NEW 3000-VOLT DIRECT-CURRENT GEARLESS PASSENGER LOCOMOTIVE, WEIGHING 265 TONS, FOR THE ST. PAUL CASCADE ELECTRIFICATION

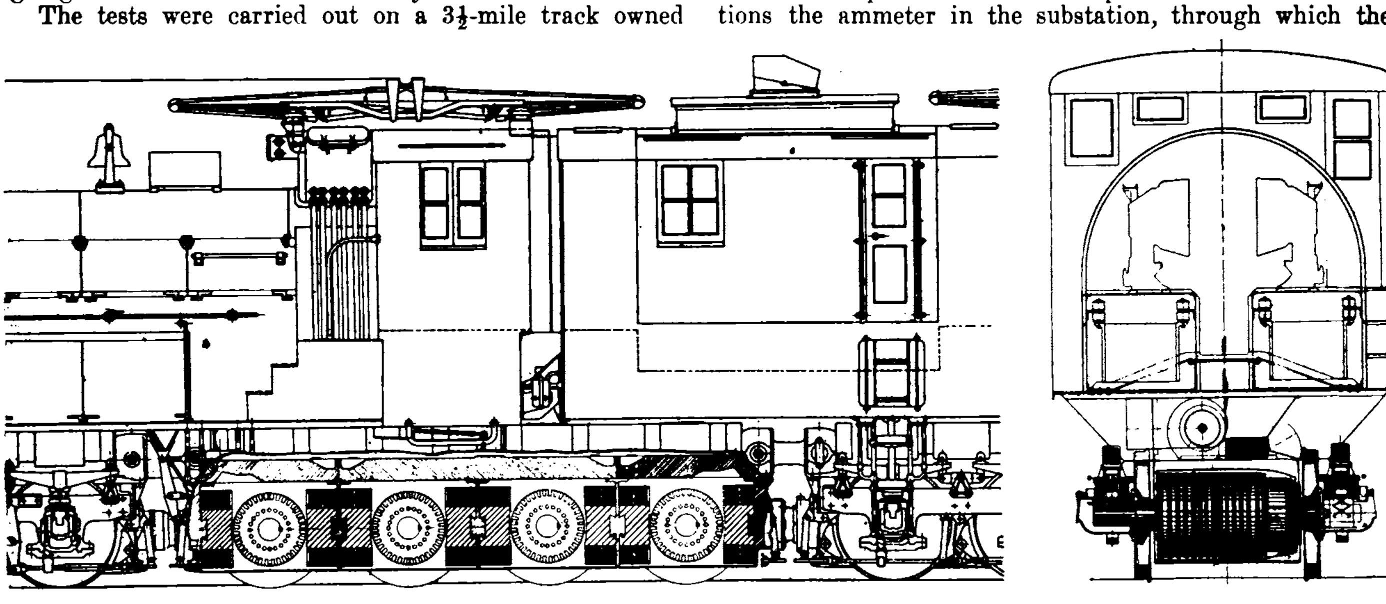
St. Paul Locomotive Tested at Erie

New Type of Machine with Bi-polar Motor Demonstrates Capability of Handling High-Speed Passenger Trains on Othello-Seattle-Tacoma Electric Zone

IN THE PRESENCE of railroad experts and others gathered at Erie, Pa., on Nov. 7 to witness the demonstration, the 3000-volt, direct-current locomotive built by the General Electric Company for the Chicago, Milwaukee & St. Paul Railway was given a series of operating tests. This machine is of the passenger type and is designed for use on the new Cascade electrification. It is equipped with bi-polar motors, gearless type, with motor armatures mounted directly upon the driving axles. In this fundamental feature the new locomotive follows the design of the gearless machines in use on the New York terminal of the New York Central Railroad. The five machines of this type ordered by the railway are now complete and will be delivered at the rate of about one a week, going into commission immediately.

The tests were carried out on a 3½-mile track owned by the manufacturing company and used largely for this purpose. A considerable part of the locomotive work of the company is now done at the Erie plant, making the possession of test facilities quite necessary. The program comprised a number of speed runs up to about 60 m.p.h., the limit for the length of track, a series of regenerative runs, and a "tug-of-war" against two powerful New York Central locomotives.

