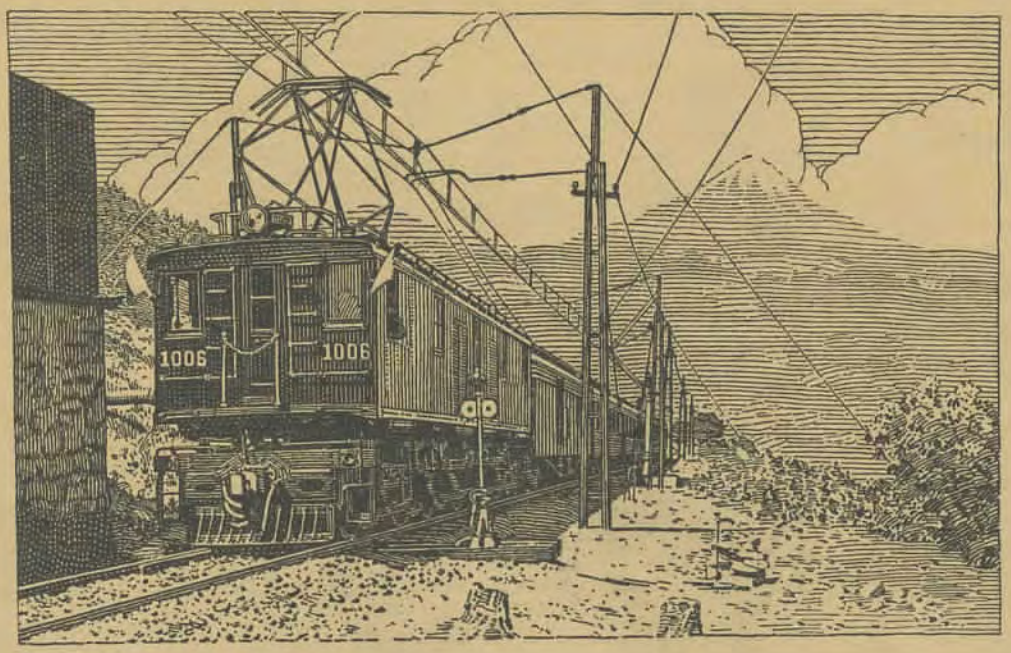


The ELECTRIFICATION of the MEXICAN RAILWAY

GENERAL ELECTRIC

The ELECTRIFICATION *of the* MEXICAN RAILWAY

GENERAL ELECTRIC COMPANY
SCHENECTADY, N. Y.

February, 1928 GEA-851

Freight Train on the Mexican Railway, Ascending 4.7-per cent Grade between Bota and Alta Luz

Mexican Railway Company Freight Train Hauled by Two 150-ton Electric Locomotives

Electrification of the Mexican Railway

ONE of the most interesting electrifications ever undertaken is that of the Mexican Railway Company, Ltd., on the single-track line between Mexico City and Vera Cruz. This line, which is 264 miles in length, exclusive of branch lines, was, at the time of its construction, one of the most difficult engineering problems ever encountered. At its maximum elevation, the road reaches a height of 8323 feet above sea level. It is significant that the 30-mile section between Esperanza and Orizaba was chosen for the initial electrification. This is by far the most difficult section because of heavy curvatures and grades reaching 4.7 per cent ruling and 5.25 per cent maximum.

This section of the road, locally called the Maltrata Incline, traverses a remarkably scenic country under the shadow of Orizaba Peak, one of the several extinct volcanoes in the immediate

