Substations

Fourteen substations are equipped for converting the 100,000-volt alternating-current to 3000 volts direct-current. They are distributed along the route at an average distance apart of 32 miles. Each station contains step-down transformers, motor-generator sets, switchboard and the necessary controlling and switching equipment. The transformers receive the line current at 100,000 volts and supply the synchronous motors at 2300 volts. Each synchronous motor drives two 1500-volt direct-current generators connected permanently in series, thus supplying 3000-volt current for the locomotives.

Overhead Construction

The overhead construction employs the principle of the flexible twin catenary originated by the General Electric Company. The details of construction and installation were entirely under the supervision of the Railway Company's engineers. With this quite novel but remarkably successful construction, the current is collected in both high speed passenger service and heavy freight service without any sparking.

Cost

Electric locomotion has been undertaken with the expectation of effecting a sufficient reduction in the cost of operation to return an attractive percentage on the investment required, as well as to benefit by all the operating advantages of electric locomotives. According to statements made by the Railroad officials, about $12,000,000.00 will be expended, and with the work more than half completed there is every reason to believe that the cost of construction will come inside the estimates.

THE MECHANICAL FEATURES OF THE LOCOMOTIVES OF THE CHICAGO, MILWAUKEE & ST. PAUL MAIN LINE SERVICE

By A. F. Batchelder

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The author gives a concise statement of the most important mechanical features of the St. Paul locomotives. He describes the make-up of the frames and superstructure and gives the arrangement of apparatus. The article is profusely illustrated, many of which show considerable detail.—Editor.

Much has already been said about the operation of the electrified portion of the Chicago, Milwaukee & St. Paul Railway in the Rocky Mountains, it having been in operation now approximately a year, including an extremely severe winter, when many steam operated roads were unable to keep their trains moving regularly enough to prevent congestion at points even where the natural conditions are not considered severe. This electric division, through a most difficult section of the Rockies, with long grades both up and down and with severe cold weather and bad storms operated with its new equipment without any apparent difficulty, not only keeping the road clear of congestion, but almost universally making up time that had been lost on the adjoining steam operated portions of the road. It, therefore, seems fitting at this time to give a more detailed description of the mechanical part of the electric locomotives that were making such a remarkable record in the hauling and braking of the enormous trains that were handled up and down these mountain grades so effectively. The principal dimensions and features of these locomotives are as follows:

GENERAL DATA

Gage	4 ft. 8½ in.
Service	Freight
Voltage	3000 volts d-c.
Wheel arrangement	4-4-4-4-4-4
Maximum tractive effort	132,500 lb.
Continuous tractive effort	71,000 lb.
Length over all	112 ft. 0 in.
Total wheel base	102 ft. 8 in.
Width over all	10 ft. 0 in.
Height, trolley locked down	16 ft. 8 in.
Rigid driving wheel base	10 ft. 6 in.
Rigid guiding wheel base	6 ft. 0 in.
Diameter driving wheels	52 in.
Diameter guiding truck wheels	36 in.
Size main driving journals	8 by 14 in.
Size guiding truck journals	6½ by 12 in.
Total weight	576,000 lb.
Weight on drivers	450,000 lb.
Weight per driving axle	56,250 lb.
Spring borne weight per driving axle	40,000 lb.
Dead weight per driving axle	16,250 lb.
Weight on guiding truck wheels	126,000 lb.
Weight per guiding axle	31,500 lb.
Spring borne weight per guiding axle	27,274 lb.
Dead weight per guiding axle	4,226 lb.
Maximum tractive effort in per cent of weight on drivers	30 per cent
Continuous tractive effort in per cent of weight on drivers	16 per cent
Normal braking power in per cent of weight on drivers	89 per cent
Normal braking power in per cent of total weight	69 per cent

On account of the enormous tonnage to be handled and the great power of these locomotives, a total of eight traction motors are used, requiring an overall length of locomotive of 112 ft. For the purpose of negotiating curves easily with minimum flange wear, and in order to secure a simple and effective weight equalization and foundation brake system, the running gear is made in sections or individual trucks, articulated in such a manner as to give positive guiding from one to another, and also to take up the bumping and hauling stresses directly through the running gear frames. This arrangement also gives a most convenient opportunity for supporting the motors and is advantageous for receiving forced ventilation. In order to eliminate any possibility of undue lateral strains on the track and for operating in either direction, a four-wheel bogey guiding truck, see Fig. 1, has been connected to the outer driving truck at each end of the running gear.