In the speed runs a couple of light passenger coaches only were attached, the purpose being to demonstrate the accelerating qualities of the machine, as well as its riding qualities. In regenerating, the electric locomotives was driven by the steam locomotives already referred to, and the regenerated current was held at such a valve as to maintain a speed of about 25 m.p.h. Under these conditions the ammeter in the substation, through which the



ARMATURE OF ST. PAUL LOCOMOTIVE MOUNTED BETWEEN WHEELS ON DRIVING AXLE

FRANK J. SPRAGUE, WHO HAS ALWAYS BEEN AN ARDENT ADVOCATE OF DIRECT-CURRENT TRACTION, IS AT THE LEFT. THE TWO AT THE RIGHT ARE OTTO G. HITCHCOCK AND J. B. COX

test track was supplied with power, showed a current of from 400 to 500 amp., at a voltage of 3000, indicating a return of 1200 kw. or more to the supply circuit.

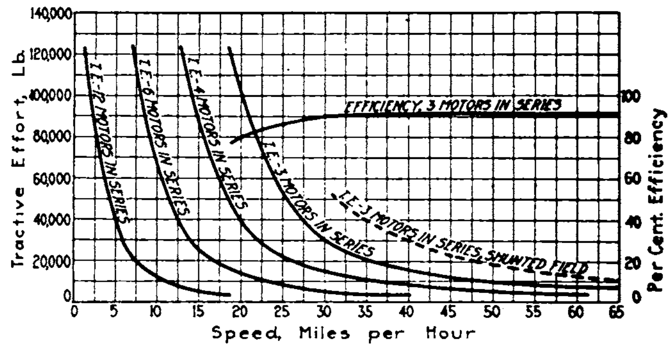
In the backing or "tug-of-war" test the steam locomotives were first allowed to push the electric machine for a short distance, when the latter was notched up in "reverse," gradually bringing the steam locomotives to rest and ultimately backing them up.

A preliminary account of the gearless locomotive for the St. Paul was given by A. H. Armstrong in a paper read before the New York Railroad Club last spring and printed in the issue of this paper for March 23, 1918, page 561. Additional details are now available. The locomotive weighs 265 tons, of which 229 tons are on the drivers. There are fourteen axles, twelve of which are driving axles and two guiding axles.

The gearless drive was adopted to give simplicity of mechanical design, eliminating gears, armature and suspension bearings, jackshafts, side rods, etc. The weight of the armature and wheels is the only dead weight on the track, amounting to approximately 9500 lb. per axle. This is about 25 per cent of the total weight per driving axle, which is 38,166 lb.

To show the position of the armature relative to the field poles a cross-section of some of the motors is reproduced. The cross-section of the locomotive in the vertical plane of the armature axis gives further information as to the motor mounting. These views appear at the foot of page 827.

An important feature of the locomotive is the design of the leading and trailing trucks and the method of suspension of the cab weight upon them. The successive trucks are coupled together in such a way as to "dead-