One of the 150-ton, 3000-volt Direct-current Locomotives

Running Gear of 150-ton Articulated Type Locomotive

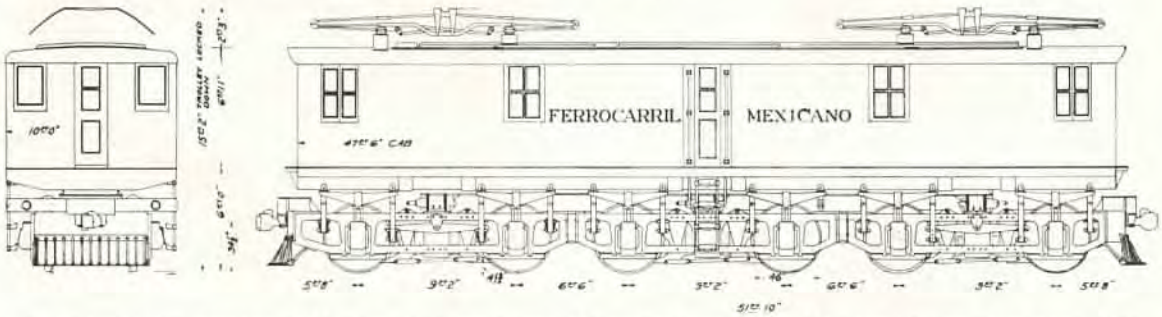
Mexican Railway Company 3000-volt Electrification. View at Nogales Station, Showing Concrete Poles and Cross-span Construction Over Two Tracks

vicinity which range in height from 17,000 to 18,000 feet.

After the success of the original installation had been demonstrated, the electrification was extended to Paso del Macho, making a total distance of 70 miles.

The most recent type of steam locomotive replaced by electric locomotives weighs 150 tons and was designed especially for this division. It is known as the Fairlie type, and is an oil-burner. These engines are double-ended and have a three-axle driving truck at each end, with all the weight on the drivers.

The original motive-power equipment for electrification includes ten 150-ton, 3000-volt, d-c. locomotives, used for both freight and passenger duty. Because of the severe grades and heavy curvatures, ranging from 12 to nearly 16 degrees, the speed of both passenger and freight trains is limited.



Outline and Dimensions of 150-ton, 3000-volt Type of Locomotive for the Mexican Railway Company, Ltd.

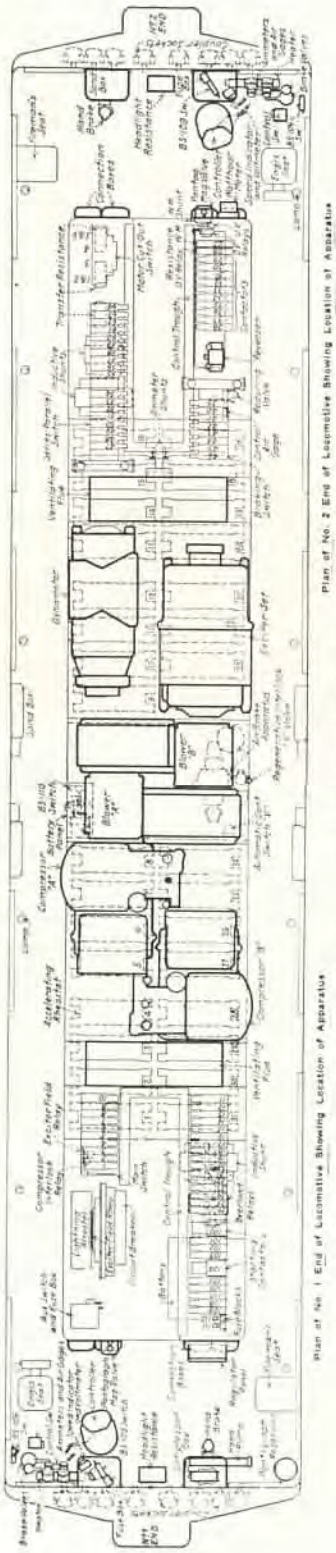
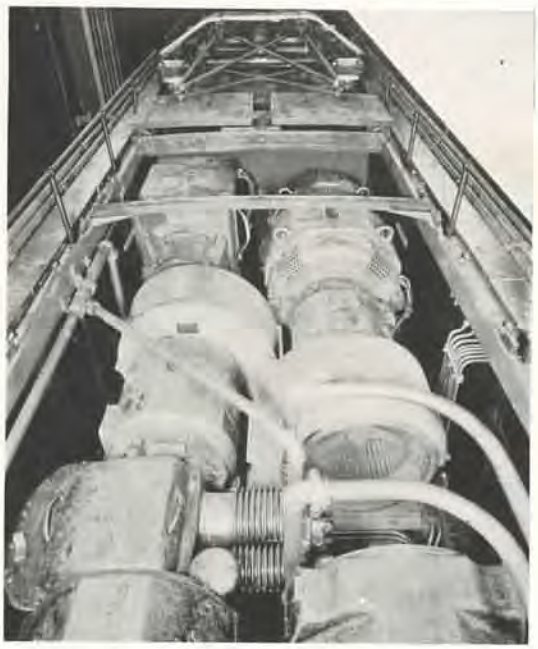


