# STREET AND ELECTRIC RAILWAYS

## PART II

# STREET AND ELECTRIC RAILWAYS.

## PART II.—TECHNICAL.

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## CHAPTER I.

### EQUIPMENT.

#### I.

#### POWER-PLANT EQUIPMENT.

*Power-plant engineering.*—The general statistics of the industry for 1907 show the 945 operating companies enumerated to have 829 power houses, equipped with 2,552 steam and gas engines, inclusive of steam turbines, with a total capacity of 2,384,518 horsepower. In addition, there were 228 water wheels or hydraulic turbines, with a capacity of 91,961 horsepower, making a total of 2,476,479 horsepower in 2,780 units, an average of 891 horsepower per unit. A considerable gain in average size of unit over the figures of the last report is shown, while the individual units have also become much larger.

The general conditions that were noted as applying to power-house construction in 1902 have been in no wise changed in the intervening period, and the statements that then applied are equally true with respect to the data embodied in the present report. While in some instances the pressure has been raised in order to meet the conditions of longer lines and larger networks, the standard voltages have remained practically the same throughout the period. One noteworthy feature in this respect has been the gradual transition from direct current in the generating plants feeding into the system without manipulation, to alternating current feeding to intermediate substations where rotary converters or motor-generator sets are installed for delivering direct current to sections of the line. The usual method in electric-railway work is, transmission at about 13,000 volts alternating current and utilization at about 600 volts direct current; and the subsidiary apparatus, lightning protectors, etc., are adjusted to such conditions. The general principles of construction of alternating-power plants do not differ from those in plants for the direct current, except in the size of the units, which have been carried to proportions not attempted with earlier types when direct current was the sole dependence. The water-tube boiler is the usual type chosen for such large plants, because it can be made in larger sizes without fear of explosion and occupies less ground space per horsepower than the fire-tube boiler. In the modern plants the size of the units is such that a two-story boiler room is common. Until a few years ago the chief prime mover for driving generators of larger size in railway plants was the compound condensing steam engine, the triple-expansion engine not finding much favor. In one instance during the period covered by the report a duplex compound engine was installed with two low-pressure cylinders horizontal and two low-pressure cylinders vertical. This was a generating unit of 5,000 kilowatt capacity. The next step was the introduction of the present turbine. With compound condensing engines the steam pressure commonly used has been 175 pounds, while with steam turbines the pressure has easily been carried to 200 pounds. Owing to the large size to which the alternating-current units have been developed, there has been a marked tendency toward the division of installations into units, each unit consisting of a generating engine and the condenser, together with the necessary number of boilers to furnish steam for the individual engines, and the auxiliaries connected with the boiler rooms. As the idea is that each unit shall be entirely independent of every other, there are several separate but interrelated power plants under the one roof. There is thus obtained a minimum of danger of a complete shut down, but if the unit is carried out rigorously into all the details, such conditions are less economical, as there is necessarily a greater amount of reserve apparatus. For the alternating current, generators that employ a periodicity of 25 cycles per second have been commonly adopted in the United States. The large modern machines are usually of the revolving-field type. The revolving parts carry low-voltage current, the high voltage to line being confined to the stationary

parts where there is little risk of accidental contact on the part of station attendants. Operation in parallel, so that all these generators feed at once into the same system, is attended with no difficulty.

*Concentration in large plants.*—Throughout the whole period covered by this report the tendency has been toward the abolition of smaller stations and the concentration of the generating apparatus in one very large building. While this involves a greater use of substations, it is economical, owing to a larger basis of production of electrical energy. The main plant is almost invariably located on the outskirts of the city served, on a site which is convenient for the securing of materials, coal, condensing water, and other supplies. Moreover, better supervision of the plant is obtained, and, in general, a much finer type of building is possible.

*Power plant of the Interborough Rapid Transit Company.*—A station in which the installation, as well as the building, is in many respects typical is the power house of the Interborough Rapid Transit Company in New York, situated on the Hudson River at West Fifty-ninth street, and put into operation in 1904. This is believed to be the largest electric-railway power plant in the world. It provides for a single row of large engines and electric generators contained within an operating room placed beside the boiler house, with the capacity to produce approximately not less than 100,000 horsepower when the machinery is operated at the normal rating. This plant was primarily designed for and equipped with reciprocating engines, but barely had it gone into operation before the transition was made to steam turbines. As originally designed and constructed the plant consisted of five generating sections or independent units, each similar to the other in all details, and comprising in each section 12 boilers; 2 engines, each direct-connected to 5,000 kilowatt alternators; 2 condensing equipments; 2 boiler-feeding pumps; 2 smoke-flue systems; and detail apparatus necessary to make each section a unit independent and complete in itself. The steam-engine and steam-pump equipment embraced 9 main engines, each of a capacity of from 8,000 to 11,000 horsepower direct-connected to the 5,000 kilowatt generators, and 3 steam turbines direct-connected to generators of 1,875 kilowatt capacity each for lighting, and two 400-horsepower engines direct-connected to 250 kilowatt generators for furnishing direct exciting current to the fields of the alternators. Each of the large engines at Fifty-ninth street consists of two compound condensing engines, weighing 720 tons, one at each end of the crank shaft, the alternators being placed at the center of the shaft between the engines. The 44-inch high-pressure cylinder is placed horizontally, and the 88-inch low-pressure cylinder vertically. The two connecting rods of each engine are associated with a common crank pin; the two cranks are set at an angle of 135° to each other, giving 8 impulses to the shaft at equal intervals in each revolution; the stroke is 60 inches. The steam pressure is 175 pounds, and the steam consumption on the basis of the development of 8,000 horsepower is about 13 pounds per horsepower per hour.

It may be noted that the building housing this huge plant is 690 feet in length and 200 feet in width, the boiler room taking 83 feet of this width and the engine section 117 feet. The operating-room section is symmetrical in its construction, consisting of a central area with galleries at both sides, the northern gallery carrying the electric-control apparatus, etc., while the southern opens on the boiler room and is occupied chiefly with steam-pipe equipment. The outward facework of this structure is French renaissance in style, in cut granite and light-colored buff pressed brick, finished with buff terra cotta at the windows, cornices, parapets, etc. The interior of the operating room is in light cream pressed brick, with enameled brick wainscoting.

The complete 12-unit power house has 6 chimneys, spaced 108 feet apart on the longitudinal center of the boiler room, each chimney rising 220 feet above the grate bars, with an inside diameter of 15 feet at the top. The chimneys are supported upon the steel structure of the building, at an elevation of 76 feet above the basement floor and 63 feet above the grates, with 162 feet in total height of brickwork above the top of the supporting platform. Coal is delivered direct to the plant from barges on the Hudson River, the pier constructed at Fifty-eighth street inclosing the pipes through which the condensing water is taken from and returned to the river. The coal-handling equipment comprises a moving electric hoist with crushing and weighing apparatus combined with belt conveyors for the manipulation of the coal after its delivery and preparation.

*Change to steam turbines.*—As noted above, the change has already been made in this great plant from reciprocating engines to steam turbines, of which there are 3 of 1,250 horsepower and 1 of 5,500 horsepower. The new development in dynamo and steam-power mechanism generally designated as "turbo-generators" was described in some detail in the census report on electrical machinery, apparatus, and supplies.[1] It was there noted that the two types are horizontal and vertical, and that the leading horizontal type made in the United States follows rather closely the older method of construction. The adoption of both the horizontal and the vertical types has been general throughout the field in the past five years, and the results are summarized in the report of the Committee on Power Generation made to the American Street and

[1] Bulletin 73, "Electrical Machinery, Apparatus, and Supplies," Census of Manufactures, 1905.

Interurban Railway Engineering Association for the year 1907–8. This report embodies observations continuing in some cases over four years, the average being two years and eight months; the replies were made by systems having experience with direct-connected and belt-driven turbo units ranging from 200 kilowatts up to 2,700 kilowatts, and with steam turbines from 75 horsepower to 5,000 horsepower. It is stated to be shown conclusively that the cost of repairs, maintenance, and labor in operation is favorable to the turbine plant. The advantage in economy of labor cost of operation of the turbine over the reciprocating engine is hardly apparent in plants of less than 1,000 horsepower, but in larger plants it seems to be an important factor. In one plant of good size, where both reciprocating engines and turbines were of the same size, the labor cost of operation was given as 0.059 of a cent per kilowatt hour for turbines, and 0.108 of a cent for engines; and the cost of repairs and maintenance per kilowatt hour as 0.0303 of a cent for turbines and 0.0407 of a cent for engines. The report of the committee states that differences in fuel consumption per kilowatt hour under like conditions of load did not show that the turbine possessed such a decided advantage. The answers to questions on this point were more nearly equally divided, but the evidence generally seemed favorable to the turbine. The reliability of a prime mover in electrical operation is one of the vital and essential elements in its service. Such units often have to endure extreme variations in load, and at occasional intervals are under adverse pressure conditions. Replies from 20 out of 27 lines indicated that, on the ground of reliability, they considered the turbine equal or preferable to the reciprocating engine, while 5 lines preferred the reciprocating engine on this ground. For operation under varying steam pressure the replies were not so favorable to the turbine, 5 of the answers being favorable to the reciprocating engine. It is noted that at one time there was a feeling of anxiety in some quarters that the erosion of turbine blades and buckets by the steam might be so material a factor in a high maintenance cost as to affect the economy in their use, but now there seems to be little cause for uneasiness on this point, since those who have had turbines in use the longest report no erosion. It seems necessary, however, to provide proper means for separating entrained moisture from the steam in all cases.

Even though the turbine is a much simpler and possibly more reliable unit than the reciprocating type, the high vacuum and superheat essential to its most economical operation necessarily add more complicated and less reliable equipment to both boiler and engine room. It is probably on account of this essential auxiliary equipment that a great many replies from users of the turbine were not more favorable to the turbine.

Steam-driven equipment is preferred under nearly all circumstances, and especially where the exhaust is needed to heat the feed water. In a few replies, engineers preferred electrically driven exciter units and circulating pumps. The condensers preferred by companies replying were necessarily of various types, as local conditions and the quality and quantity of water available governed their choice. The vacuum obtained by railway companies operating turbines varies from 26 inches to 29¾ inches, one company reporting as high as 29 inches, and another 29¼ inches. From 31 replies only 9 companies reported that they did not superheat steam.

