DETROIT RIVER TUNNEL LOCOMOTIVE

A series of acceptance tests has been completed recently by the General Electric Company and the Detroit River Tunnel Company, jointly, upon electric locomotive No. 7500, the first of six locomotives for the Michigan Central Railroad, one of the New York Central lines, and to be operated in the tunnel under the Detroit River now under construction. The electrical equipment of this locomotive, which is the most powerful in point of tractive effort ever designed for operation by direct current, was built and installed by the General Electric Company. The mechanical details, including the trucks and cab structure, are the product of the Schenectady works of the American Locomotive Company.

The Detroit River tunnel will connect the West Detroit yards of the Michigan Central Railroad with the new Windsor yards in Windsor, Ont. The electrified zone, embracing the tunnel with its approaches, terminal tracks and sidings, will cover a distance of approximately 33,000 ft. Maximum grades are encountered on the approaches, where a 2 per cent grade extends for approximately 2000 ft. at each end of the tunnel.

The locomotives are designed for hauling both freight and passenger trains through this tunnel, and also for switching service at the terminals. The specifications under which they were built demand a maximum service, consisting of hauling an 1800-ton trailing train up the 2 per cent grades at a speed of not less than 10 m.p.h., with two locomotives operating as multiple units. Their capacity is such that they are capable of repeating trips with this weight of train continuously with a lay-over of 15 minutes at each end without undue heating of the motors.

The locomotive is classified by the builders as of the 0440-E-200-4GE209 type, which is the conventional method of stating that it is an articulated four-axle type of electric locomotive, weighing 200,000 lb. and equipped with four GE-209 motors.

The articulated running gear may be considered as consisting of two four-wheel trucks coupled together; but the method of coupling and the relation of the equalizing systems on the two trucks make it necessary to consider the two trucks together. The truck side frames, as will be seen from the illustrations, are heavy steel castings of a truss pattern. In order to obtain the necessary weight on drivers the members of this frame are made heavier than actually required for strength, the top member having a section 5 in. x 7 in., while the other members are proportionally heavy. This gives a peculiarly massive and substantial appearance to the whole running gear. The truck end frames and bolsters are castings of heavy box girder type, rigidly bolted to the side frames and fitted in such a manner as to relieve the bolts of shear. Draft gear, buffers and all truck frame members are calculated for buffing stresses of 500,000 lb. and pulling stresses in proportion.

The system of spring suspension is of the locomotive type, the weight being carried on semi-elliptic springs resting on the journal box saddles. The system of equalization by which these springs are connected together is ingenious and interesting. The *A* end of the running gear—or what may be called the forward truck—is side equalized, the two springs on each side being connected together through an equalizer beam. This equalizes the distribution of weight between the two wheels on one side, giving to this truck a two-point support, and consequently leaving it in a condition of unstable equilibrium as regards tilting stresses—that is, stresses tending to tip the truck forward or backward. The *B* end of the running gear, or what may be called the rear truck of the locomotive, is cross-equalized, the two springs on the rear axle being connected together through an equalizer beam. The other two springs on this truck are independent and are connected directly to the truck frame. This results in a three-point suspension on the rear truck, leaving it in a condition of stable equilibrium, capable of resisting stresses in any direction, whether rolling or tilting. The two trucks are coupled together by a massive hinge, so designed as to enable the rear truck to resist any tilting tendency of the forward truck. This hinge combines the two trucks into a single articulated running gear, having lateral flexibility with vertical rigidity. It will be noted from the above description that the running gear has what may be called a compound three-point suspension. The rear truck has in itself a three-point suspension, while the forward and rear trucks together form an articulated frame having a three-point suspension, consisting of the two-point support of the for-

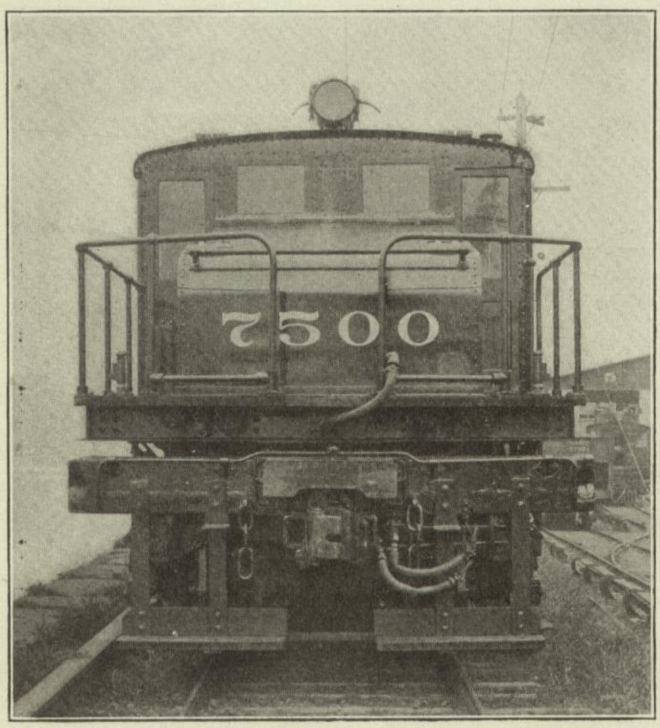
Articulated Electric Locomotive for Service in Detroit River Tunnel of the Michigan Central Railroad

ward truck and the independent equalization of the rear truck.

