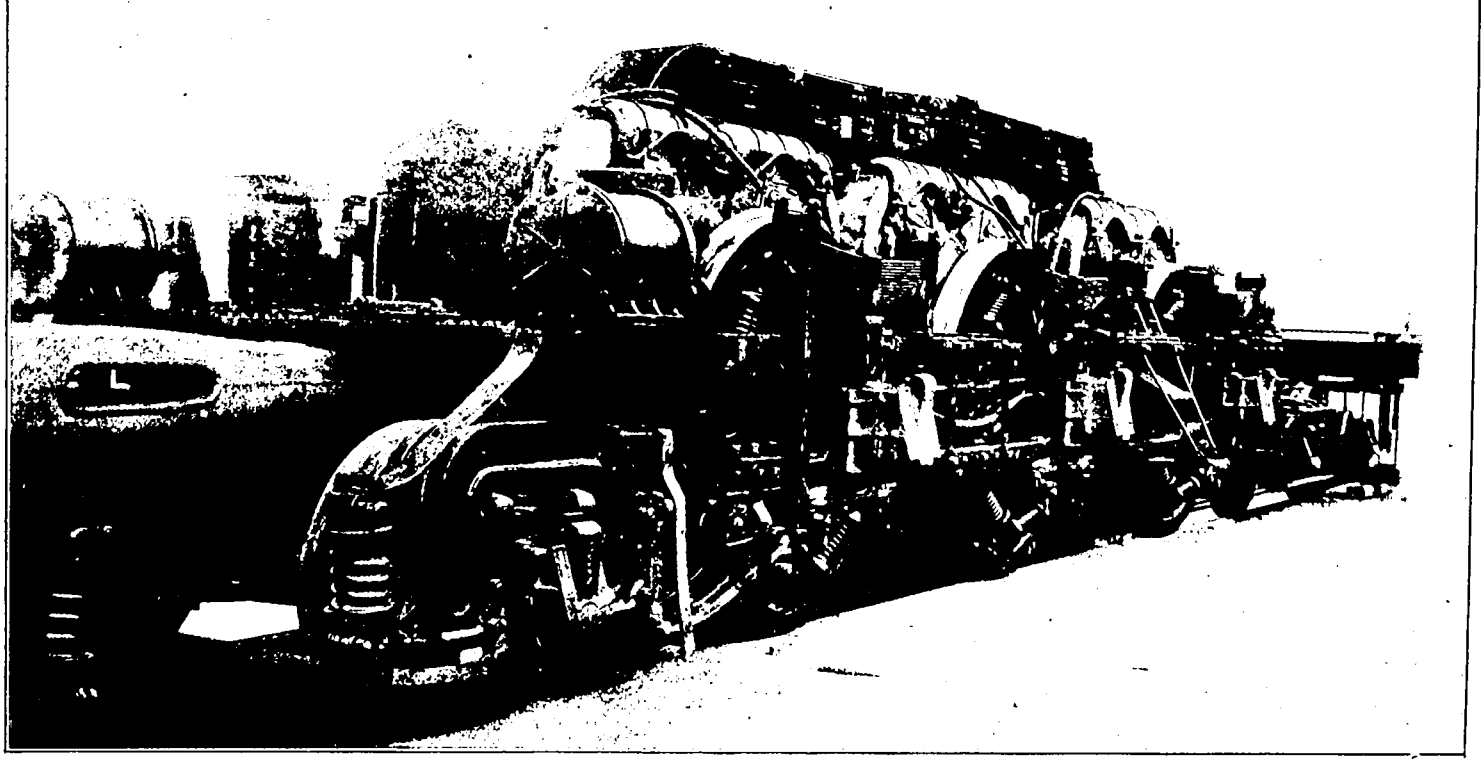


Running Gear of One Half of the Locomotive With Motors in Place

Electric Passenger Locomotives for the St. Paul

Ten Quill-Geared Units Will Be Used to Haul Passenger Trains Between Harlowton, Mont., and Avery, Idaho

THE TEN Baldwin-Westinghouse electric locomotives mentioned in the November 7, 1919, and February 1, 1918, issues of the *Railway Age* are now being delivered to the Chicago, Milwaukee & St. Paul for passenger service on the Rocky Mountain division. The completed locomotive complies very closely with the design which was described almost two years ago.

