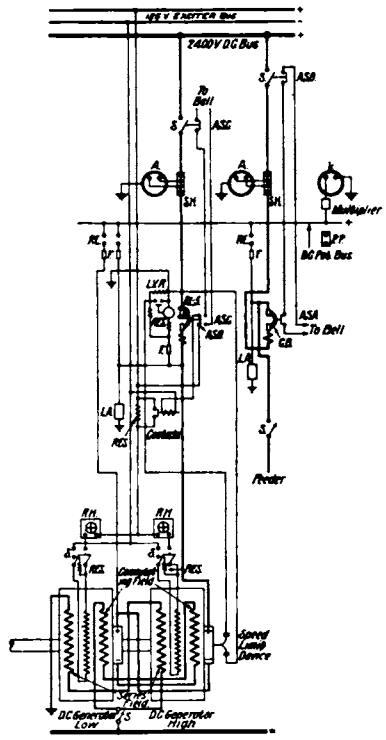
The main buses are located above and to the rear of the circuit-breaker panels and are protected by asbestos lumber covering which inclines upward from the top of the circuit-breaker panel to the wall behind the switch-



Butte Electrification—Steel Transmission Tower Carrying 100,000-Volt Lines—Trestle at Washoe Smelter, Showing Steel Bridge Construction—Section Switch and Operating Lever

board to form a barrier. This prevents circuit-breaker arcs from reaching the buses and also protects the buses from objects which might fall from above.

The ammeters are incased in insulating covers, while the voltmeter, mounted on a swinging bracket, is connected to the circuit on the grounded side with the separate resistance on the positive side, thus making the potential from meter to ground a minimum. Every precaution possible is taken to insure the safety of operators by covering live parts of the board.

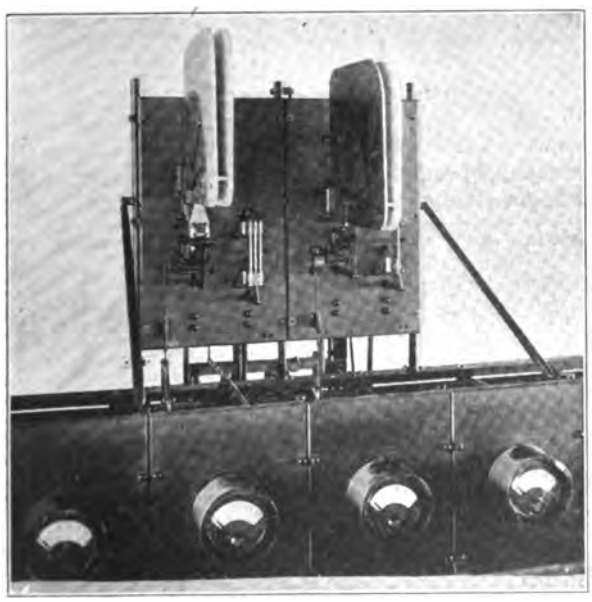



**Butte Electrification—Substation Wiring Diagram**

### OPERATING DETAILS

Eight passenger trains are operated per day between Butte and Anaconda, four each way. Single locomotive units are used for this purpose. During the first seven months of service, the freight service having been begun some months earlier than the passenger service, the freight locomotives made approximately 201,000 miles and hauled 2,365,000 tons of ore.

The freight traffic consists largely of copper ore and amounts to more than 5,000,000 tons per year. This material is handled in steel ore cars weighing about 18 tons and having a capacity of 50 tons each. Trains of thirty loaded cars weighing 2000 tons are made up at the Butte Hill yards and hauled by two-unit locomotives to the Rocker yards, where 4000-ton trains are made up for the main line. At the West Anaconda yards the trains are again broken up, and 1400-ton trains are sent up Smelter Hill to the ore bins. All of the shifting and "spotting" of cars at the smelters and in the sorting yards is done by single locomotive units.



**Butte Electrification—2400-Volt Circuit-Breakers**

CONDENSED INFORMATION ON FREIGHT MOVEMENT

| | West Bound | | | East Bound | | |
|---|---|---|---|---|---|---|
| | Butte Hill Line | Main Line | Smelter Hill | Smelter Hill | Main Line | Butte Hill Line |
| Trailing load in tons | 2000 | 4000 | 1400 | 1000 | 1260 | 650 |
| Number of cars | 30 | 60 | 20 | 55 | 70 | 35 |
| Number of 80-ton locomotives per train | 2 | 2 | 2 | 2 | 2 | 2 |
| Approximate grade against load in per cent | 2.5 | 0.3 | 1.1 | 1.1 | 1 | 2.5 |
| Approximate speed on level tangent track, m.p.h. | | 21 | | | 25 | |
| Approximate speed on maximum grade | 12 | 16 | 16 | 20 | 16 | 16 |
| Average trolley voltage | 2200 | 2200 | 2200 | 2200 | 2200 | 2200 |
| Length of run in miles | 4.6 | 20.1 | 7 | 7 | 20.1 | 4.6 |

The steam locomotive crews, consisting of engineman and fireman, easily acquired proficiency in handling the electric locomotives. In fact, two or three days' instructions from a competent electrical man were ordinarily sufficient. The change from steam to electric haulage was made without any change in the personnel of the train crews and without any delays or alterations in the schedule. The engineers, without exception, have expressed themselves as being greatly pleased with the easy operation of the locomotives.

## LIGHT VESTIBULED CARS FOR CHARLOTTE, N. C.

The Southern Car Company, High Point (N. C.), has recently furnished to the Charlotte (N. C.) Electric Railway four cars, and to the Greenville (S. C.) Spartanburg & Anderson Railway six cars, of the single-truck, arch-roof, full-vestibuled type shown in the accompanying illustration. These cars have no bulkheads, and the swing-type vestibule doors are arranged to operate in connection with the steps. The car bodies proper are 21 ft. 2 in. long over the corner posts, 32 ft. 6 in. over the vestibuled sheeting, 34 ft. 6 in. over the bumpers, 8 ft. 3 in. wide over the sills and 8 ft. 5½ in. high over the drip rails. The longitudinal sills are of long-leaf yellow pine with channel reinforcement. The cross timbers and the end sills are of oak reinforced with ⅜-in. x 4½-in. plate. The side sills and end sills are tied together with corner angle-irons. The posts and roof framing are of white ash while the top rails and the intermediate rails in the roof are of long-leaf yellow pine. The sides of the car are sheathed up to the window rail with 3/16-in. steel. The arch roof is made up of white ash rafters and a concealed steel rafter.


Charlotte Electric Railway—Single-Truck Vestibule Car

The vestibuled platforms are each 5 ft. 8 in. long. They are carried on oak platform knees, which are reinforced with steel. The interior finish of the cars is in natural mahogany, and the ceilings are of agasote. Six pairs of transverse seats are installed on each side in addition to short longitudinal corner seats. The cars are equipped with Consolidated electric heaters and Crouse-Hinds incandescent headlights.