The braking equipment is arranged so that the action is mechanically independent on each truck. Two pairs of 12-in. brake cylinders apply the brakes, and separate valves and cutout cocks are supplied, so that the pair of cylinders controlling either truck may be cut out without affecting the other.

The draft rigging consists of a standard M.C.B. vertical plane coupler, with yoke, springs and follower plates, designed to comply with the railroad company's specifications. This draft rigging, as well as the spring buffers, is mounted upon the outer end frames of the trucks. This arrangement insures that all pulling and buffing stresses are transmitted on the same horizontal line through the draft rigging, side frames and connecting hinge pin of the trucks. The center pins and cab platform framing are entirely relieved of all longitudinal stresses except those due to the weight of the cab, platform and equipment.

Center pins and side bearings are provided on the running gear for the support of the cab. The center pin on the



Detroit River Tunnel Locomotive—End View

A end is a swivel pin, having a turning motion only, while that one the *B* end has a turning and sliding motion. This construction allows the longitudinal motion necessary to take care of the variation in distance between the truck center pins occurring as the locomotive passes around curves. The side bearings on the *A* end have a clearance of about ⅛ in. when the cab is level, while those on the *B* end have a clearance of about ½ in. The result of this arrangement is that under ordinary circumstances the cab is carried on a three-point suspension, since the side bearings on the *A* end support all normal rolling action of the cab, the side bearings on the *B* end coming into play under abnormal conditions only.

The cab platform is built of four 10-in. longitudinal channels running the whole length of the locomotive, which are tied together by the end channels and bolster plates. Such ballast as is necessary to bring the weight of the locomotive up to the required amount is bolted to the two center sills, and the space remaining between them forms a passage leading from the blower to the motors for carrying the air for forced ventilation. A floor plate, consisting of two sheets of ⅜-in. steel, is riveted to the platform sills, and serves to stiffen and square the platform framing. In the operating cab a ⅞-in. wood flooring is placed over this steel floor.

The sides and ends of the cab are built of ⅛-in. steel plate, supported by a framework of small angles, while the roof is of No. 8 gage steel. The main operating cab occupies the central portion of the locomotive and covers a floor space of 15 ft. 6 in. x 10 ft. It is fitted with windows on each side and two windows and two glazed doors in each end, allowing a practically unobstructed view in every direction. The cab contains the engineer's seat, and such apparatus as is required in the operating compartment of the locomotive. Auxiliary cabs extend from the main cab to the ends of the locomotive, and occupy a floor space of 9 ft. x 6 ft. each. These cabs house the air tank, sand boxes, rheostats and contactors. Hinged perforated doors in the sides of the auxiliary cabs, clearly shown in the illustration, give access to the rheostats and the connections back of the contactors, while folding doors between the auxiliary and main cabs allow access for inspection of the contactors. The edges of the auxiliary cabs are bolted to the platform and main cab, so that they can be readily removed when it is necessary to make heavy repairs.

The difference in width of the auxiliary and main cabs allows room for a narrow platform or running board, extending from the main cab along the sides of the auxiliary cabs to the ends of the locomotive. This running board is protected by hand rails running around the outside of the locomotive from one side of the main cab to the other. The doors of the main cab open to this platform, and the steps reaching the ground are located near the doors. One marked advantage of this construction is the unobstructed view given the engineer, both ahead and to the rear.

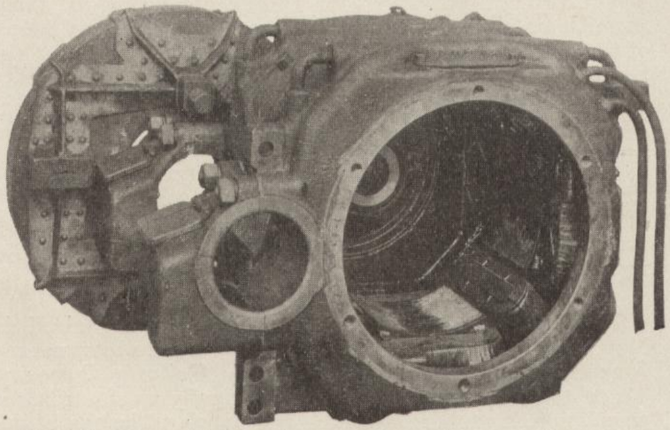
A type C-79 controller and the operating handles for the air brakes are located in the cab within easy reach of the engineer's seat. Sander valves are located beside the engineer, and over his head are switches for the headlight and control circuits. Directly in front are illuminated air gages, ammeter and a foot-operated trolley valve for raising and lowering the overhead trolley. Sanders are arranged to sand the rails in front of the leading wheels on either truck.