The motive power equipment for the initial electrified division of 440 miles over the Rocky Mountains consisted of 32 freight, 10 passenger and 4 switching locomotives. When it was decided to electrify the division over the Cascade mountains 15 new passenger locomotives were ordered. Five of these, built by the General Electric Company, described in the October 24, 1919, issue of the *Railway Age,* will be used on the Cascade division; the other ten described in this article will be used on the Rocky Mountain division. The original 10 passenger locomotives will be regeared for freight service, and a part of the 42 freight locomotives will be used on each electrified division.

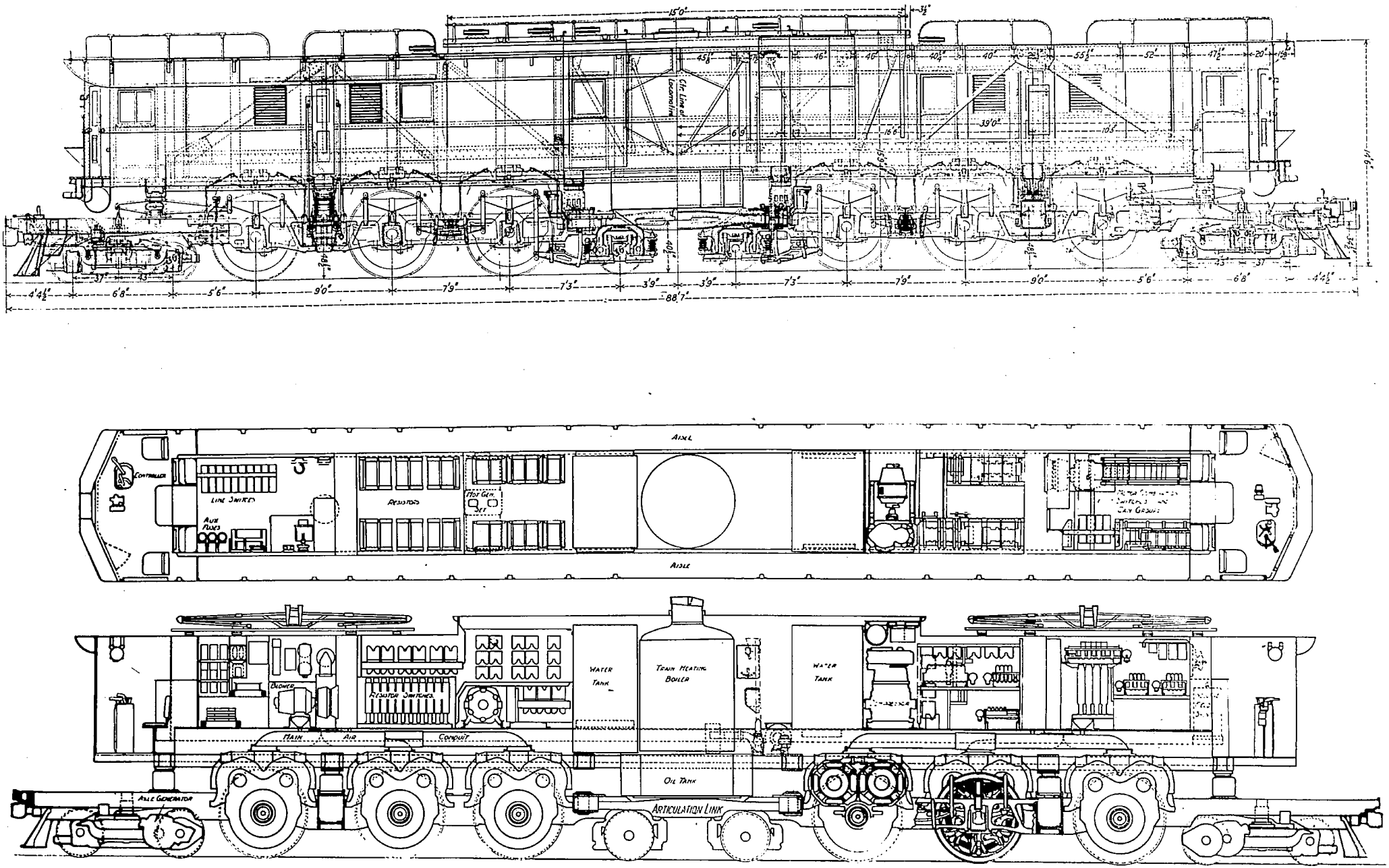
The new passenger locomotives for the Rocky Mountain division will develop 4,200 horsepower for an hour without exceeding the normal rated temperature of the motors and have a normal starting drawbar-pull of 100,000 lb. The drawbar-pull may be increased until the wheels are slipped without injury to the electrical apparatus.