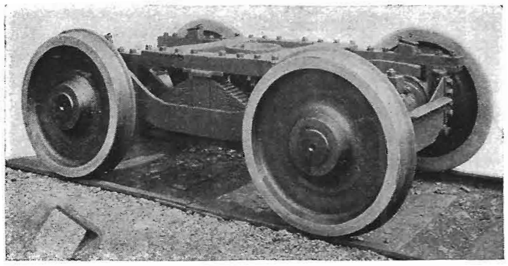

Fig. 1. Guiding Truck

The complete locomotive consists of two duplicate sections, each having a cab mounted on two driving trucks, one truck being symmetrical and the other unsymmetrical with an extended frame carrying the draft rigging and center pin for the guiding truck, see Fig. 2. The guiding trucks are of the well-known equalized type common to steam locomotives, having inside journal bearings, 6½-in. by 12-in., and are arranged to carry the load on the center bearing through a bolster which provides a lateral movement 4 inches each way from the center against a constant pressure. This lateral movement of the bolster is only required in cases where the locomotive negotiates curves greater than 14 degrees, or where entering sharp curves at high speeds tending to produce lateral lurches of the locomotive.

As stated above, the extended frame of the unsymmetrical driving truck carries the bumper beam, buffer and draft gear of the Miner Class 18A friction type, see Fig. 3. Also one end of the superstructure is carried on longitudinal center sills through cast steel center bearings. The center bearing for the cab superstructure, see Fig. 4, is so located as to distribute the weight properly between the guiding truck and the driving axles. The side frames, transoms and other parts taking the bumping and hauling stresses are designed to stand 500,000 lb. static pressure with liberal factors of safety. The side frames are of cast steel, 4½ inches thick, placed on 80-inch centers and are bolted to the machined surfaces of the cross transoms with taper bolts. At the inner end of this truck is bolted a cast steel end frame, see Fig. 8, to which is fastened the hinge joint which is also designed to stand 500,000 lb. static pressure. The middle transom, see Fig. 9, is of steel, cast hollow, with supporting lugs for the nose of the traction motor and with provision for taking air from the blower duct in the superstructure through a telescoping duct directly into the motors. This gives a very simple and effective method of conducting the air from the blower to the motors. The symmetrical driving truck has a transom at each end identical to the inner end transom of the unsymmetrical truck, with hinge joint bolted to each of them. This truck has a middle transom, also identical, which carries the motor supports in the same manner as on the other truck and also serves as a support for the superstructure, the air duct being through the center bearing. This center bearing, see Fig. 10, is made to provide for any change in distance between bearings, due to the curving of the trucks, allowing longitudinal motion besides swiveling, but preventing all transverse movement of the superstructure.

The weight of the locomotive is distributed to the wheels by an equalizing system consisting of main elliptic springs, side equalizers, and double coil springs. The unsymmetrical trucks are so equalized as to effect a three point bearing which is accomplished by side equalizers between the driving wheels on each side, making an effective transverse axis one-half way between the driving axles, the third point being the center bearing of the guiding truck. This unsymmetrical truck being supported in equilibrium, serves through its hinged joint as the steadying agent for the symmetrical truck, which is also provided with side equalizers having its transverse axis one-half way between the axles. With this