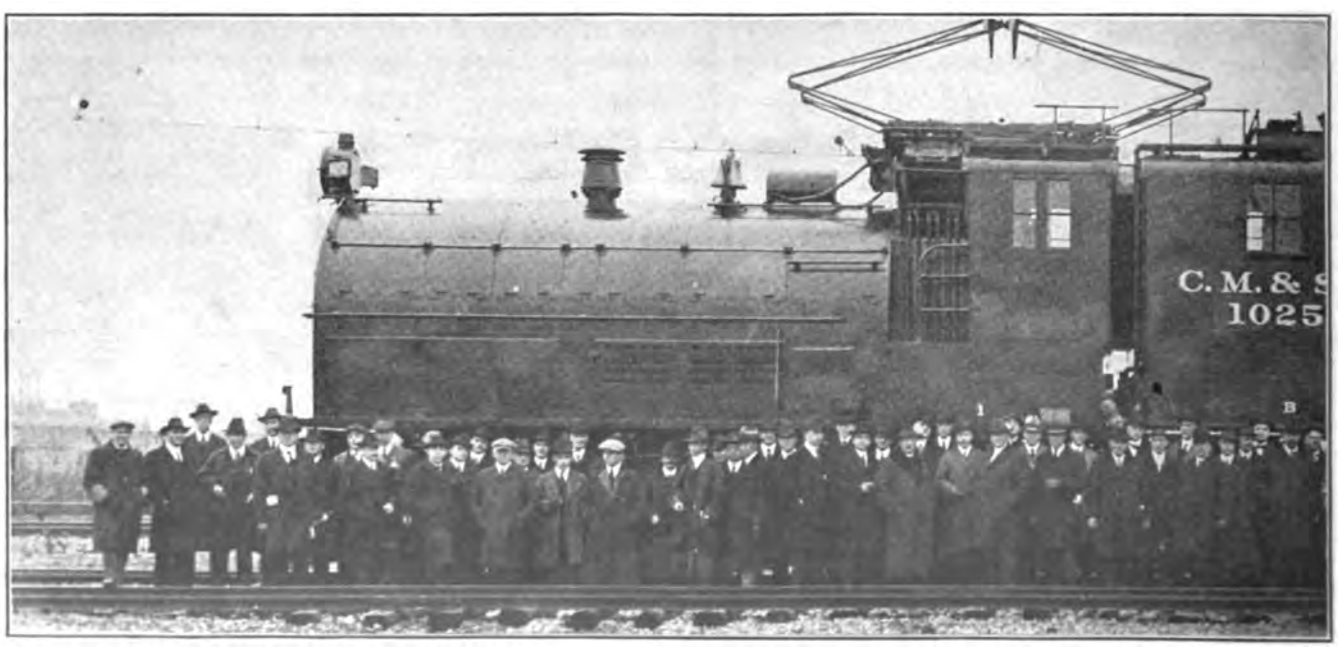


CHARACTERISTIC CURVES OF GEARLESS LOCOMOTIVE FOR THE ST. PAUL

beat" or break up any lateral oscillation which may be caused by inequalities of the track. The weight of the main cab is so supported on the front and rear trucks that any lateral thrust or kick of the leading or trailing wheels against the track is cushioned by the movement of the main cab, which increases the weight bearing down on the wheels at the point where the thrust occurs and automatically reacts to prevent any distortion of the track. This design is said to result in very satisfactory riding qualities at high speeds.

Exhaustive tests on the General Electric Company's test tracks at Erie, Pa., have demonstrated excellent riding qualities of the new locomotive at speed up to 65 m.p.h., the limit on the length of the test track available. The tests also indicate that the locomotive will operate at much higher speeds equally well.

The locomotive is designed for handling in normal service a twelve-car train weighing 960 tons trailing against a grade of 2 per cent at 25 m.p.h. To do so requires 56,500 lb. tractive effort, equivalent to a coefficient of adhesion of 12.3 per cent of the weight upon the driving



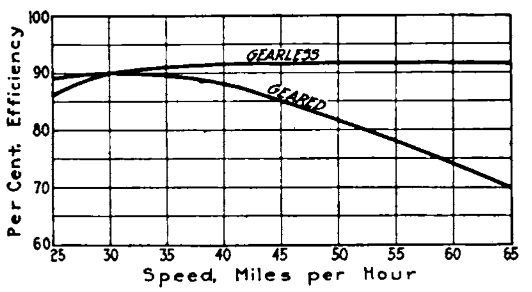
GROUP OF RAILROAD MEN GATHERED AT ERIE, PA., TO WITNESS DEMONSTRATION TESTS OF ELEC axles. This allows a margin between the operating tractive coefficient and the slipping point of the wheels sufficient to permit the locomotive to hold trains containing as many as fourteen cars in emergencies, and the motors have corresponding necessary extra capacity. For continuous operation the locomotive is designed to operate at 42,000 lb. tractive effort at a speed of 27 m.p.h.

The principal data for the new locomotive are given in the table on page 830.

Part of the Motors Furnish Excitation During Regeneration

In most respects the control equipment of the new locomotive is similar to that in use on the locomotives which have been operating on the St. Paul for nearly four years. An important difference, however, is in the means used for exciting the motors which are acting as generators during regeneration. Four of the main motors are utilized for this purpose, which is possible because eight motors are ample to supply all of the generator capacity required on down grades.