The locomotive consists of two duplicate running gears of the Pacific type, placed back to back, supporting a single cab. The wheel arrangement of the locomotive is 4-6-2-2-6-4, with 68-in. drivers, a rigid wheel base of 16 ft. 9 in. and a total wheel base of 79 ft. 10 in. Rigid and floating center pins have been provided to relieve the cab structure of pulling and bumping strains, all such forces being transmitted directly through the running gear.

Many of the desirable features of steam locomotives have been included in the mechanical design, and in the design of the electrical apparatus the makers have included equipment which was found to be particularly good in previously built electric locomotives. These points are essentially: the limited amount of high voltage auxiliary apparatus, the stability of the operation of the main motors, the wide range of speed operation and the disposition of the apparatus in its grouping and mounting.

The articulation of the various trucks was considered one of the most important points of design. It was the endeavor to have each truck laid down so that each one would take care of itself and would not have to be led along by any of its companion trucks. During a series of tests made at East Pittsburgh, Pa., this feature of the mechanical operation of the locomotive was pronounced and the locomotive was declared to have especially good riding qualities. An extensive study was also made of weight distribution and its equalization between trucks. With this latter end in view, comparatively long spring hangers have been used so that any slight increase or decrease in their length for the purpose of shifting the load does not have any noticeable effect on the position of the locomotive springs.

The 3,000-volt direct current power is conducted through the necessary switches and resistances to six motors of the twin-armature type mounted on the locomotive running gear. The two armatures of each motor are permanently connected in series, and the control is so arranged that at least two motors are always in series, with the result that the voltage across any one armature never exceeds the value of 750 volts during motor operation. In addition to this, the control is further arranged so that all main motor fields are connected on the grounded side of the circuit, thus maintaining most



Side Elevation and Plan and Section of Locomotive, Showing General Arrangement of Apparatus

of the voltage stresses on the motors practically in line with commercial usage for the past 15 or 20 years.

One motor is mounted over each driving axle on the frame of the locomotive, and power from each armature is transmitted by pinions to a gear with an 89:24 reduction. The gear is mounted on a quill shaft, which is also supported on the locomotive frame, and which surrounds the locomotive axle with an appreciable clearance. The connection between the driving wheel and the quill shaft is made by springs. One end of each spring is connected to the quill shaft, while the other engages a bracket on the spoke of the driving wheel.

This arrangement permits the driving wheels to follow the unevenness of the roadbed, without affecting gear mesh, as well as cushioning the torque of the motor. In the design of this type of quill shaft the details have been governed by the experience obtained from the successful application of a similar type of drive on the New York, New Haven & Hartford locomotives, making due allowance for the increase in tractive effort.

The cab structure of the locomotive, which also partially encloses the main motors, contains the auxiliary apparatus necessary for the proper functioning of the motors. Enginemen's operating compartments are located at either end, connected by aisles extending along the side of the cab. All high voltage apparatus is enclosed in compartments to give complete protection to the engine crew while the locomotive is in operation. When the locomotive is "dead" easy access is afforded for inspection and adjustment of all apparatus by removing the compartment sides and by center aisles opening through expanded metal doors into the cross aisles.