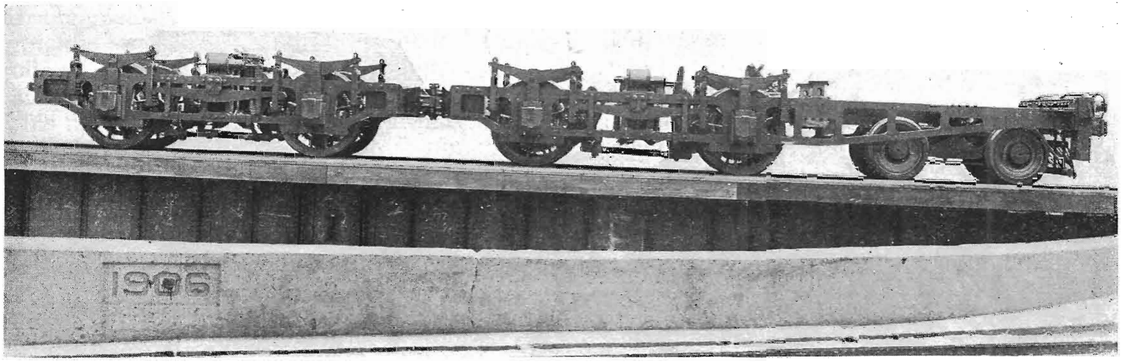

Fig. 2. Running Gear of One-half Unit

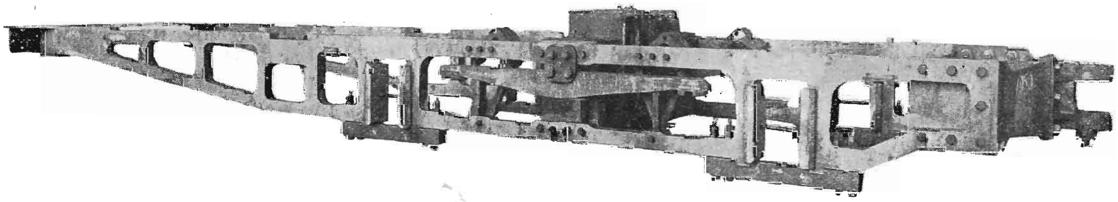

Fig. 3. Unsymmetrical Truck Partly Assembled

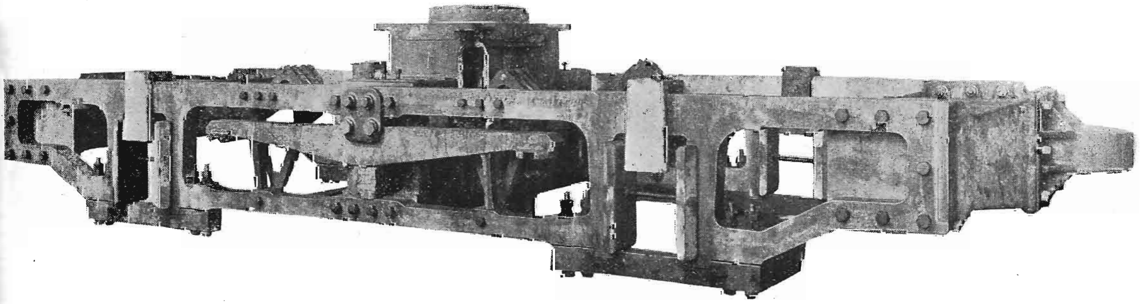

Fig. 4. Symmetrical Truck Partly Assembled

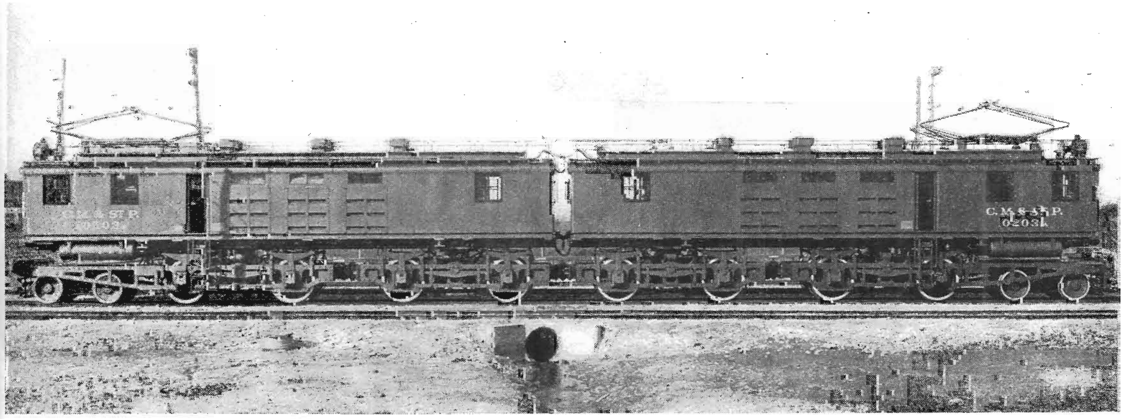

Fig. 5. Freight Locomotive for Chicago, Milwaukee & St. Paul

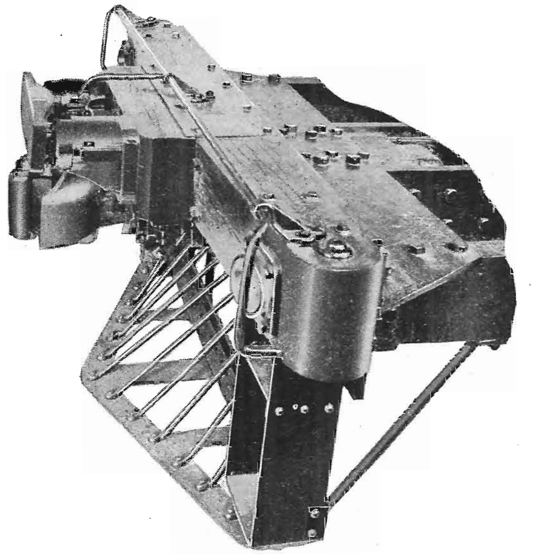

Fig. 6. End Frame and Draft Gear

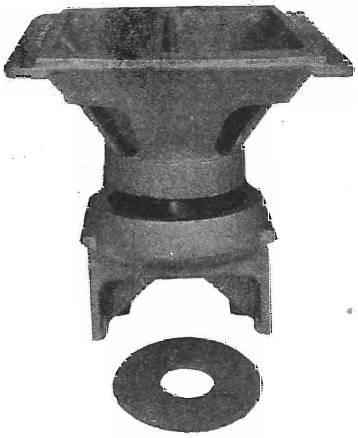

Fig. 7. Forward Cab Center Plate

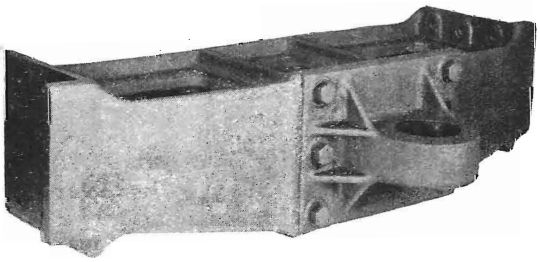

Fig. 8. Truck Inner End Frame