The questions, "Do you consider it equally necessary for turbine and reciprocating engines to be heated up before starting?" and "Which has the advantage of time?" were asked. It was one of the earlier claims that a turbine, on account of its simplicity, could be started more quickly than the reciprocating engine, but replies to the above question do not prove this, as practically all users of turbines reporting regard it equally necessary to heat the turbine, and a few report favorably to the engine on account of the complicated auxiliary equipment of the turbine.

Replies to the questions, "Do you inspect your turbines systematically by opening?" and "To what extent and at what intervals?" were, with but three exceptions, that they are inspected systematically, but as to the extent of the inspection there is a variety of practice. Some inspect externally once each day, while some companies inspect thoroughly, externally and internally, once every three or four months; the internal inspection being for the purpose of examining blade clearance and removing any scale formation.

The replies on the question of overload indicate a wide range of practice, it being common to take full advantage of the overload possibilities of the units for peak loads as being more economical than starting additional units.

*Double-decked plants.*—An interesting development in connection with the use of steam turbines in electric-railway work is the double-decked generator station of which some examples fall within the census period. This type of station possesses certain advantages where the building area is restricted, as in a city, on a harbor frontage, or against a hillside. The ground area in the West Point station, at West Point, Ohio, of the Youngstown and Ohio River Railroad Company (under construction during 1907), is 2 square feet per kilowatt, although in another plant at Fort Wayne, of similar character, the plant covers only 1.42 square feet per kilowatt. The West Point station was designed to supply electrical energy to a network of interurban railways through alternating-current substations. The site selected is at the foot of a hill where, for condensing purposes, use can be made of impounded water from two passing streams. The various features embodied in this plant, where barometric condensers are used and where coal-handling machinery has been avoided as unnecessary, are enumerated as follows:

The generating machinery is on the second floor of the station, 33 feet above the boiler room on the ground floor; the weight of the generating apparatus is supported entirely by the steel-building skeleton, all the footings being carried down to the same stratum—rock; the box columns are 27 feet high; the floor structure is continuous, being tied in from wall to wall, thus reinforcing the entire structure; water-cooled floor columns pass through the middle of the boiler setting to reduce the weight and cost of the beams spanning the battery; and all other columns straddle the boiler setting. The barometric condensers are hung from the floor girders directly under the turbine exhaust nozzle, and as they are designed for moderate vacuum there are no air pumps; the steam piping is simple and direct, with few bends, and drains back from the turbine throttle; all important steam-header and supply lines are controlled by pedestal-extension valves from the turbine floor and nonreturn valves are placed in the delivery pipe from each boiler, to prevent back flow; the header serves largely as an equalizer, hence it is small in size (8 inches). The equipment has been designed for 200-pound pressure and high steam velocities; all auxiliaries are steam driven, so that steam may be had for feed-water heating, and the feed water is taken from the condenser hot well; the circulating pumps are interconnected for relay working and are primed by steam siphons or by the service pump; the pump suction pipes are submerged 8 feet in the intake bay to avoid surface air. There is a two-story side addition for accommodating the transformers; the alternating switchboard is located in the division wall, leaving a clear rectangular operating room and a separate switch room; the generators are air-cooled by positive blast piped from the outside in order to reach cooler air and to avoid the possibility of steam from the boiler room reaching the insulation; the turbine bedplate is leveled on the plate girders throughout its length with a cast-lead pad 1 inch thick; there is a reserve exciter unit, steam driven, the exhaust steam being taken to the heater; the transformers are mounted on trucks to facilitate replacement by a reserve unit which is provided; an ash hoist is installed from the level of the ash tunnel to the level of the sliding track; the crane reaches the basement through a removable section of the flooring; the flue connections pass directly to the stack, with no bends; the steel stack is self-supporting and brick lined; and there is an elevated tank in the turbine room to provide a head for the gland water and building service.

*Low-pressure steam turbines.*—Reference has been made above to the low-pressure turbo-generator unit in the power house of the Interborough Rapid Transit Company. This exemplifies a further departure in generating practice, but is not unique, as some interesting examples already exist in the traction power-house field. The 5,500-horsepower low-pressure turbine last installed takes the exhaust of one of the present 5,000-horsepower reciprocating compound engines, and thus makes a triple-expansion combination which had hitherto been an unfamiliar element in street-railway engineering. The turbine is directly coupled with an induction generator rated at 5,000 kilowatts, 3-phase, 25 cycles, and is connected without switching apparatus to the leads of the reciprocating-engine generators. This low-pressure turbine has no governor, but is controlled by the generator, which latter is controlled by the governors on the reciprocating engine. This turbine is of the vertical-shaft, 3-stage type; the design of operation includes the separation of oil from the steam before it enters the turbine, so that the condensing steam, already used three times, can be used over again in the boilers, thus effecting a large saving in the quantity of water used. It is stated that double the output in electrical energy is obtained from the combined unit over that obtained formerly from the reciprocating engine alone, at a greatly reduced steam consumption per kilowatt.

*Boston Elevated gas-engine plants.*—Among the developments in power generation has been the use of gas engines, although these have not yet been carried into such large units in railway power plants as in the department of electric light and power in central-station practice. The Boston Elevated Railway Company has had for some time two gas-engine plants, both of them generating direct current and feeding into the overhead system of supply in multiple with steam-driven power stations. These have been operated most of the time in two eight-hour watches, from 7 a. m. until 11 p. m., and shut down the other eight hours. These plants are of considerable capacity. The Somerville power station has one pair of gas producers with the usual auxiliaries, two 600-brake horsepower gas engines, each 2-cylinder, 4-cycle, and two 350-kilowatt direct-current generators. The fuel for the producer is soft coal, the same as that used in the regular central stations, mostly run-of-mine Pocahontas. The figures from January to August, 1907, show an average consumption of 1.404 pounds of coal per brake horsepower hour, and 2.034 pounds per kilowatt hour, as compared with 3.447 pounds of coal per kilowatt hour for all the Boston Elevated steam plants. The station load factor, based on sixteen hours per day and seven days per week, is 41.6 per cent; the engine load factor, 83.2 per cent; and the generating load factor, 98.4 per cent. This plant started in May, 1906.

*General gas-engine practice.*—An interesting variation in gas-engine practice is found in the Warren and Jamestown Street Railway Company (Pa.) single-phase system traversing the valley of Conewango Creek, through which the waters of Lake Chautauqua empty into the Allegheny River. The power house of this road is located at Stoneham, 5 miles south of Warren, Pa., on account of its proximity to the natural-gas pipe lines from which its fuel supply is obtained. The

equipment includes two 300-kilowatt alternating-current generators of the revolving-field type, which are direct-connected to horizontal gas engines, operated at a speed of 150 revolutions per minute. The two units are connected in parallel. A plant of similar nature has also been installed at Independence, Kans. In these horizontal double-acting gas engines the builders have sought to construct a prime mover simple in design and in operation, substantial and permanent in construction, reliable in working, and insuring the best economy compatible with simplicity. The resemblance to approved steam-engine practice is strong, and the engine should be considered not as an example of radical change in construction, but as an adaptation to gas working of the experiences of builders in the design of the Corliss steam engine.

The largest gas engine employed in street-railway practice appears to be the 3,000-horsepower engine installed in one of the power houses of the Georgia Railway and Electric Company of Atlanta. The engine in question, which gives a striking idea of the development already reached by prime generators of this kind, is a 3,000-horsepower horizontal, twin-tandem, 4-cycle, double-acting machine, with cylinders 39 by 54 inches, direct-connected to a 2,000-kilowatt, 3-phase, 25-cycle, 6,600-volt alternator. It occupies a floor space of approximately 64 feet 10 inches by 32 feet 2 inches. The weight of the fly wheel, which has a diameter of 20 feet, is 42 tons, and the approximate weight of the entire engine is 62½ tons. The engine makes 94 revolutions per minute and supplies current for both the railway and the lighting rotaries for the system of the Georgia company.

*Reciprocating steam engines.*—While the tendency toward the adoption of steam turbines in place of reciprocating engines appears to be overwhelming, not only in the electric-traction field but in kindred enterprises, the reciprocating engine is not without its advocates, and is still used. The best illustration of this adherence to earlier standard practice is furnished by the plant of the Pacific Light and Power Company, at Redondo, Cal. This company supplies electrical energy for lights and stationary motors, but the greater part of the current from its new station is used for operating the street railway at Los Angeles and adjacent suburban towns, including all the well-known Huntington systems of interurban roads. This plant has a normal rating of 16,000 kilowatts, divided into three 5,000-kilowatt units, generating current at the unusual potential of 18,000 volts, 50-cycle, 3-phase. These generators are of the fly-wheel type, and are operated in multiple with the previously existing apparatus of the transmission system of the company. The plant includes three 34 by 70 by 56 inch combined double horizontal and vertical compound side-crank engines, each having two horizontal high-pressure cylinders and two vertical low-pressure cylinders; each of which is also directly connected to an alternator. The particularly interesting point about this plant is that it utilizes crude oil obtained from wells near it. Owing to this system of oil firing, the boiler-room labor cost is at a minimum, and in view of the remarkably low fuel consumption the statement has been made that this plant is developing energy at a cost probably lower than that of any other large American central-station plant. The contract covering this station, made under a bonus agreement, embodied an economy guarantee providing for a fifteen-day test of one unit on a commercial railway load under any load curve within the limits of the rated output of the generator; the total output to be not less than 60,000 kilowatt hours nor more than 78,000 kilowatt hours for 19.5 hours of run, there being 4.5 hours standby each day. On this load the contractor guaranteed an output of electrical energy of 170 kilowatts per 334-pound barrel of oil, each pound of which contained 18,500 B. t. u.[1] The committee, reporting on this fifteen-day test, gave the result as 252.8 kilowatts per barrel of oil, a performance equivalent to slightly less than 25,000 B. t. u. in the fuel output. The bonus earned as a result was $363,310, undoubtedly the largest ever paid on such a steam-power plant guarantee.

*Production of electrical energy.*—In Chapter III, Part I, Statistical, figures of power-plant equipment are very fully discussed and a variety of tables are included as to the number and size of steam engines, water wheels, gas engines, etc., and the dynamo-electric generators that they drive. Beyond the discussion already given, it is not necessary to recapitulate here those data.