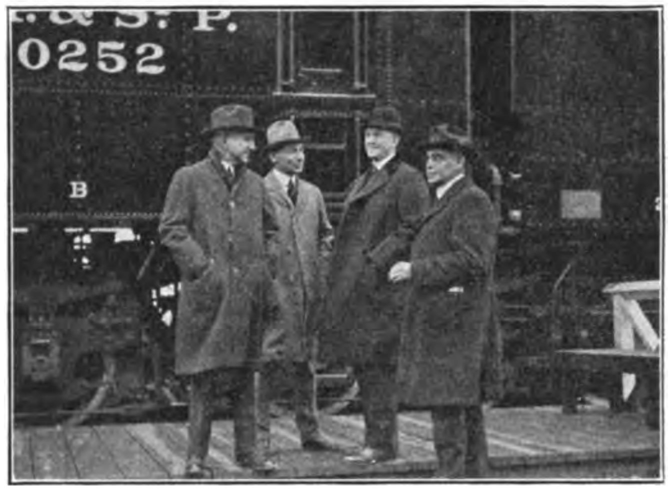
By thus utilizing some of the traction motors it has been possible greatly to reduce the size of the motor-



COMPARISON OF EFFICIENCY CURVES OF GEARED AND GEARLESS LOCOMOTIVES FOR THE ST. PAUL

generator sets used for control, accessories and train lighting. An appreciable reduction in the weight of the control equipment is obtained and at the same time provision is made for effective regenerative electric braking on down grade.

The motor-generator set furnishes control current for operating the contactors and for charging an 80-volt storage battery which supplies light as well as power for the accessory apparatus.