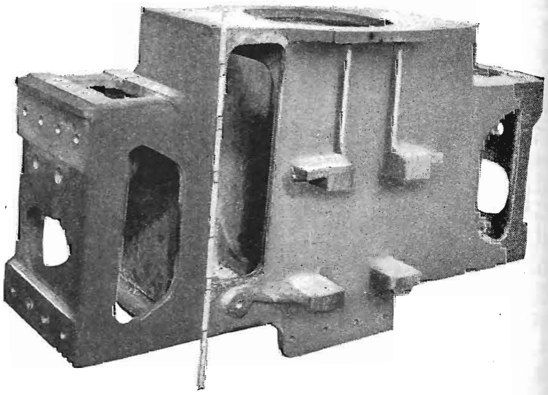

Fig. 9. Main Transom of Driving Truck

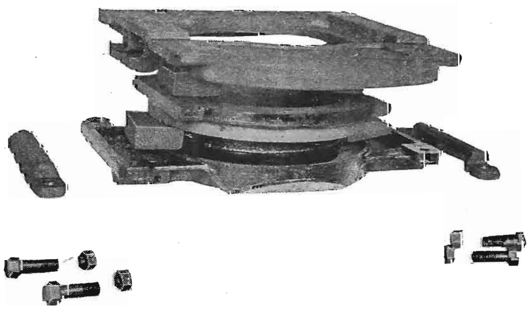

Fig. 10. Sliding Center Plate

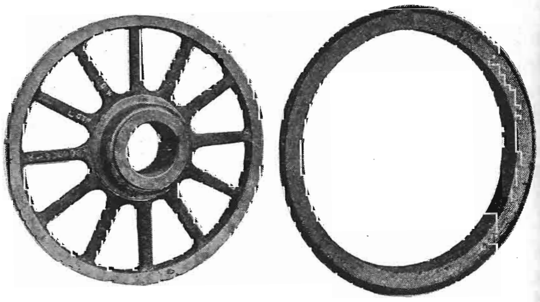

Fig. 11. Wheel and Tire

arrangement the end of the symmetrical truck which is attached to the unsymmetrical truck follows the same vertical movement as the latter, the hinge allowing no vertical play. This necessitates allowing vertical play in the hinged joint between the two symmetrical trucks.

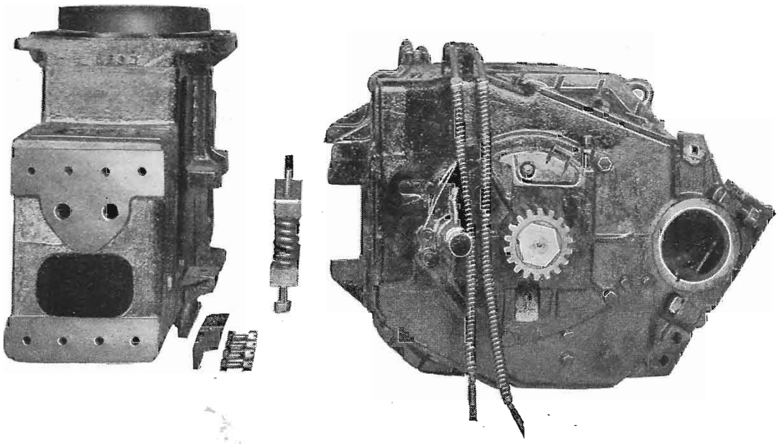

Fig. 12. Motor Nose Suspension

Each of the driving trucks is equipped with inside hung brakes of the simple push rod type supported by specially designed brackets, each side being operated by its own individual 12-in. by 10-in. cylinder. There are no brakes furnished for the guiding trucks.

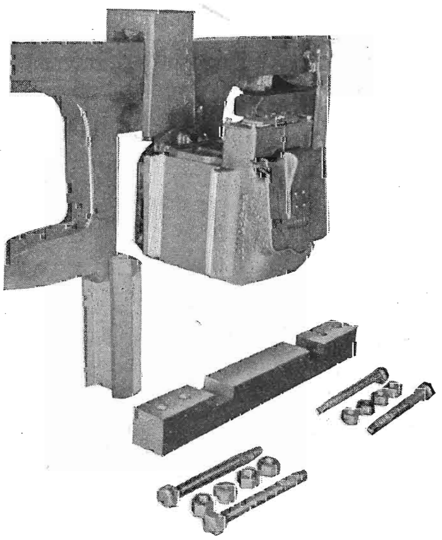

Fig. 13. Journal Box Assembly

The wheel centers are of steel castings with twelve spokes and provided with hub extensions to receive the motor gear. The tires with MM tread and flange are $5\frac{1}{2}$ inches wide and 3 inches thick and are held on by shrinkage.