A CP-26 air compressor is located in the center of the main cab. This is a two-stage, four-cylinder compressor, geared to a 600-volt, direct-current series motor. The compressor has two low-pressure and two high-pressure cylinders so arranged as to divide the work of compression into four equally distributed stages per revolution. It has a capacity of 100 cu. ft. piston displacement per minute when pumping against a tank pressure of 135 lb. Ample circulating pipes are provided for cooling the air between stages and between pump and tanks, in order that a moderate temperature may be maintained. The compressor is controlled by a governor, consisting of a pneumatically operated piston controlling the contact of the motor circuit switch, and so arranged as to close or open this circuit at any predetermined limits of pressure.

The motor equipment consists of four GE-209 motors. This is a standard General Electric box frame, commutating pole type of motor, and has a rating of approximately 300 hp. At its one-hour rating the motor will develop a torque of 4050 lb. at 1-ft. radius. The gearing between motor and axle has a 4.37 reduction, and the driving wheels are 48 in. in diameter. With this reduction, each motor will develop a tractive effort of 9000 lb. at the rail head, which gives a total tractive effort for the four motors of 36,000 lb. at 12 m.p.h. The motors have an overload capacity sufficient to slip the driving wheels, and the locomotive can develop at the slipping point of the wheels an instantaneous tractive effort of 50,000 lb. to 60,000 lb. The maximum speed of the locomotive, running light upon a level track, is about 35 m.p.h.

There are two gears and pinions per motor, one at either end of the armature shaft. This construction was used on account of the unusually heavy torque and the excessive overloads that the motors will be called upon to carry. In large sizes of motor equipments, with a gear and pinion at only one end of the shaft, it has often been claimed that a large proportion of the wear and breakage of pinions is due to the tilting of the motors under heavy loads, which concentrates the pressure at one end of the tooth. The form of construction adopted in the Detroit locomotive will eliminate any such danger.

The motors are designed for forced ventilation. Air is delivered into the motor frames at the end farthest from the



Detroit River Tunnel Locomotive—Commutating Pole 300-Hp Motor

commutator, passes between the field coils and around the armature, and finally escapes through suitable discharge openings over the commutator. The blower used for this purpose has a capacity of 2000 cu. ft. of air per minute at 2¼ in. of water pressure, and is driven by a direct-current series motor. This blower delivers air to the passage between the two center sills above described, from which the ventilating ducts are tapped off to the motors at appropriate points.

The control system used is the Sprague-General Electric multiple unit type, with two master controllers in the main cab and the contactors in the auxiliary cab. Multiple unit connections have been supplied, so that three locomotives may be operated in unison, if necessary. The problem of starting and accelerating a train of from 1000 tons to 1500 tons weight, which may consist of 40 or 50 cars, is a rather delicate one. Such a train is not a rigid mass, but a long, elastic body, and any inequality in the starting torque results in waves of jerking and buffing strains, which may reach abnormal values in some parts of the train. Consequently, the control for these locomotives was designed especially to produce a uniform increase of speed and torque during the period of acceleration. The control combinations are arranged so that the motors may be operated four in series, two in series and two in parallel, or four in parallel. There are nine resistance steps in series, eight in series-parallel and seven in the parallel position. In a test run with a train of 1578 tons weight, consisting of one locomotive and 26 freight cars, the acceleration from a standstill to 10 m.p.h. was accomplished with marked smoothness. The maximum increase of drawbar pull was about 6500 lb. on the first few steps, after which the maximum throughout the remainder of the acceleration was from 2000 to 3000 lb. To an observer standing in the caboose of such a train the rear end of the train is started so gradually that the beginning of the motion is almost imperceptible. The contrast with the results obtained with a steam locomotive is very striking.

The locomotive is equipped with third-rail shoes to take current from an inverted third-rail. It is also fitted with an overhead trolley, which, as stated previously, can be raised or lowered by a foot-operated valve in front of the motorman.

General data of the locomotive are given in the following table:

Number of motors	4
Gear ratio	4.37
Number of driving wheels	8
Diameter of driving wheels	48 in.
Total wheel base	27 ft. 6 in.
Rigid wheel base	9 ft. 6 in.
Length inside coupler knuckles	39 ft. 6 in.
Length of main cab	15 ft. 6 in.
Height of cab	12 ft. 6 in.
Maximum height, trolley up	15 ft. 6 in.
Maximum height, trolley retracted	14 ft. 10⅛ in.
Maximum width	10 ft. 2⅝ in.
Width of cab	10 ft. 1 15/16 in.
Total weight	199,000 lb.