The manner of regenerating power for operation on down grades used on these locomotives embodies features which have not been used before. The main driving motors are series motors, and in order to make them regenerate power to the line it is necessary that they be separately excited. The control of the excitation of the main motors for regeneration is initiated manually by the operator from the master controller, the exciting current coming from two small generators geared to one of the axles of each bogie truck. These small generators in turn are excited from an independent source, consisting of a motor-generator set operating in parallel with a small storage battery. All of the main motors are used during regeneration. Efforts have been made in the design of main motors and the axle generators to guard against any possibility of snow getting into the windings. One of the axle generators is mounted on each bogie truck in a standard street railway motor frame.

Condensed Table of Locomotive Weights and Dimensions

Normal trolley voltage	3,000 volts
Total weight	275 tons
Weight on drivers	336,000 lb.
Weight on lead trucks	66,000 lb.
Weight on trailing trucks	41,000 lb.
Total wheel base	79 ft. 10 in.
Driving wheel base	16 ft. 9 in.
Maximum rigid wheel base	16 ft. 9 in.
Diameter of drivers	68 in.
Diameter of lead truck wheels	36 in.
Diameter of trailing truck wheels	36 in.
Locomotive capacity at 23.8 m.p.h. (1 hr. rating)	4,200 H. P.
Normal starting tractive effort	100,000 lb.
Normal speed on level track	55 m.p.h.
Capacity of steam boiler	4,000 lb. per hr.
Capacity of water tanks	25,500 lb.
Capacity of oil storage tank	750 gal.
Cab length	78 ft. 0 in.
Total overall length	88 ft. 7 in.

Chicago, Milwaukee & St. Paul Electric Passenger Locomotive.

Control

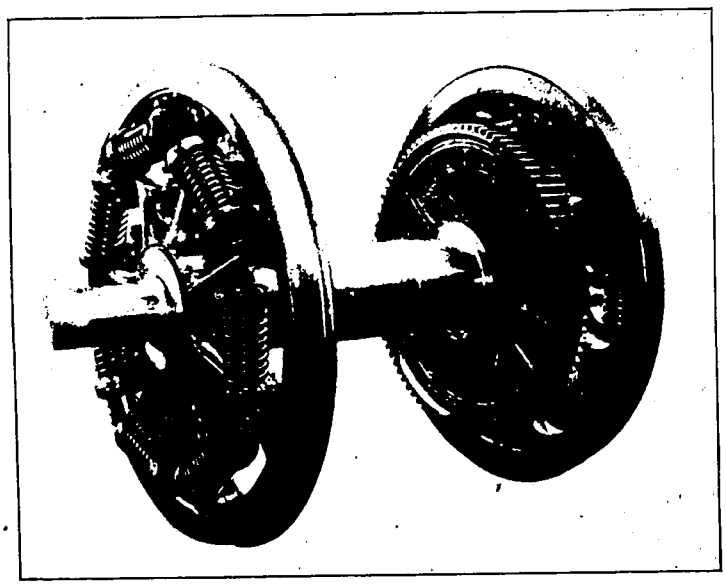
The locomotive control provides three motor combinations, giving one full series and two series-parallel connections.

The two latter connections consist of two parallel circuits of three motors in series and three parallel circuits with four motors in series. In each of these motor combinations three running notches are provided, which are full field, short shunt and long shunt. This provides a total of nine running speeds without resistance connected in the circuits.

While descending a grade the excitation of the motor field is entirely under the control of the engineman and may be increased or decreased as desired, causing corresponding increments and decrements to the regenerative effort of the locomotive, thus varying the speed of the train through any desired range. The full motor capacity of the locomotive is available for regeneration, and under all conditions of grade on which it will be used it should be able to handle any train down grade that would require double-heading on the way up.