The journal boxes are steel castings machined to receive the bearing brasses and the frame pedestal shoes. The pedestal shoes and journal box flanges are so designed that when the shoes are dropped the journal box can be removed from its place without lifting the frame, making it convenient to renew the thrust plates which are provided at the back of the boxes.

The motors are supported in the usual way directly on the axle on one side, and by a nose bracket through double acting springs to the bolster on the other side. The motors drive through yielding gears mounted directly on the axle, one at each end of the motor.

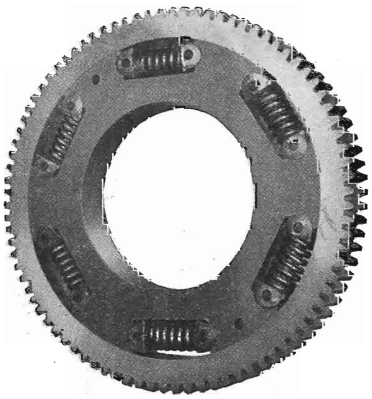

Fig. 14. Spring Gear

The superstructure of each section is made up with two 12-in. longitudinal center sills

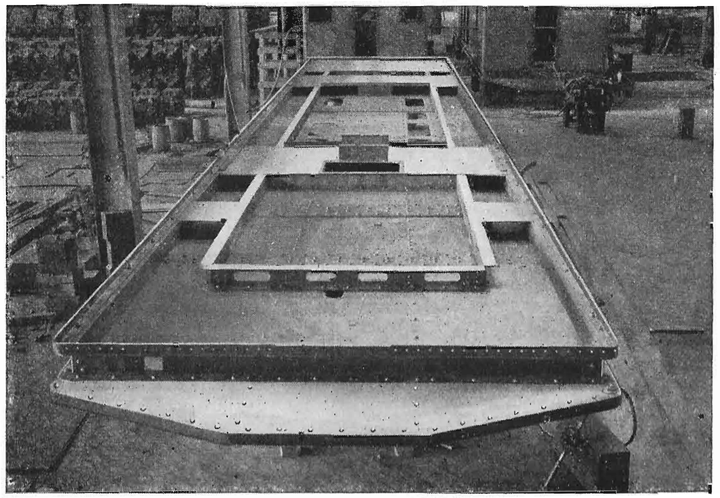

Fig. 15. Top View of Cab Platform

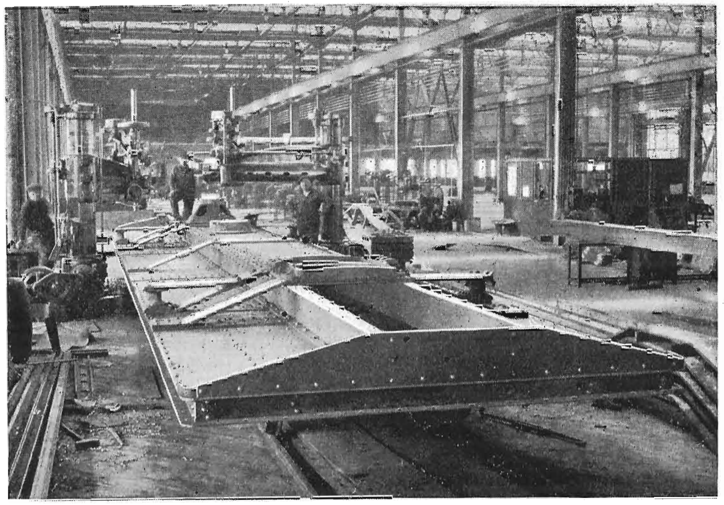