With regard to the total output, as related to the capacity of the plant, the cars operated, the car miles run, or the passengers carried, it may be pointed out that these figures are, in general, subject to qualifications which would prevent reaching a very exact determination as to the exact amount of prime power or electrical energy employed in operating a car mile or in carrying one passenger. It will have been noted that the income of electric railways from the sale of current for light and power amounted to $20,093,302 in 1907. Of course all this current sold should be deducted from the current available for the operation of cars, but as no data as to charges made for such current are available, and as prices per kilowatt hour vary from a fraction of a cent to several cents, it is obviously impossible to determine from the income just what quantity of current was sold. Subject to such qualification, however, it would appear that the 1,617,731,300 car miles were operated at a nominal kilowatt output of 4,759,130,100 kilowatt hours, a consumption of slightly less than 3 kilowatt hours per car mile. This amount of electrical energy was

[1] The British thermal unit is the quantity of heat which will raise the temperature of one pound of water one degree F., at or near its temperature of maximum density, 39.1°.

produced by dynamos having a rated capacity of 1,723,416 kilowatts; the average operation was thus at the rate of 2,761 kilowatt hours annually per kilowatt capacity of dynamo. The number of passengers carried, including transfers and free passengers, was 9,533,080,766, or the consumption of energy per passenger was almost exactly 0.5 kilowatt hours. This, however, is again subject to deduction, for the reason that an appreciable amount of the business of the electric railways was the handling of freight, express, and mail matter.

The number of cars in use in 1907 was 83,641, showing a provision in the power house of slightly less than 21 kilowatts per car. In the report for 1902 the provision per car was given for various groups of roads and ranged from 10 to 38 kilowatts per car, the latter amount being provided for cars of the heavier types on interurban roads; the average for all companies being 13.5 kilowatts. The general average for 1907 (20.6 kilowatts per car) is generally applicable, owing to the fact that not only on interurban roads but also on city lines the tendency has been wholly toward the introduction of a larger, heavier type of car, carrying more passengers than the cars that were in vogue in 1902. The figures as to current consumption per passenger or per car mile should be accepted with great reserve, owing to the various elements that enter into the problem, such as size of car, season of the year, condition of track, number or steepness of grades, condition of wheels, the use of trailers, the employment of overhead contact, slot contact, or third rail, and other elements, all of which have a considerable effect upon current consumption.

*Data of production costs.*—The following figures covering a period of one year have recently become available in connection with the cost of producing electric power in a generating station devoted to interurban railway service. The plant is a turbo-engine alternating-current station equipped with two 65-horsepower and three 500-horsepower water-tube boilers, and three generating units. One unit is a 2,000-kilowatt, 13,200-volt, 25-cycle, 3-phase steam turbine set, and the other two are reciprocating engines direct-connected to high-grade alternators of 500-kilowatt and 1,000-kilowatt rating. The plant is hand fired, natural draft being used; the operating steam pressure is 150 pounds per square inch. The current generated at the station is delivered to transmission lines supplying rotary converter and step-down transformer substations, the cars being served with direct current at 600 volts. The road is about thirty miles long from end to end, most of the line being double tracked, with several single-track branches, aggregating a total length of track of 79.06 miles. The passenger-car mileage during the year was 1,820,985.

The total number of kilowatt hours generated during the year and delivered at the alternating-current busbars of the power plant was 10,050,616. Of this energy, 8,095,060 units were delivered at the direct-current busbars of the four substations, giving a transmission and reduction efficiency of about 80 per cent; and the individual substations utilized from 1,500,000 to 3,000,000 kilowatt hours each, according to their locations and loading. The total expenses of station and substation operation were as follows:

| | Station operation. | All substations. |
|---|---|---|
| Total | $82,619.30 | $2,048.87 |
| Coal | 58,295.52 | ..... |
| Wages | 15,620.20 | 1,840.59 |
| Supplies | 3,539.61 | 208.28 |
| Repairs, steam | 3,500.35 | ..... |
| Repairs, electrical | 1,663.62 | ..... |

The cost of coal in this station for the year averaged $4.80 per ton. The plant is located about twenty-two miles from tide water, and the fuel had to be teamed to the storage yard before it could be wheeled into the boiler room. The total operating force consisted of 3 engineers, 4 oilers, 9 firemen, and 4 coal passers. The condensing engines and turbine were operated with a cooling-tower installation having motor-driven fans and pumps to make up the water supply by repeated use of the condensation; jet condensers were used on the engine sets, which were cross-compound units. The turbine outfit is not operated while the station is running under light or average loads. The usual surface-condenser installation is provided for the turbine, with an extra large allowance of cooling surface on account of the high temperatures sometimes reached by the water in the summer season. The total coal consumption of the plant during the year was 12,150 tons, New River being the kind of fuel used. The unit cost of operation is given in the following statement:

| | Cost per kilowatt hour alternating at generating plant (cents). | Power-station cost per kilowatt hour, direct current at substations (cents). |
|---|---|---|
| Total | 0.822 | 1.045 |
| Coal | 0.581 | 0.720 |
| Wages | 0.155 | 0.216 |
| Supplies | 0.035 | 0.045 |
| Repairs | 0.051 | 0.064 |

## II.

### SUBSTATIONS AND CONVERTERS.

*Effect of using alternating current.*—The marked tendency toward the adoption of alternating current is shown particularly in the statistics of substations. In 1902 only 105 companies employed substations, whereas in 1907 the number had increased almost threefold and had reached 312. As a matter of fact these figures do not tell the whole story, as a great

many generating plants include substations within themselves, as shown by the statistics on the apparatus. The evolution in this respect has been in many instances toward the combination of generating plant and substation due to the consolidation of smaller roads into one system or network. Where it has been found desirable to carry out such a process of consolidation and to generate current on a large scale, the various power plants of the smaller roads acquired have sometimes been dismantled or abandoned, but the original generating machinery has very often been left intact, thus constituting a reserve in case of any inadequacy on the part of the distant main power plant. This is again the case where water power is depended upon. In many instances the distant hydroelectric source delivers its current to substations in which are located complete steam plants, ready to start up at short notice in case of interruption or a breakdown of the transmission circuits.

A large quantity of current is purchased by traction companies from central electric light and power stations. In many such instances the traction company, as a measure of precaution, has maintained its own generating plants in readiness in its substations receiving the purchased electrical energy. These substations often are of such large capacity as to be equal to many of the actual generating plants in which no substation machinery is to be found. The chief features of modern substations included in this report are rotary converters, stationary transformers, reactances, switchboards, blowers for cooling the transformers, cables connecting the substations with the main generating plants, and occasionally storage batteries.

The substations in general use have apparatus designed for 3-phase working, based upon the use of 11,000-volt current with delta-connected transformers, and 33,000 to 66,000 volts with what are known as Y-connected transformers. Such apparatus is standard, with a frequency of 25 cycles per second. The standard rotary converters for 25-cycle work in railway service are compound wound, the series field being designed for a compound of 600 volts at no load and full load when supplied from a source of constant potential with not more than 10 per cent resistance drop and with 20 to 30 per cent reactance in the circuit. The 200 and 300 kilowatt machines are wound for 3-phase operation, but all the larger machines are usually wound for 6-phase. The 3-phase and 6-phase machines require different voltages from the stepdown transformers in the substation on account of the use of diametrical connections for 6-phase instead of the double delta.

*Methods of operation.*—Three methods of starting the rotary converters are in use, namely, the application of alternating current at reduced voltages to the collector rings; the use of the machine as a direct-current motor while starting; and the use of an auxiliary starting motor mechanically connected. The use of the self-synchronizing alternating-current starting method is most common. The transformers employed are usually arranged on the unit system, namely, one bank of three single-phase transformers, or one 3-phase transformer to each converter, and these units are usually of a rated capacity about 10 per cent in excess of that of the converter. Such transformers are of the oil-insulated and the air-blast types. The latter are limited to work done with a nominal line potential not to exceed 33,000 volts, while the others may be used for higher voltages. Air-blast transformers are always made of the shell type and are practically used in large sizes where water is not available for the purpose of cooling the cores. Three-phase transformers, as compared with three single-phase transformers of corresponding aggregate capacity, have greater compactness, lighter weight, and lower first cost, and their use is usually preferred except for stations with one converter, where a spare transformer may be wanted; or in the largest size where the weight of the 3-phase transformer would render it unwieldy to handle. Air-blast transformers are used with a pressure varying between one-half ounce per square foot for the small size and 1 ounce for the larger size, and blower sets usually comprise 3-phase induction motors, driving down-blast, steel-plate fans, direct connected. For change to direct-current voltage by the field rheostat or automatically by compounding, which calls for a corresponding change in the alternating-current voltage, a 3-phase reactance coil is provided between the low-tension winding of the transformer and the converter. Standard reactances are rated in kilovolt amperes, equal to 15 per cent of the kilowatt rating of the converters which they accompany. Either air-blast or the oil-cooled type of reactance may be used for rotary converters of any capacity with the exception of 200-kilowatt converters for which oil-insulated transformers and reactances are available; air-blast reactances being used with air-blast transformers, and oil-cooled reactances with oil-insulated transformers of either the self-cooling or the water-cooled type. From substations of this general type, and with this general apparatus, the direct current is delivered directly to the consumption circuits, although in a great many instances storage batteries are associated with the equipment as an emergency feature.

*Work of Oregon Electric Railway.*—A typical illustration of substation work may be cited from the Oregon Electric Railway Company's system, begun in 1906 and opened in 1908, operating between the cities of Portland and Salem with branches, and utilizing 5 substations distributed along the 70 miles of line to feed the middle sections, while the ends of the line are fed from substations belonging to the local power companies in Portland and Salem. These substations are built of reinforced concrete, with corrugated iron roof on steel beams. As is usual in such work the sub-

station is also made to serve the purpose of a waiting room and ticket office. The attendant acts as electrician, station agent, and telegraph operator. Each building is divided into two parts, namely, the high-tension compartment, which contains the lightning arresters, disconnecting switches, oil switches, etc., and the operating room, which contains the transformer, switchboard, and converters. The high-tension compartment is divided into two stories, the upper one containing the oil switches and the lower one the high-tension busbars.

