The
ELECTRIFICATION
of the
MEXICAN RAILWAY

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GENERAL ELECTRIC COMPANY
SCHENECTADY, N. Y.

February, 1928
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 vicinity.
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.
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-
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.

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 switching 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.

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. 8 1/2 in.
Wheel arrangement ...............04440
Diameter of drivers ...............46 inches
Number of driving axles ............6

Passenger Train Hauled by Two Double-ended Steam Locomotives up 4 1/2 per cent Grade North of LaBota

The six motors, with which each locomotive is equipped, are of the box-frame, twin-gearered, commutating-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.

Weights
Total wheel base ...............40 ft. 6 in.
Max. rigid wheel base ..........9 ft. 2 in.
Width overall ................10 ft. 1 1/2 in.
Height over trolley locked down ..15 ft. 2 in.
Length inside knuckles .........52 ft. 11 in.

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-gearered, 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.
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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