Fig. 16. Underside of Cab Platform

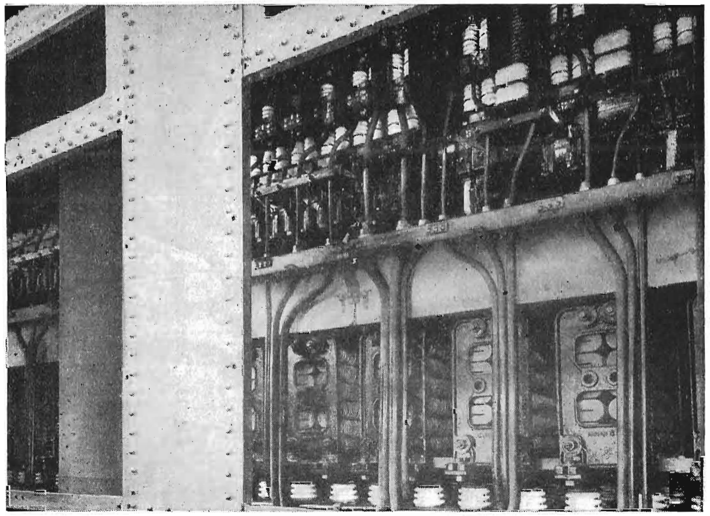

Fig. 17. Contactor and Rheostat Compartments

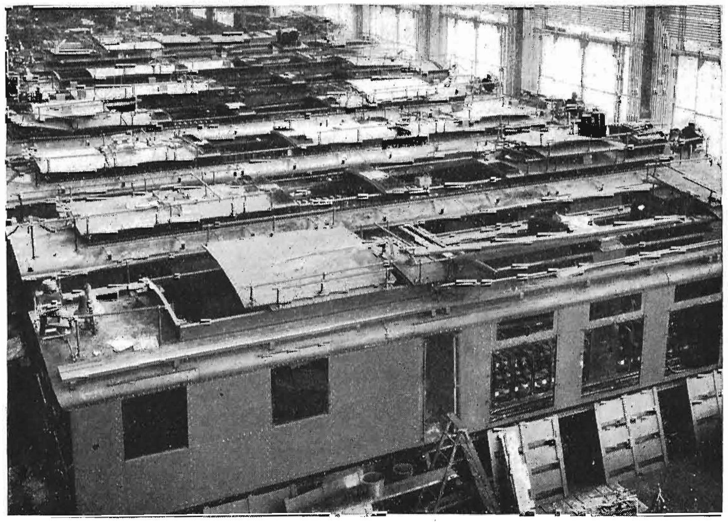

Fig. 18. Locomotives Under Construction, Showing Hatches and Openings

spaced 31 inches apart, with a plate bolted to the bottom and a ⅜-in. floor, extending over the entire structure, bolted to the top, forming a box girder and providing the air duct to conduct the ventilating air from the blower to the motors. These sills also serve as struts for the bolster girders. A second floor carried by the first floor through 6-in. channels forming ducts for the wiring conduit is provided as the floor for the apparatus cab.

The cab is made of steel and structural shapes built up in the usual way with ventilating louvres in the sides. Doors are located at each end and one on each side. The windows are conveniently located to provide