The low-tension wiring for alternating current and direct current is carried in fiber conduits embedded in the concrete floor. The system is designed for 60,000 volts, but is operated at 33,000 volts. The high-tension line with this voltage enters the building under a weatherproof hood through 18-inch holes, and passes down the inside wall through a disconnecting switch and a choke coil to the lower room, where it crosses to the high-tension busbars. The lightning arresters are fastened to the rear wall and are separated from the disconnecting switches and the choke coils by concrete barriers. These lightning arresters are connected through disconnecting switches to the line just after it enters the building. From the high-tension busbars tap circuits pass through disconnecting switches up through the floor to the oil switches, and then down again and through the partition wall to three 185-kilowatt transformers connected in delta, stepping the current down from 33,000 to 430 volts. From these transformers four circuits are brought out from the secondary winding of each transformer and are connected in diametrical 6-phase relation to a 500-kilowatt synchronizing converter, which delivers the direct current to the consumption circuit. This converter has speed-limiting devices and a low-voltage circuit breaker. A range of voltage to meet all conditions is secured by a 75-kilowatt ampere reactance coil in each substation, also by 5 per cent taps on the low-tension side of the main transformer at Oregon City, where the transmission line begins, and 2.5 per cent taps on the high-tension side of the substation transformers. It should be mentioned as illustrative of the practice which also prevailed in many of these transmission systems that the electrical energy generated at the hydro-electric plant in Oregon City for the system is delivered at 10,000 volts by the dynamos and stepped up to 33,000 volts for transmission by three delta-delta connected 33-cycle, 750-kilowatt, water-cooled, oil-insulated transformers, which are housed in a reinforced concrete building. Without going into further detail, it may be said that this system serves to illustrate the latest standard practice in connection with such electric-railway work.

*High-voltage practice at Syracuse, N. Y.*—An interesting example of the use of 60,000-volt current in connection with substations is to be found in the city of Syracuse, where electrical energy generated at Niagara Falls is utilized. The transmitting distance is approximately 165 miles, and the Syracuse installation is one part of the comprehensive plan for supplying all the central portions of New York state with hydro-electric power developed at Niagara. This electrical energy is generated at the Canadian hydro-electric plant of the Ontario Power Company, and is delivered to the transmission line of the Niagara Falls, Lockport, and Ontario Power Company as 60,000-volt, 3-phase, 25-cycle current. At the city line of Syracuse it is delivered to the transmission circuits of the Syracuse Rapid Transit Railway Company at practically 55,000 volts, estimating a loss of 8 per cent for the total distance of 165 miles. From the city line the high-tension circuit carrying this voltage runs along the Erie Canal to the substation of the Syracuse Rapid Transit Railway Company. In this substation the current is stepped down at one operation in lowering transformers from 55,000 volts to 430 volts alternating current, and is passed thence through the rotary converters and is delivered to the railway feeders at 600 volts direct current. In this substation the high-tension cables are brought in through three sections of 36-inch vitrified pipe piercing the wall, one pipe for each leg or side of the 3-phase circuit. Within each pipe is set a circular disk of half-inch plate glass, each plate having a 3-inch hole through its center, through which is passed the cable. The disk of plate glass is employed instead of the common method of filling in the vitrified pipe with cement. In addition to the usual apparatus of lightning arresters, oil switches, static interrupters, cut-outs, etc., a 50-cell, 40-ampere storage battery is installed, with the necessary incandescent lamps, switches, etc., for operating the various electrically controlled switches in the station.

## III.

### LINE CONSTRUCTION.

*Increase of span wire.*—During the five years from 1902 to 1907 there have been but few changes in the general standard of construction for city and interurban lines, the fundamental elements and conditions remaining the same. Warned by frequent breakage and interruptions, managers of both city and interurban overhead lines have been prompted to adopt heavier trolley wire and more substantial fittings and anchors, with the object of reducing failures and accidents and of prolonging the life of the overhead construction. In cities the old type of center-pole bracket construction has been largely discarded in favor of span-wire construction, which is less unsightly and, on account of its greater flexibility, less expensive to maintain. No. 00 wire remains as the standard on a large number of roads, although the period has witnessed the introduction of a considerable quantity of No. 0000 trolley wire on city lines.

*Practice on interurban roads.*—With regard to interurban roads the great increase in speed has been a

severe trial on the earlier type of overhead construction, so that in more recent work an effort has been made to secure as nearly as possible perfect alignment of trolley wire, while providing at the same time a greater degree of elasticity or resilience, thus absorbing the unavoidable blows of trolley wheel or contact bar due to the oscillation of the car body or to irregularities in the track.

*The catenary type of construction.*—A notable departure of the period is the adoption of what is known as the catenary type of construction, which is used on both alternating and direct current systems, and supports the contact service wire by means of long catenary spans between supporting poles, in the manner illustrated in this report. Catenary construction was adopted in this country primarily for use on single-phase alternating current lines, but its numerous mechanical advantages have led to its adoption by a number of roads using direct current. The advantages referred to consist in securing a wider pole spacing and flatter trolley wire; flexibility of suspension; the minimization of the effect of the blows of current-collecting devices at the suspension points; and finally a reduction in the frequency of the breakage of trolley wire under the strain of supporting the weight of the entire span from pole to pole. For high-tension alternating-current and direct-current trolley work the insulation possible from the practical standpoint with the old form of construction is insufficient, while with catenary construction the messenger or supporting cable can be insulated for the highest voltage yet proposed for any trolley line.

*Miscellaneous urban examples.*—With regard to ordinary city work the practice of a number of leading companies may be cited. The surface lines of the Boston Elevated Railway Company comprised in 1907 a total of 412.64 miles of track, using No. 00 round trolley wire and $\frac{5}{16}$-inch 7-strand galvanized span wire on its construction. Little trouble was experienced from lightning on the trolley wires, and lightning arresters were put in only at the junctions of underground and overhead feeders, and at the power-station terminals. Some idea of the amount of construction work associated with such a system may be formed from the fact that it includes over 18,000 poles, more than 200 miles of underground feeding cable, and nearly 150 miles of underground return cable.

In Philadelphia the standard construction of the Philadelphia Rapid Transit Company includes No. 0000 groove trolley wire and $\frac{5}{16}$-inch 7-strand, 5-span wire, with pole spacing at 100 feet and lightning arresters every 1,000 feet. There are 7 emergency stations in winter and 8 in summer, each caring for about 75 miles of line. The maintenance department is divided into regular maintenance crews, emergency crews, and a pole gang, each of which is under a separate foreman. The regular maintenance foreman has two crews, each consisting of 2 linemen, a helper, and a driver; the pole gang consists of a foreman and 5 helpers; and the emergency foreman has charge of the stations above noted. The equipment of the station consists of 1 two-horse telescopic tower wagon and 4 horses, in addition to which 3 of the stations are equipped with telescopic tower cars for heavy work. The tower-wagon horses are kept in quick-hitching harness, and the rivalry between the various crews in establishing records for speed is encouraged by the company, which holds periodical competitions and offers prizes to the crew making the best time in leaving the house after receiving a call. The best record made was $55\frac{3}{5}$ seconds. During the census year the 8 stations had an average of 1,048 emergency calls of all kinds per month.

In and around Los Angeles, Cal., the Pacific Electric Railway Company operates some 100 miles of city car lines and 400 miles of interurban system. The city lines are largely bracket construction with No. 0000 trolley wire "figure 8," and where span-wire construction is used $\frac{3}{8}$-inch and $\frac{5}{16}$-inch cable is employed. Poles are spaced 115 feet apart and the butts of all those of wood are impregnated with local crude oil as a preservative. It is stated that no lightning arresters are used on this system. The maintenance of the overhead city lines requires a force of 12 men and 1 foreman, 2 tower wagons, a tower car, and a gasoline automobile tower wagon. The resort to automobiles for this purpose has not become general, but has many recommendations. The car in question is a 30-horsepower commercial truck rebuilt and strengthened and carrying a large tool box as well as a material box, mounted on each side of the tower, and a fourth box under the rear of the car for storing rope and tackle. This automobile has performed the service of two tower wagons drawn by horses.

In Minneapolis and St. Paul, the Twin City Rapid Transit Company uses span-wire construction on practically all its 364 miles of city and suburban lines. The trolley wire is No. 000, supported by single anchors, and the span wire is 3-strand No. 11. The poles are spaced 100 to 110 feet apart, and the butts are treated with creosote for 3 feet of their length at the ground line. The insulation consists of a piece of maple, 12 inches long and square in section, which, before mounting, is thoroughly boiled in paraffin. It carries two bronze hanger castings and a malleable-iron sister hook. The hanger castings are designed for a driving fit over the ends of the maple insulating stick, and are secured by split cotter pins; the sister hook which slips over the wooden piece is held near the middle on either side by a cotter pin inserted through $\frac{1}{4}$-inch holes in the stick. As thus assembled the hanger has a total depth of $7\frac{3}{32}$ inches, affording two ears $11\frac{1}{2}$ inches between centers for attaching to the trolley wire. The hanger is comparatively light, is a good insulator, and is readily renewable.

At Denver, the Denver City Tramway Company has adopted as its standard for new construction No. 0000 grooved trolley wire. For carrying single No. 00 trolley wire on standard old construction, $\frac{1}{4}$-inch 7-strand span wire is used, but for double or single No. 0000 trolley wire or No. 00 trolley wire, $\frac{5}{16}$-inch 7-strand wire is used. Span-wire construction is used and is the standard for all new work. Poles for both kinds of work are spaced about 100 feet apart wherever possible and are painted with carbolineum preservative compound at the butts. Lightning arresters of various types are employed at intervals of from one-third to one-tenth mile, according to the location of the line and the local prevalence of trouble from lightning.

The Detroit United Railway has for all its city lines span construction with No. 00 trolley wire and $\frac{5}{16}$-inch 7-strand span wire, poles being spaced 110 feet apart, with lightning arresters 3 to the mile, except near substations, where they are placed 7 to the mile. The companies at Milwaukee, Wis., employ No. 0000 trolley wire of grooved section with span-wire construction and pole spacing of 110 feet, with 8 to 10 lightning arresters per mile of track. The city is divided into three districts for emergency line repair work, and a station serving about 40 miles of line is located in each district. The Louisville Railway Company, of Louisville, Ky., has No. 00 round trolley wire and $\frac{1}{4}$-inch span-wire cable. Poles are spaced 100 feet apart, with the butts painted with crude oil to prevent decay; and lightning arresters are placed 5 to the mile. No center-pole bracket construction is used.