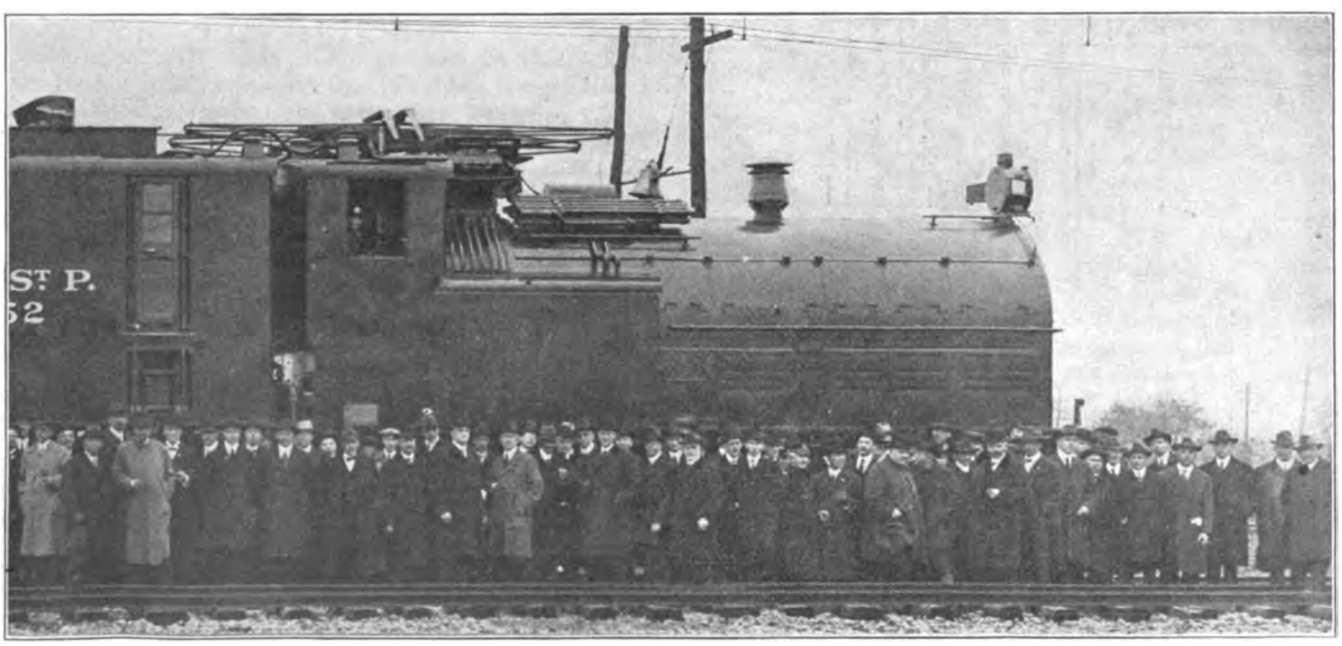


F. C. PRATT TALKING OVER THE FINE POINTS OF THE LOCOMOTIVES WITH H. F. F. ERBEN, J. M. SHERWIN AND M. GRISWOLD

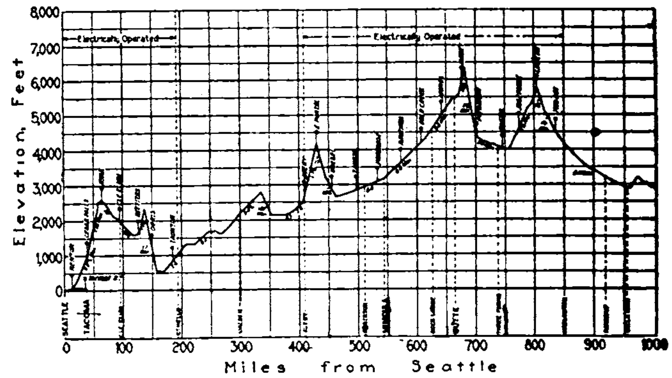
The master controller is constructed in three sections, arranged for both motoring and regenerating, all of the cylinders being suitably interlocked to prevent incorrect manipulation. For full-speed operation the twelve motors are connected three in series with 1000 volts per commutator. Control connections are also provided for operating four, six, or twelve motors in series. Additional speed variation is obtained by tapping the motor fields in all combinations. Cooling air for each pair of motors is supplied by a small motor-driven blower, an arrangement which was adopted to avoid the heavy duct losses encountered when a single large blower is used.

Auxiliary Apparatus Is Well Distributed

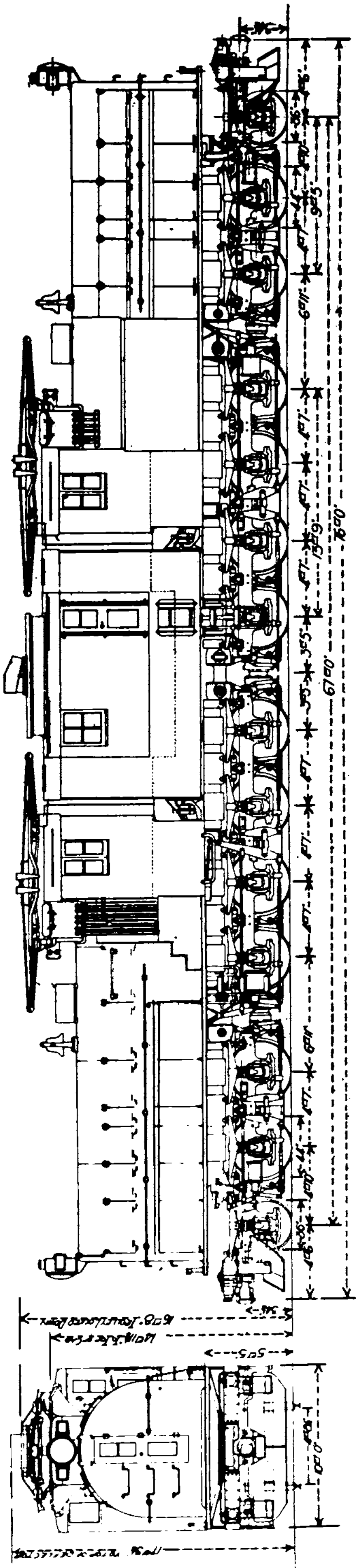
The 3000-volt contactors and resistors are mounted in the curved end cab at each end of the locomotive. In one of these cabs there is also the 3000-volt direct-current air compressor and storage battery. In the other is a small motor-generator set and the high-speed circuit breaker. The operating cabs contain the master controller, indicating instruments, and a small air compressor (in the No. 2 cab) operated from the battery circuit with sufficient capacity for raising the pantograph. Near the controller are the usual air-brake handles for standard braking equipment.



TRIC LOCOMOTIVES FOR THE CASCADE DIVISION OF THE CHICAGO, MILWAUKEE & ST. PAUL RAILWAY



PROFILE OF ST. PAUL RAILWAY OVER WHICH GEARLESS PASSENGER LOCOMOTIVES WILL OPERATE



END AND SIDE ELEVATIONS OF GEARLESS LOCOMOTIVE JUST COMPLETED FOR PASSENGER TRAFFIC ON THE CHICAGO, MILWAUKEE & ST. PAUL RAILWAY