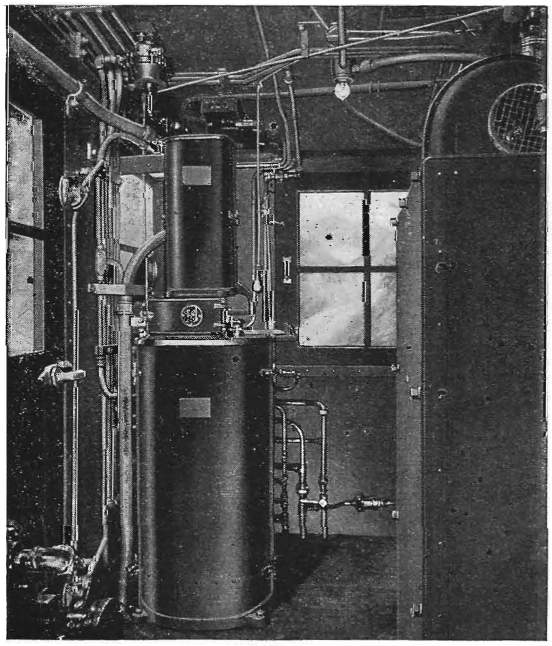

Fig. 19. Motorman's Cab

light for the inspection of all apparatus. Each cab is divided into two compartments consisting of the main apparatus cab 47 ft. long by 10 ft. wide, and the motorman's cab, 5 ft. long by 10 ft. wide. The motorman's cab is arranged in the usual way with a front door, and two doors leading into the apparatus cab. The apparatus cab is arranged with an aisle 23 inches wide and extending the entire length on each side with the control and other apparatus compartments arranged in the middle, and with hatches in the roof for the placing of all apparatus. The motor-generator set for regenerative braking, the blower, and air compressor, are carried

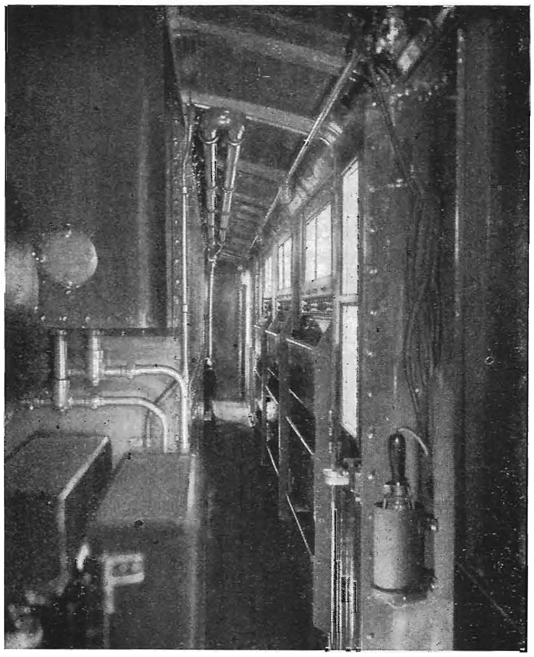

Fig. 20. Side Aisle of Apparatus Cab

directly through their supports, on the main box girder forming the air duct.

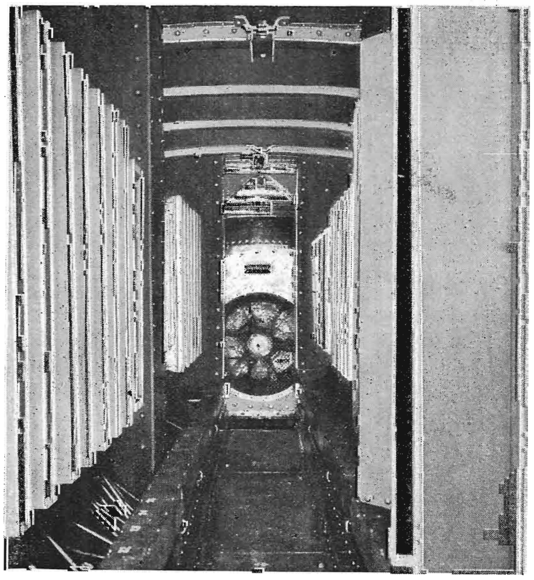

Fig. 21. Center Aisle of Contactor Compartment, Looking Toward Blower, showing Contactor Arc Chutes and Method of Fastening Hatches

The compartment for the rheostats, switches, etc., is arranged with the rheostats supported near the floor, and above them, a floor between, are mounted the contactors, switches, etc. Ventilating flues leading from the rheostat compartment through the roof provide excellent natural ventilation. Ventilation by this method is obtained by air being taken through openings in the floor, passing over the rheostats and up the flues to the top. Doors are arranged to be easily removed to get at the connections of the rheostats and the back of the contactors. The front of the contactors and switches are accessible from a center aisle.

The arc chutes of all contactors face into this aisle which provides liberal arcing space. The arrangement of these rheostat and contactor compartments has been found particularly desirable on account of the ease of inspection and removing of parts for replacement. Also by this means all the high tension apparatus which might be a source of danger is safely enclosed.

Freight Train on Two Per Cent Grade