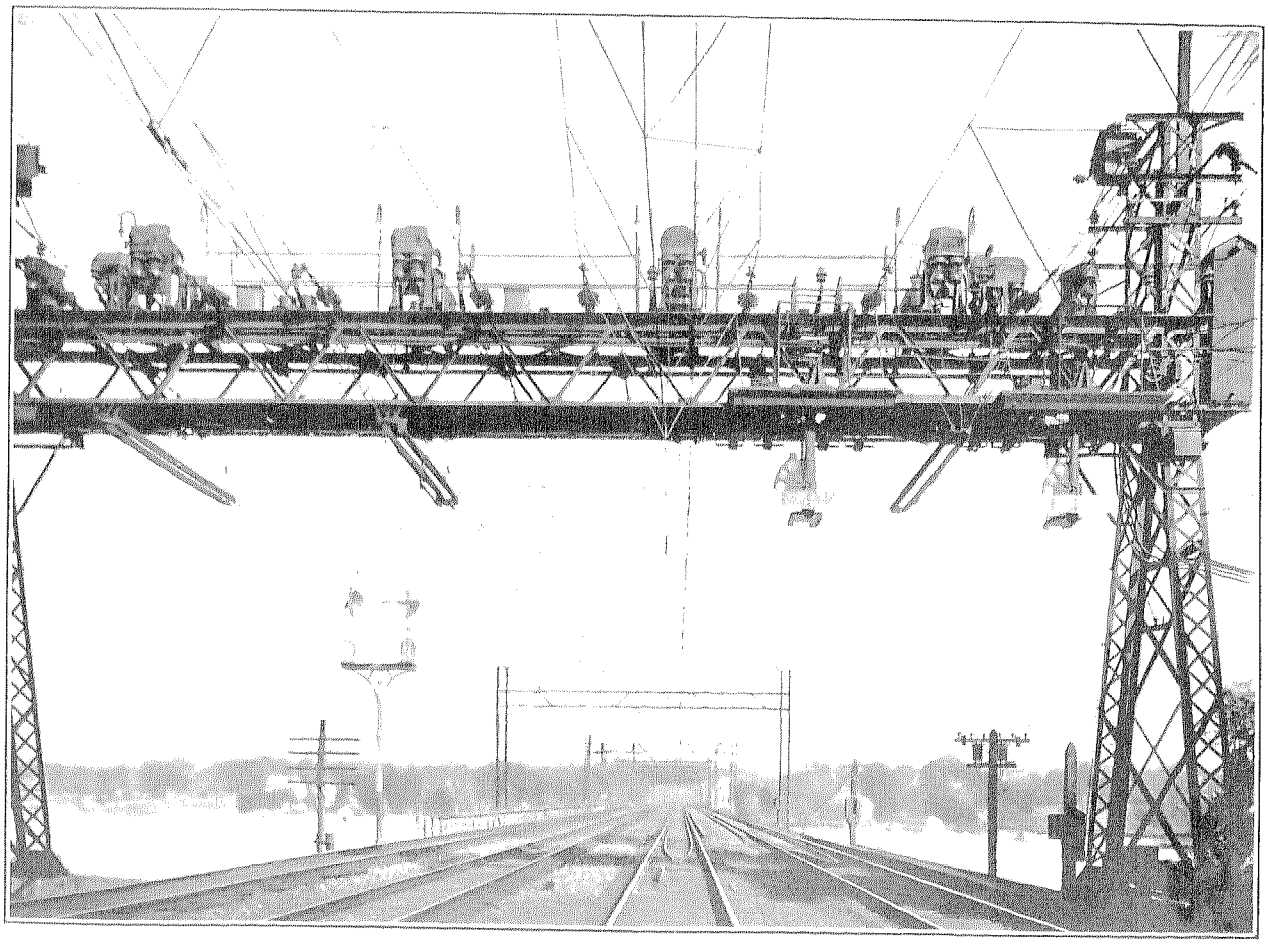
At Indianapolis, Ind., the Indianapolis Traction and Terminal Company uses No. 00 round trolley wire and $\frac{3}{8}$-inch 7-strand cables for span wires. The poles, which are not treated with any preservative compound, are spaced 100 feet apart on both bracket and span-wire construction. At Birmingham, Ala., the Birmingham Railway, Light and Power Company employs No. 000 grooved trolley wire as its standard, supported by $\frac{3}{8}$-inch 7-strand extra galvanized iron wire for double-trolley work and $\frac{5}{16}$-inch or $\frac{1}{4}$-inch span wire for single trolley. Poles are spaced 100 feet apart for both span-wire and bracket construction, the former type of construction greatly preponderating. The entire length of the poles used is treated by the vacuum creosote process, 10 pounds of creosote per cubic foot being the injection; and lightning arresters are spaced 7 to the mile.

Bracket construction with and without catenaries is still found extensively in connection with some of the interurban systems. The older lines of the Indiana Union Traction Company, for example, comprising about 200 miles, are built with span-wire construction, but some of the more recent work of nearly equal length has been put in with bracket construction. The Cleveland, Southwestern and Columbus Railway system has 138 miles of side-bracket pole construction and uses span wire only in cities and towns. With this bracket construction its poles are spaced 110 feet apart and lightning arresters are spaced one-third mile, except near substations, where from 6 to 7 per mile are put in. The Fort Wayne and Wabash Valley Traction system has 140 miles of bracket construction and 37 miles of span, chiefly on sharp curves and in cities.

*Various styles of catenary.*—Rudimentary forms of catenary construction have long been familiar in this country, in the construction of loops of wire for the purpose of holding up by frequent clips the telegraph and telephone cables, the weight of which would otherwise cause too much sagging and bring them too near the ground, thus overstraining the insulating supports. As originally developed for traction work, in improved forms, catenary construction was intended for single-phase alternating-current lines, but, as already noted, has been adopted for both alternating and direct current. The single catenary type of suspension is that in which there is one upper catenary wire to which the lower current-carrying wire is attached vertically below. A typical illustration is that furnished by the Oregon Electric Railway system, put into operation in 1908, where a $\frac{7}{16}$-inch galvanized steel messenger cable, as it is called, having a safe tensile strength of 12,000 pounds, is suspended from the insulators on brackets with 150 feet span, and anchored every half mile on straight track and at the end of every curve. At the curve the construction is modified by stringing a $\frac{5}{16}$-inch galvanized steel cable between the supports, which serves as a spring guy, to which $\frac{1}{4}$-inch pull-off bridles are attached at 15-foot intervals, thus making a very smooth curve. The contact wire is No. 0000 hard-drawn copper which is suspended from the messenger cable at intervals of 15 feet, and section insulators are provided at every substation so that this network can be cut out between any two stations without affecting the rest of the line. The insulation of all this catenary construction is particularly well made and is in reality designed for 1,500 volts, so that later this pressure can be used, thus increasing to a very large extent the current-carrying capacity of the entire system without disturbing in any way the overhead trolley wire or feeder installation. This catenary line is employed for direct-current work.

Another type of catenary is shown in the work of the Syracuse, Lake Shore and Northern Railroad between Baldwinsville and Fulton, N. Y., where over

TRAIN ON NEW YORK, NEW HAVEN AND HARTFORD RAILROAD, SHOWING OVERHEAD CONSTRUCTION.



BRIDGE SUPPORTING CONSTRUCTION, NEW YORK, NEW HAVEN AND HARTFORD RAILROAD.

200 steel catenary bridges have been put in to carry the double-track overhead-line construction. These bridges, resembling the familiar signal bridges that are seen along main lines of steam railroads, are made up of two A-frame side towers and a connecting truss across the track built of light angles and channel iron. Each foot of the A-frame is mounted on a concrete foundation pier 2 feet by 2 feet, of varying depth; the cross truss is 30 feet long and its top chord is approximately 25 feet above the rails. These bridges are spaced not less than 300 feet apart on tangents and 70 feet on curves. The messenger cable is $\frac{7}{16}$-inch in diameter, stranded and galvanized, and supports a No. 0000 copper trolley wire. In the original construction $\frac{5}{8}$-inch steel-rod anchors from the messenger to the trolley wire were spaced 10 feet apart, or 30 to the span, but in order to give greater flexibility this space has been increased to 30 feet, or 10 to the span; the longest anchor is 77½ inches in length. While direct current has been adopted, the line is electrically insulated for 6,000 volts alternating current, which may be used. It is asserted that these catenary bridges, which provide much greater stability to the whole overhead line, cost only $800 per mile more than standard double-track, wooden-pole bracket, span-wire construction.

An illustration of direct-current three-point catenary suspension is furnished by the Texas Traction Company, constructed, but not in operation, during 1907, between Dallas and Sherman, an operating distance of 60 miles, and using 600-volt current. Idaho cedar poles, 40 feet long with 7-inch tops, set 7 feet 6 inches in the ground, are used to carry the brackets. They are spaced 150 feet apart on tangents and curves not exceeding 3 degrees, but on sharper curves the span is reduced proportionately, being only 55 feet on a 20-degree curve. The messenger cable is $\frac{3}{8}$-inch 7-strand steel, and the trolley wire is No. 000 grooved copper, stretched 19 feet above the rails. Steady braces on the trolley wires are located at each feeder tap and halfway between taps, averaging about 500 feet apart, and are also used on each bracket and curve in connection with bridle pull-offs. The trolley messenger wires are anchored every half mile on tangents and at the ends of curves; and all catenary wiring is insulated with 9-inch wood strain insulators. In cities and towns through which the line passes span-wire catenary construction is used.