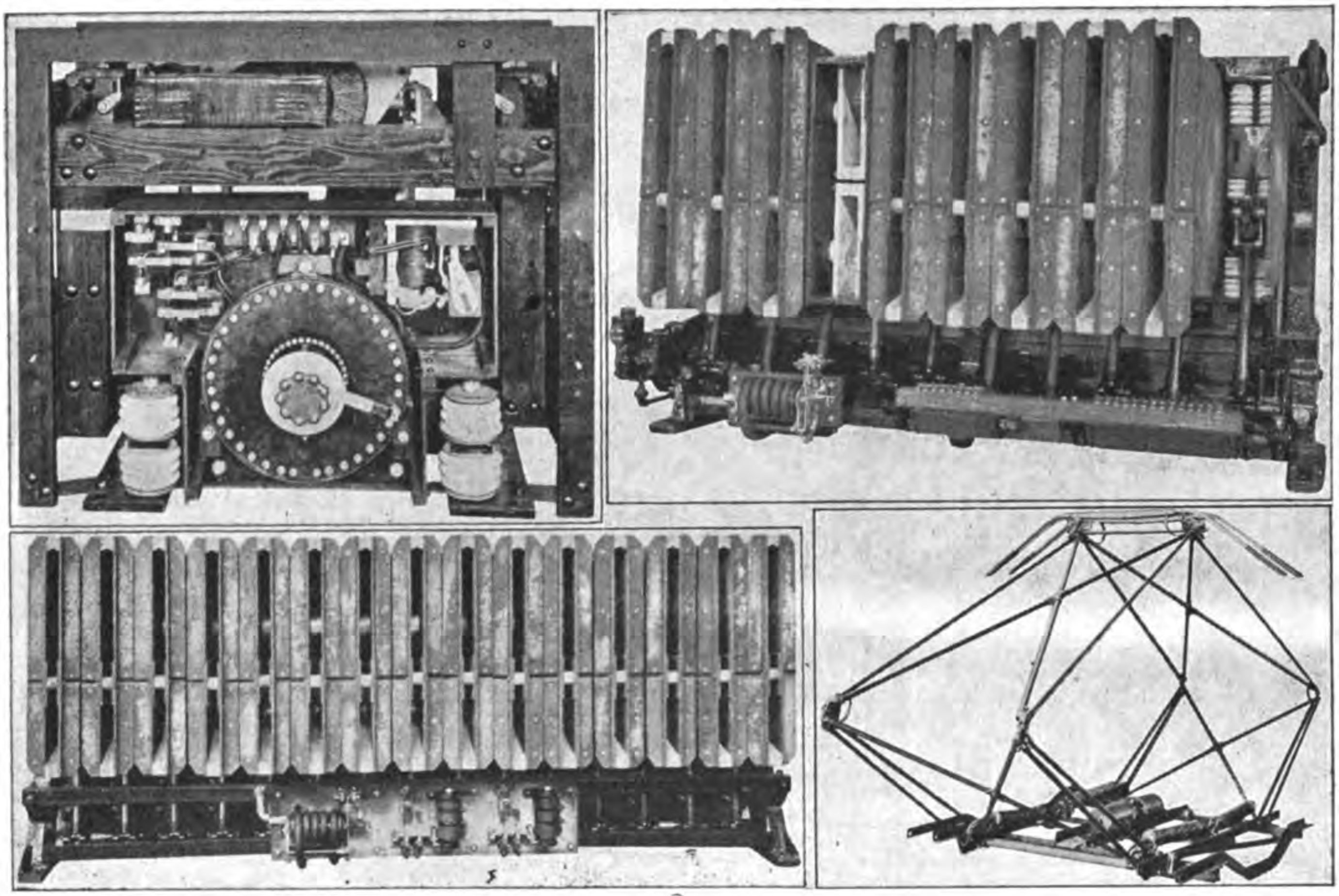
The center cab is occupied by the oil-fired steam boiler for heating passenger trains, with accessories including tanks for oil and water, circulating pumps, and a motor-driven blower to furnish forced draft. A slider pantograph similar in construction to those now in use is mounted on each end of the operating cab. This pantograph has two sliding contacts, giving a total of four points per slider with the double contact wires. The pantograph and flexible twin contact-wire construction enable the locomotives to collect current as high as 2000 amp. up to 60 m.p.h. without noticeable arcing at the contact points. The second pantograph is held in reserve. Sand boxes with pipes leading to each pair of driving wheels are located directly beneath the pantograph outside the operating cab.

PRINCIPAL DATA OF GEARLESS LOCOMOTIVE FOR C., M. & ST. P. RY.