Diagram Showing Location of Apparatus on Mexican Railway Locomotive

In the substitution of electric locomotives for steam, there were several unusual conditions. First, the steam engines replaced have practically the same weight as the electric locomotives now in use; second, they have all the weight on the drivers; and third, they operate equally well in either direction. Nevertheless, in making the substitution, ten electric units have replaced 23 steam locomotives.

The two principal reasons for the greater capacity of the electric locomotives are the greatly increased speed in service on grades, and the higher percentage of availability. Whereas electric locomotives are available approximately 90 per cent of the time, the steam locomotives would ordinarily be available only about 30 per cent of the time. It has further been found that one electric locomotive can handle the normal passenger trains of eight cars on grades, whereas two steam locomotives were formerly used. This is due partly to the lack of steaming capacity on the long grades for the continuous pull, and partly to the faster schedule for passen-



View Looking Down into Auxiliary Machinery Compartment

View Showing Overhead Construction and Steel Poles

ger trains. The greater continuous capacity of the electric locomotives has also made it possible to handle heavier freight trains with two electrics than was possible with two steam engines. Where two steam engines handled a 360-ton train, two electrics are now handling a 660-ton train at a higher speed.

An analysis of the operating speeds on the upgrade run shows that one of the passenger trains which formerly required two hours and 50 minutes for the 30-mile run is now handled in one hour and 50 minutes, an increase in schedule speed of from 10.2 to 16 miles per hour. A typical freight run shows a decrease in running time of from four hours to two hours and 25 minutes, or an increase from 7.3 to 12.1 miles per hour.

While it was not expected that much improvement in speed would be shown on the down-hill run, as a matter of fact, the running time of most of the trains has been reduced. This is due to the elimination of stops for fuel and water and for cooling wheels and brake shoes. It will be appreciated that the schedule speeds, mentioned heretofore, require actual running speeds, not including stops, approximately double that of steam.

Passenger Train with 150-ton Electric Locomotive at Maltrata

Substations

Two substations, one at Maltrata and the other at Portrero, furnish power to the lines. The original 30 miles were fed from the substation at Maltrata. This substation contains two 3000-kilowatt synchronous motor-generator sets with necessary transformers and switc ing equipment. The second substation, at Portrero, is a duplicate of the one at Maltrata except that it contains two 1500-kilowatt synchronous motor-generator sets. The total substation capacity for the electric zone is thus 9000 kilowatts.

One of the 150-ton Fairlie-type, Double-end, Oil-burning Steam Locomotives

Locomotives

There are ten 150-ton, 3000-volt locomotives on this road, which replaced 23 steam locomotives ranging in weight from 110 to 150 tons. The mechanical and electrical features of these locomotives are as follows:

ELECTRICAL DATA

Nominal voltage of system	3000 v. d-c
Tractive eff., 1 hr. blown (3000 v.)	54,000 lb.
Speed at 1 hr. rating, full field	19 m.p.h.
Total horsepower, 1 hr.	2736
Tractive eff., cont. 3000 v., full field	48,500
Speed at continuous rating, 3000 v.	19.5 m.p.h.
Total horsepower, continuous	2520
Number of motors	6
Type of motors	GE-278-A-1500/3000 v.
Gear ratio	90/18-5.00
Tractive eff. at 30% tract. coef.	92,700 lb.