*Catenary on main lines of railroad.*—The catenary construction of the single-phase alternating-current system of the New York, New Haven and Hartford Railroad is the most conspicuous instance of this method in operation in this country. This road furnishes an example of successive evolution and improvements during and since its construction in the census period. The original catenary construction has the working conductors suspended from two messenger cables by terminal supports or anchors, the catenaries being carried by bridges, which also serve to support signal and other apparatus, the simple and the more complicated forms of bridge being illustrated herewith. In switch yards of the line a more flexible construction has been adopted by supporting the catenary from span wire instead of from bridges, while on still other sections, as for example the New Canaan branch, a single catenary has been employed. In the latest developments, shown in the accompanying illustrations, the auxiliary conductor has been attached by short clips to the single working conductor used in the earlier work, these clips being located midway between the triangular anchors of the messenger cables, or at a distance of 10 feet apart, so that each clip has a flexible support. Where the line passes under very low highway bridges this form of construction is modified by substituting for the single clip and the single working conductor a double-arm clip, which supports two working conductors in the same horizontal plane and permits the trolley contact bow on the top of the locomotive to make two contacts. The new working conductor is of steel and No. 0000 in size, while the fomer working conductor, which now serves simply as a support, is of copper. In speaking of the various features connected with this later development of construction, Mr. W. S. Murray, the electrical engineer of the railroad, says:

> Very soon after the commercial service was put on an electric basis, it was found that the current-collecting device on the electric locomotive, commonly known as the "shoe," was producing two very serious effects on the copper wire: (1) Reducing its cross section by wear, and (2) kinking it badly at the point of suspension. The result of the combination brought about fractures of the trolley (the messengers never breaking). Moreover, on account of the extreme roughness of the copper wire, due to kinking, the locomotive shoe was constantly interrupted in its contact with the trolley, delivering, and in turn receiving, hard blows in its uneven progress along the line and causing excessive sparking. The fourth wire has proved the panacea of all of these troubles. During the past three months of operation upon it absolutely no kinking has been noted and the wear is inappreciable. In the original form of construction where the locomotive shoe made contact with the copper wire, it was found that on account of the high expansion properties of copper wire, changes in temperature lengthened considerably the span between the hanger points, and because of the ductility of the copper the passage of the shoe at high speed, with some considerable upward pressure, gathered up the slack in form of a kink at the hanger point. Steel does not possess this disadvantage, as it has a much lower expansion coefficient than copper, is not ductile, and has no tendency to kink.

## IV.

### TRACK CONSTRUCTION AND RAILS.

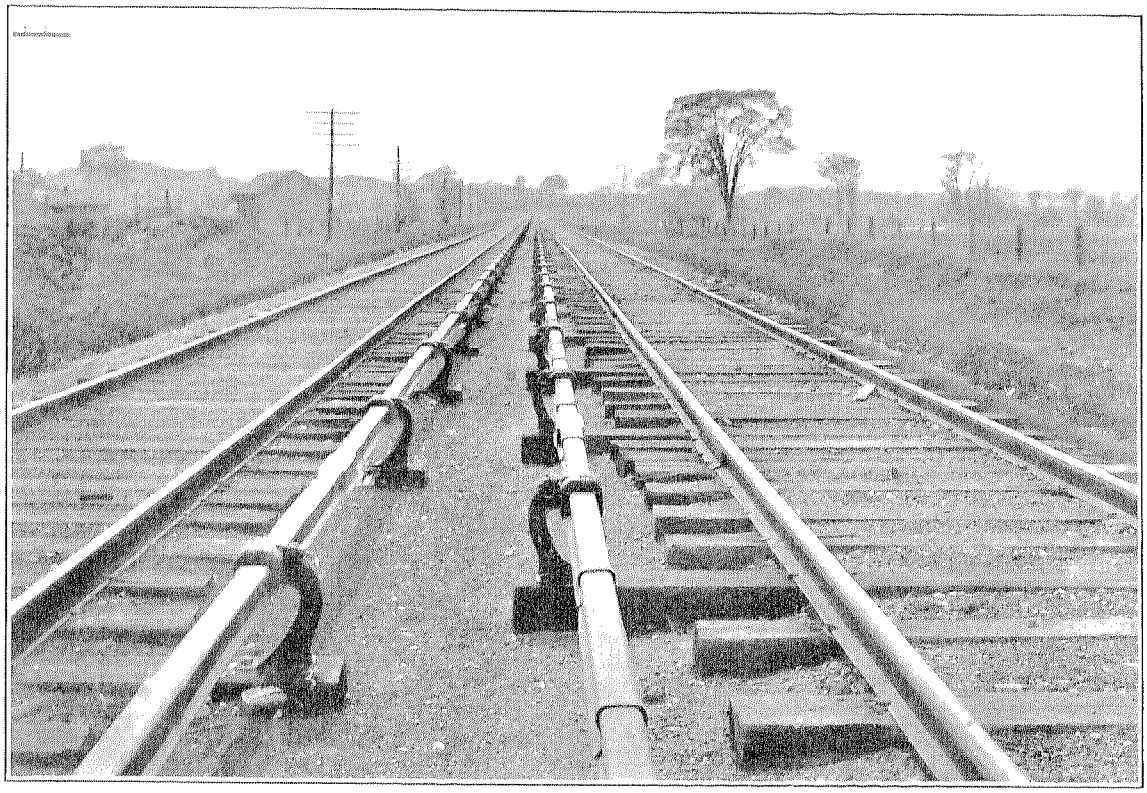
General details with regard to track and rails will be found in the statistics of Chapter IV, Part I, and the tables accompanying it. From the data therein given it seems that a very large majority of the trackage of street railways is equipped with rails of either the girder or the T type. As already noted, in 1902 there were 364 of the 388 roads using T rails in part

which reported T and girder rails, and of 814 roads all but 10 used either T or girder rail in whole or in part. In 1907 T or girder rails were reported by all but 12 of the 944 companies making reports under this head. As the question of rails is closely connected with the general problem of track construction and paving, the two must be discussed together.

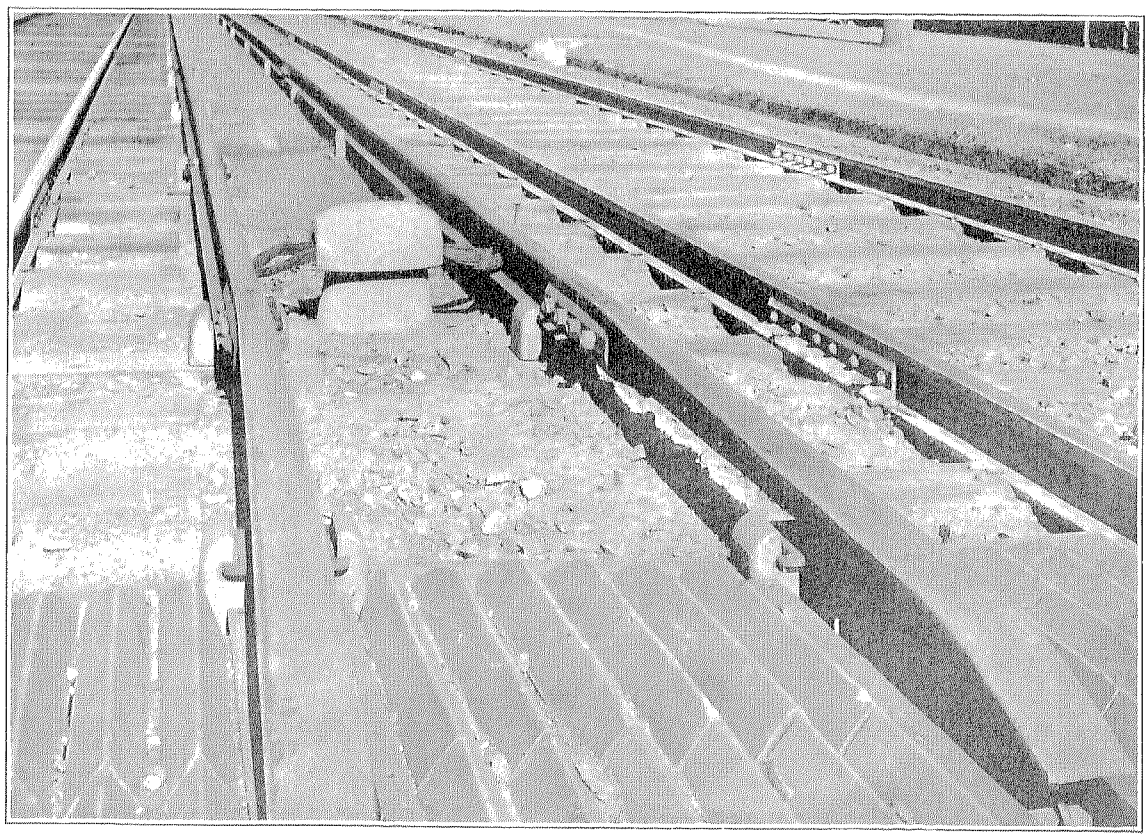
*Evolution of track at Minneapolis.*—Track work is largely a process of evolution, and the history of Minneapolis may be taken as a case in point. Prior to 1896 the only paving in Minneapolis was old-fashioned untreated cedar blocks laid upon pine boards, with granite blocks laid upon this as a base. In the spring of that year, owing to the unsatisfactory condition of the business streets, the city council decided to experiment with asphalt, and made a contract for the paving of the commercial district with that material. The Minneapolis Street Railway Company protested vigorously against the use of this material adjacent to street-car tracks, as the life of asphalt depends upon an absolutely rigid foundation, and it was not thought possible to deaden or wholly prevent the vibration due to the passage of cars. The asphalt paving, however, being decided upon, the company put in a high grade of construction, laying the rails in Portland cement with welded joints, and with ties spaced two feet apart. The asphalt was laid down between the tracks and up to the outer edge of the tracks, which were protected by granite blocks. In a very short time the paving adjacent to the tracks showed signs of disintegration and within two years repairs were begun, which continued almost without interruption until 1906, before which date all the construction had been taken up and replaced. The company then adopted its present method, which has been applied not only to the paved streets but throughout the city, until practically all the tracks in use to-day have been rebuilt with heavier rails, leaving only a very small percentage of mileage in the city as it was in 1896. According to the later method, after the old tracks are torn out and the roadbed is made ready for the reception of the new rails, 6 inches of crushed rock is thoroughly rolled by steam rollers. On this bed the ties are laid 2 feet apart, the space between being filled with concrete and firmly tamped, and on these ties, 91-pound rails with welded joints are spiked. The spaces between the rails of each track and between the double tracks are then paved with cut-granite blocks, thoroughly grouted with Portland cement. This style of pavement has proved satisfactory, and is a preferred highway for bicycles, automobiles, and general traffic.