Length inside knuckle	76 ft. 0 in.
Length over cab	68 ft. 0 in.
Total wheelbase	67 ft. 0 in.
Rigid wheelbase	13 ft. 11 in.
Diameter driving wheels	44 in.
Diameter guiding wheels	36 in.
Weight electrical equipment	235,000 lb.
Weight mechanical equipment	295,000 lb.
Weight complete locomotive	530,000 lb.
Weight on drivers	458,000 lb.
Weight on guiding axle	36,000 lb.
Weight on each driving axle	38,166 lb.
Number of motors	12
One-hour rating	3240 h. p.
Continuous rating	2760 h. p.
Tractive effort—one-hour rating	46,000 lb.
Tractive effort—continuous rating	42,000 lb.
Tractive effort—2 per cent ruling grade with 960-ton trans	56,500 lb.
Coefficient of adhesion ruling grade	12.3 per cent
Starting tractive effort—25 per cent coefficient of adhesion	115,000 lb.
Rate of acceleration starting 2 per cent ruling grade	0.48 m. p. h. p. s.

The new locomotives will operate over the section between Othello, Seattle and Tacoma, including 17 miles of 2.2 per cent grade from the Columbia River west and 19 miles of 1.7 per cent grade between Cedar Falls and the summit of the Cascades. The traffic over this division consists of the heavy main-line transcontinental passenger trains "Olympian" and "Columbian," carrying from eight

TWO POWERFUL STEAM LOCOMOTIVES PUSHING ELECTRIC LOCOMOTIVES IN REGULATION TESTS



TOP, AT LEFT, HIGH-SPEED CIRCUIT BREAKER, SIDE VIEW, WITH COVERS AND ARC CHUTE REMOVED. TOP, AT RIGHT, CONTACTOR GROUP WITH ARC CHUTES IN PLACE. BOTTOM, AT LEFT, GROUP OF AIR-OPERATED CONTACTORS. BOTTOM AT RIGHT, AIR-OPERATED PANTOGRAPH

to twelve steel passenger coaches which will be handled over the maximum grades without helpers. Freight pushers are already in operation on a 2.2 per cent grade, using two of the locomotives from the original electrification. It is expected that electrical operation during the coming winter will assist in overcoming many of the delays which are commonly met with during winter operation in this district.

Dr. Whitten on Zone Fares and City Planning

Zone Fares Would Tend Toward More Economical City Development and Avoid Highly Congested Centers

AMONG the witnesses for the League of Municipalities in the Public Service Railway's zone fare case last summer was Dr. Robert H. Whitten, technical advisor to the City Plan Commission of the City of Cleveland and formerly with the New York Public Service Commission of the First District.

In discussing the comparative merits of the flat versus the zone fare from the city planning standpoint, Dr. Whitten said the flat fare was advantageous for wider spreading of the population and industry. A factory could locate anywhere and draw its labor supply from the entire city because the laborer could be carried for a single uniform fare from any place to any place. The physical development of the American city has been molded in very large measure by the flat fare system. Its development, compared with a European city, was distinctly scattered. The sprawling development of such American cities was, however, uneconomic from the city planning viewpoint. It called for more miles of track, water pipe, gas pipe, electric wiring, sewers, pavements, etc., thus increasing the cost of supplying the city with the necessary utilities.

The application of the zone fare would tend toward more compact development and also to develop sub-centers for local retail trade, amusement and social purposes. These centers would draw from a 1- to 2-mile radius and would be benefited if the initial fare was 3 instead of 5 cents.

While the American city as a whole was less compactly developed than the British city, there was nevertheless in the largest American cities a compact or even congested central development that was sometimes even more pronounced than in British cities of like size. In spite of the effect of the transit lines in spreading out population, a large proportion of the people from choice or necessity lived close to the heart of the city. As far as the poorer class was concerned, this was largely due to a desire to live within working distance of the largest number of opportunities of employment. It was possible that this tendency toward congestion in the central area with its many light manufacturing plants has been accentuated by the flat fare. A zone fare plan with a low initial fare would probably tend to reduce congestion in the central areas as many families would be able to live a mile or two further out from the center than under a 5 or 7-cent flat rate.

The population spot maps shown by Dr. Whitten included New York, Philadelphia, Cleveland, Chicago, Newark, Boston, London, Manchester, Glasgow, Berlin and Paris. All were on a scale of 2 miles to the inch with one dot representing 1000 people. New York had a marked congestion on the lower east side of Manhattan Island. While central Philadelphia showed no such marked congestion as lower Manhattan, it was congested in comparison with central Paris or London.