MECHANICAL DATA

Track gauge	4 ft. 8½ in.
Wheel arrangement	04440
Diameter of drivers	46 inches
Number of driving axles	6

Passenger Train Hauled by Two Double-ended Steam Locomotives up 4½-per cent Grade North of LaBota

Total wheel base	40 ft. 6 in.
Max. rigid wheel base	9 ft. 2 in.
Width overall	10 ft. 1½ in.
Height over trolley locked down	15 ft. 2 in.
Length inside knuckles	52 ft. 11 in.

WEIGHTS

Total weight on drivers	309,000 lb.
Dead weight per axle	12,150 lb.
Elec. and air brake equipment	135,000 lb.
Mechanical equipment	174,000 lb.

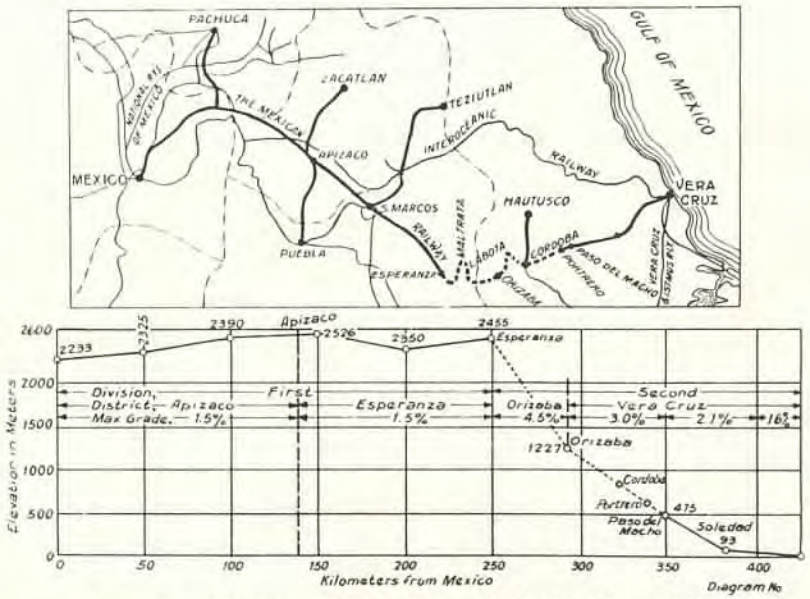
Each locomotive is of the twin-geared, articulated-truck type. A single cab is mounted on two equalizer frames which, in turn, are carried upon three two-axle articulated trucks. A motor is geared directly to each axle with twin, cushion-type gears.

Exterior of Maltrata Substation

The six motors, with which each locomotive is equipped, are of the box-frame, twin-geared, cummutating-pole, railway type with forced ventilation. They are designed to operate two in series on a 3000-volt circuit, or 1500 volts per commutator. The windings are therefore insulated for 3000 volts to ground. An 18-tooth steel pinion is mounted on each end of the armature shaft, and these mesh with 90-tooth cushion-type gears on the axle.

An unusual feature of the design of this locomotive is the provision for removing the motor, wheels, or axle from any of the trucks without removing the cab. By disconnecting the motor leads and jacking up the motor and the side frames, the wheels and axle and finally the motor can be lowered into a pit.

Interior of Maltrata Substation



Map and Profile of Mexican Railway between Mexico City and Vera Cruz. Electrified Portion Indicated by Dotted Lines

The power for the operation of the auxiliaries is provided by a 3000/1500-volt dynamotor which carries a 4-kilowatt, 65-volt control generator mounted on a shaft extension. The two blower motors and the two compressor motors are normally operated in series across the 3000-volt supply using the mid-point of the dynamotor for equalization. This scheme allows the operation of the compressors and blowers directly from the trolley in case of failure of the dynamotor, and of one compressor or blower in case of the failure of the other machine.

An exciter set, used for regeneration, is driven by a 1500-volt motor operated from the 1500-volt dynamotor bus. If it is not necessary to operate the blowers at maximum capacity, they can also be operated on the 1500-volt circuit by connecting them in series.

The control generator supplies current at 65 volts for lights, headlights, foot-warmers, and control circuits, and for charging the storage battery.

View of Maltrata and Grade Section with Orizaba Peak in Background

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February 1928 (3M)