*Track construction in Detroit.*—In Detroit the Detroit United Railway has adopted a system of T rail for all city streets. The T-rail section used is 7 inches high, and weighs 91 pounds per yard; the space is 6 inches wide, the curb $\frac{9}{16}$ inch, and the head $2\frac{1}{4}$ inches wide by $1\frac{1}{4}$ inches deep. The substructure of the track is the same in four varieties of construction. A bed of concrete 8 inches deep and 7 feet 6 inches wide is first deposited on the subgrade. This concrete is mixed in batches containing 1 cubic yard of stone, $\frac{1}{2}$ cubic yard of sand, and 5 sacks or $1\frac{1}{4}$ barrels of Portland cement. A machine mixer with a capacity of $1\frac{1}{2}$ cubic yards, mounted on a flat car which is worked in connection with a crane car and dumping bucket, is used, working from the other track. When a batch is mixed it is discharged into the dumping bucket, which is handled by the crane car and dumped wherever required. The concrete being mixed wet is thoroughly tamped to a level surface. After this lower bed of concrete has been allowed to set for from six to ten days a 1-inch layer of clean, sharp sand is spread over the top, on which cushion of sand the oak ties 6 by 10 inches by 7 feet are laid, spaced 24 to 30 inches apart. The rails are then laid down; the ties gauged and spiked with standard cut spikes; the track is brought to perfect surface and alignment; and the bed of sand thoroughly tamped under the ties. The concrete mixer and crane car then deposit concrete solidly between the ties and over them to a thickness of 2 inches, completely embedding them and the sand cushion. On the top bed of concrete another layer of sand 1 inch thick is spread, and upon this are laid 4-inch paving brick, except in the case of nose-brick construction. The nose blocks or filler blocks are embedded in a layer of concrete and covered by it. The web of the rail in all cases is grouted $\frac{1}{2}$ inch thick on each side. Three rows of brick are laid longitudinally outside each rail, and the space between the rails is paved with the same size brick laid in transverse rows with staggered joints, a construction common to all types of street paving, including asphalt, macadam, and wood block. The surface of the brick paving is finally finished off with a thorough grouting of sand mortar. The company prefers nose-block construction in place of brick, and this will hereafter probably be part of the standard construction above described.

*Methods adopted at Buffalo.*—In Buffalo the International Railway Company in paving streets uses a grooved girder rail of 140 pounds laid on steel ties 5 feet long and spaced 5 feet apart. A concrete beam 19 inches deep and 12 inches wide is built under each rail, and the ties are embedded in the center connecting slab of concrete, which is carried down 5 inches below the bottom flange. Between ties this center slab is reduced to 6 inches in thickness. On top of the concrete is laid a 2-inch sand cushion on which Medina sandstone paving blocks are set. The paving is crowned between the rails, and on the outside alternate header and stretcher blocks are laid, into which the roadway pavement is worked. Tie-rods 2 inches by $\frac{3}{8}$ inch are spaced 5 feet apart between the ties and



COVERED THIRD RAIL ON ONEIDA RAILWAY TRACK.



THIRD RAIL AT A CROSSING, WEST JERSEY AND SEASHORE RAILROAD.

embedded in the concrete paving foundation. Both hand and machine mixed concrete in the proportions of 1 cement, 3 sand, and 6 stone are used.

*Milwaukee track and pavement.*—At Milwaukee two forms of T-rail track and pavement construction are used, one for brick pavement and the other for asphalt roadways, the "devil strip" between the tracks being paved with granite blocks. In both types the substructure and track construction are the same. A trench 7 feet 6 inches wide is excavated under each track to a depth of 6 inches below the bottom of the ties, which are 6 feet 6 inches long and are untreated. Ninety-five-pound T rails 7 inches high are laid, joined by cast welds, which are spaced opposite to each other on straight track. After the track is laid and blocked up to the surface of the trench, concreting is begun, for which purpose a motor-driven machine mixer, taking current from the trolley line, is used, mounted on a 4-wheel truck. The spout of the mixer discharges the concrete with a belt conveyer mounted on a long-swinging arm, which can reach across the entire width of the roadway, so that the concrete foundation for the track and roadway pavement can be filled in at one time, if necessary, with the same machine. In both the brick and asphalt paving construction the surface between the rails is crowned and the paving blocks are fitted in squarely under the head of the rail. The stretchers on the outside are put in flush with the top of the rail.

*Reconstruction work at Chicago.*—In Chicago, where very thorough reconstruction work has permitted the adoption of modern methods by the companies, the rail section used is a special design of 8-inch grooved rail, weighing 129 pounds per yard. Both steel and wooden ties are used, the steel ties being 4½-inch girder section, spaced 5 feet apart, center to center, and the wooden ties untreated pine, 6 inches by 8 inches by 7 feet long, spaced 4 feet apart. Among the difficulties of reconstruction was the tearing out of the old cable slot and conduit, embedded in concrete. The cast-iron yokes which formerly carried the cable sheaves were broken off with battering-rams and the cable trough was completely uncovered, although the concrete below the top surface of the trough was not disturbed. Multiple duct feeder cable conduit was then led in the old cable trough and covered with earth thoroughly tamped. Upon this the ties were distributed, and the rails laid down and fastened to the ties with bolted clips for the steel ties and screw spikes for the wooden. The track was then brought to surface and alignment by temporarily blocking up the ties in the trenches, leaving a space of about 6 inches under them; and concrete was deposited in the trench and tamped thoroughly under the ties and to a depth of 1½ inches over them. In about two days the stone-block paving was placed on the concrete in order to protect the exposed rails. After the concrete had set for seven days welding was begun and the paving, left open at the joints placed opposite each other, was not completed until after the grinding car had passed, a method which has been followed in later work. An interval of seven days was allowed after the welding before traffic was opened on the new track. The track of the Chicago City Railway Company has been electrically welded.

*Practice in Philadelphia.*—The Philadelphia Rapid Transit Company has used a special 137-pound 9-inch girder rail for all its new track construction in streets. This rail is virtually center bearing with a 3-inch tread; the gauge line is moved in ¾ inch from the center of the web, and the rail can withstand prolonged side wear before being materially weakened. The groove is self-cleaning, offering little obstruction to vehicle travel, and is deep enough to allow an extra amount of top wear on the rail head. The rail joints are of a composite or zinc type, consisting of two special fish plates with 12 rivet holes, which are riveted up, and the interstices between plates and rails filled with molten zinc, after preheating to a temperature of 350 degrees each; a high electrical conductivity and mechanical strength is thus obtained. All joints in both straight and curved tracks are staggered. Two forms of construction, depending upon the nature of the traffic, are used for the track substructure. For substructure with moderate traffic yellow-pine ties 5 inches by 9 inches by 8 feet, spaced from 24 to 26 inches apart, are laid on broken-stone ballast. The rails are fastened to the ties by bolted braces made of malleable iron, and secured to the top of the ties by three ⅝-inch lag screws before the ties are laid. The vertical leg is drilled for 2⅞-inch bolts, one of the holes being tapped with standard threads. The rails are placed on the ties and adjusted to slightly wide gauge. Bolts are then passed through the holes in the web of the rail and the vertical leg of the brace, and by tightening the nuts the rails are brought to exact gauge, and are held firmly in place by set screws put in the threaded holes of the braces and tightened up against the web of the rail. Concrete-beam construction is used for track subject to very heavy traffic in the center of the city, where the rails rest on continuous concrete beams 18 inches wide and 14¼ inches deep, joined between the rails by a slab of concrete 6½ inches deep. This monolithic structure is reinforced at intervals by cross rods embedded in the center slab and bending down in the side beams. The rails are anchored to the concrete by attachment to the cast-iron yokes embedded in the beams at intervals of 5 feet, this attachment consisting of two clips bolted down on the base of the rail with ¾-inch bolts working in transverse slots in the top of the yoke. In bringing the track to gauge two set screws bearing on these clips are used in adjusting the position of the rail laterally. The clips hold the rail down firmly on the top surface of the concrete beams and prevent heaving, while yokes simply anchor the rail down, but do not carry it.

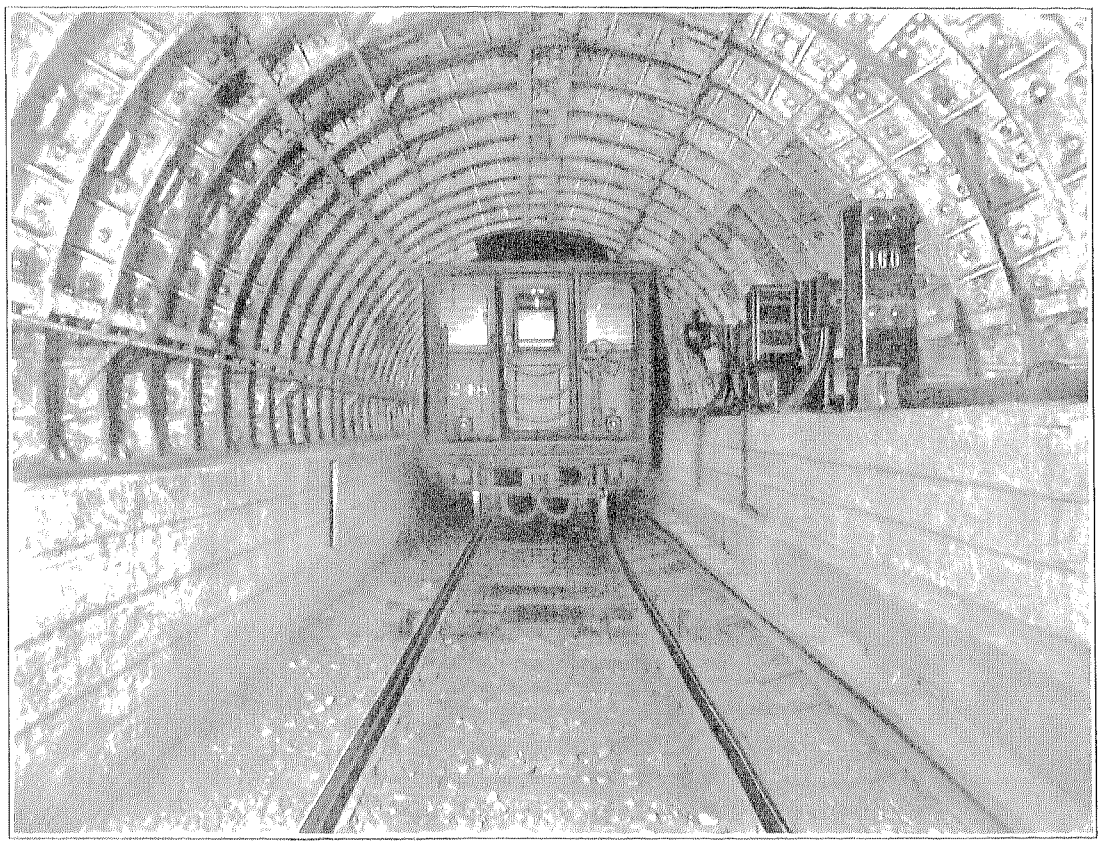
*Miscellaneous examples.*—These examples embody most of the features of modern street-railway track construction as developed during the period of this report. There are, of course, many variations of practice, depending upon local conditions; in some instances, governed by the requirements of municipal authorities as well as by the amount of capital, it is deemed wise to invest in view of the travel to be expected. The Birmingham (Ala.) Railway, Light and Power Company makes use of blast-furnace slag in place of gravel or broken stone for track foundations and in concrete.