Auxiliary Apparatus

Power for energizing the control circuit and operating the auxiliary apparatus, a small blower motor, the motor-driven air compressor, etc., when these are not being driven by the axle generator, is obtained from a small motor generator set and storage battery which are used to excite the fields of the axle generators. The high-tension winding of this set



Driving Wheels with Springs, Quill Shaft and Gear

is the only piece of revolving apparatus in a locomotive, with the exception of the main motors, which is connected to the 3,000-volt circuit. The low-tension side of the motor generator set is provided with slip rings for the generation of a low voltage alternating current for the headlight and for some of the interior cab lights. During motoring and when coasting without regeneration, the axle generators are automatically connected to the low voltage auxiliary circuit, so that the motor generator for the greater part of the time is only necessary for furnishing excitation to the axle generator field and for charging the storage battery. This reduces the necessary size of the motor generator set.

All main motor and resistance circuits are opened and closed by electro-pneumatic 3,000-volt switches which are standard for Westinghouse unit switch control. These switches are provided with blow-out coils for breaking the arc. Transfer of circuit where no high voltage current is broken is accomplished by means of cam-type contactor groups adopted for the purpose of reducing space and weight by the elimination of otherwise necessary unit switches. The control circuits of all unit switches and the cam-contactor groups are respectively interlocked electrically to prevent any improper functioning of the apparatus. All unit switches, cam-contactor groups, grid resistances, protective relays, etc., are mounted in compartments entirely closed off from the enginemen's cabs and the aisles of the locomotive, as previously mentioned.

The center compartment of the locomotive is given up entirely to an oil-fired steam boiler, its supply tank and auxiliaries. This boiler supplies steam for heating trains and is capable of evaporating 4,000 lb. of water per hour. Two storage tanks for water are provided, having a combined capacity of 25,500 lb. of water. There is also a tank for the fuel oil, with a capacity of 750 gallons. The boiler also feeds radiators in each of the operating cabs.

I. C. C. to Continue Railroad Administration Operating Statistics

THE INTERSTATE COMMERCE COMMISSION has issued an order prescribing rules pertaining to operating statistics intended to continue, with slight modifications, the compilation by Class I steam railways of the basic data required on the forms on which operating statistics are now reported to the United States Railroad Administration. Such data will be reported in full in the annual report forms and a part of them will be reported monthly as specified in Schedule II of the rules. Though the order had been made effective as of January 1, 1920, the monthly reports will not be required by the Interstate Commerce Commission while the present monthly reports of operating statistics are made to the United States Railroad Administration. This order is not intended to abrogate the classification of train-miles, locomotive-miles, and car-miles for steam roads prescribed by the commission and effective on July 1, 1914, nor to cancel requirements as to operating statistics heretofore called for in annual reports.

The railroad executives had made plans for continuing the reports if the commission had not decided to do so.

The rules prescribed in Schedule I are as follows:

1. Average number of miles of road or first running track operated, and of other main tracks, not including yard tracks and sidings, should be shown for freight service and mixed service combined, and also for passenger service and mixed service combined.

2. Train-miles, locomotive-miles and car-miles should be reported in accordance with the classification of July 1, 1914. In addition, the direction of movement should be shown; that is, whether east or west. Where movement of traffic as a whole is not east or west, north should be substituted for east and south for west, or north and south should be combined with east and west according to traffic movement. Work equipment car-miles in transportation service freight trains should also be segregated. For comparisons with operating expenses under section 10, Schedule I, train-miles and locomotive-miles should also be reported in the following form:

Class of service	Train-miles	Locomotive-miles
Freight train[1]		
Passenger train[1]		
Total		

[1] Including a proportion of mixed and special train services based on car-miles in mixed and special trains.

3. Gross ton-miles in freight transportation service should be reported as outlined below. Gross ton-miles are defined as tons of 2,000 pounds behind locomotive tender (cars, contents and caboose) moved 1 mile. They are to be computed from conductors' train reports. Gross ton-miles in mixed-train and special-train services should be computed