*General adoption of* T *rail.*—With regard to systems which are both city and interurban, the general adoption of T rail is specially to be noted, and there are several examples. The Auburn and Syracuse Electric Railroad and the Rochester, Syracuse and Eastern Railroad, for instance, now have the greater part of their city lines laid with T rail. On the Auburn and Syracuse line 90-pound A. S. C. E. section rail has been laid to replace girder rail in several streets in Auburn and Skaneateles, where pavements were of brick or macadam, and the results have been generally satisfactory, it is stated, to the company, the city authorities, and the public. About twelve years ago considerable trackage was laid in Auburn of 6-inch 70-pound girder rail, the head of the rail being only $\frac{11}{16}$ inch above the tram, which was common practice at the time, the wheel flange usually being only $\frac{5}{8}$ or $\frac{3}{4}$ inch high. This rail served its purpose until the advent of the interurban cars with wheel flanges $\frac{7}{8}$ inch high or more. With the consent of the city authorities 90-pound T rail has been substituted. The T rail was laid on new ties with 6 inches of stone ballast underneath, the space to the top of the rail being filled in with broken stone, with a top dressing of fine stone in a binder. No repairs have been made to this track since it was put down, except to keep the space between the rails up to the level of the street by spreading fine broken stone over it once or twice a year. In all these pavements of brick or asphalt, the space between the rail and for 6 or 8 inches outside is paved with brick, a special-nosed block being used to form the flange way along the inside of the rail. This block is ordinary paving brick with a beveled corner made in full size and half size for breaking joints.

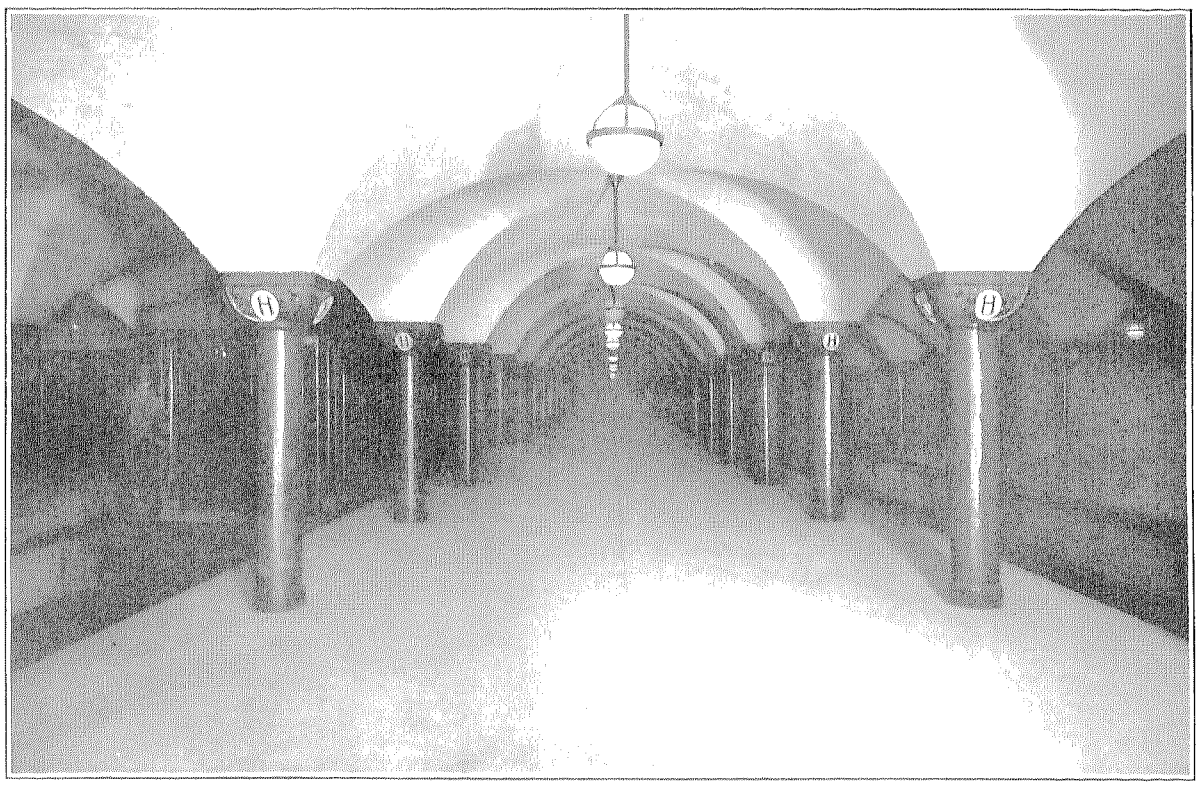
On the Rochester, Syracuse and Eastern Railroad, which passes through the streets of seven cities and villages, 90-pound T rail has been laid, and has been in service for a year or two under cars with a net weight as high as 84,000 pounds. Experience on this line brings out one of the objections to the use of the T rail in brick pavements. This consists in the fact that ice and snow freeze to the brick flange much more than is the case with the girder rail, and this impediment is also much more difficult to remove than where the latter rail is used. With snow drifting, the frequency of service has not been sufficient to prevent the flange way filling up between the intervals of car passage, and serious difficulty has been experienced sometimes in maintaining operation on grades of from 4 to 8 per cent, unless a sweeper is kept constantly going over the track to prevent the drifting and the consequent filling of the flange way.

*Steel ties and concrete beds.*—Reference has been made above to the adoption of steel ties and concrete-line construction, and some details have been given of concrete work. The increased cost of wooden ties and their decreased quality have led to the adoption of these new forms which are now in general use. Earlier forms of steel ties for electric-railway work consisted of a 7-inch channel 7 feet long, placed on top of a 6-inch bed of concrete. The steel ties that have been developed more recently are designed to give the greatest strength and holding power for the least weight of material, and are made in three weights in one standard form, namely, 20 pounds per foot, $14\frac{1}{2}$ pounds, and $9\frac{1}{2}$ pounds. The largest section has a depth of $5\frac{1}{2}$ inches with a top flange of $4\frac{1}{2}$ inches and a bottom flange of 8 inches; the intermediate section, a depth of $4\frac{1}{2}$ inches, top flange 4 inches wide, and bottom flange 6 inches; and the smallest a depth of 3 inches and a bottom flange of 5 inches. It has been the general practice to lay these ties with the wide flange on the bottom, the idea being that the greatest bearing resistance was thus obtained. The board of supervising engineers for the reconstruction of the Chicago City Railway conceived the idea of reversing this method, and laid the steel ties in the new track in that city with the wide base on top. If the tendency of a tie is to buckle, all other strains being equal, the tie thus laid with the wide flange on top has the greatest resistance on account of the increased area of the wider base. The concrete also can be placed and tamped more thoroughly under the flanges.

The most common fastening for steel ties is the steel clip with a bolt, which has proved satisfactory and is simple in design and use. In Chicago, however, the roads have deviated from this method of fastening and are using a tie plate $\frac{1}{4}$ inch thick, with special punching of the tie and special bolts and clips which can be removed from the top when it becomes necessary to renew the rail. The usual construction with steel ties for paving streets has already been mentioned in some of the foregoing descriptions. The spacing of ties is usually from 4 to 6 feet centers. The whole pavement is removed and excavation is made to the required depth for the pavement, sand cushion, and concrete, generally about 15 inches; cross trenches for the ties about 12 inches wide are dug about 5 or 6



HUDSON AND MANHATTAN RAILROAD—TYPICAL CROSS SECTION OF TUNNEL UNDER HUDSON RIVER.



HUDSON AND MANHATTAN RAILROAD—UNDERGROUND STATION, HUDSON RIVER TUNNEL.

inches below the bottom of the tie, and a trench 10 inches deep and 15 inches wide is excavated directly under the rail. The ties are placed in the tie holes and the rails are laid upon the ties, clipped to them, and surfaced and lined up as usual. The concrete is then placed under and around the tie and under the rail.

With regard to the relative cost of construction with wooden ties and steel ties, figures presented by Mr. Charles H. Clark, chief engineer of the New York and North Shore Traction Company, before the Street Railway Association of the state of New York, show a cost per 100 feet with oak ties on concrete of $164, and with steel ties of $133, a saving by the use of steel ties of 31 cents per foot, or $1,636.80 per mile.

## V.

### CONDUIT CONSTRUCTION.

As was shown in Table 24, 11 companies were operated by conduits in 1902, while the number in 1907 was 10, but there was an increase of 21.3 per cent in single trackage, namely, from 266.06 to 322.70 miles. The methods of construction during the period have not varied greatly from those discussed in the previous report, but it can not be said that the conduit has gained in favor among electric-railway managers and operators. On the part of the public, however, in some cities a strong demand for the construction of conduit systems has been made, but its immense cost is still an obstacle, and on the whole the improvements effected have apparently done little to reduce the inherent difficulties.

During 1907 it was stated that on an average 100 electric cars per day on the conduit system on Manhattan Island, out of a total of 1,800 or 2,000 in use, were disabled by trouble from plows alone, although the plow had been greatly improved over the original design, and was then, as it is now, the subject of constant attention. Other difficulties encountered in the system lie in the maintenance of a constant width of conduit slot between the rails and of a constant uniform distance between the bar conductors carried in the conduit. A track can be kept closely to gauge by tie-rods and a slight difference in width of gauge is accommodated, so to speak, by the tread of the wheels, which readily adjust themselves. In fact, in large radius curves the gauge is frequently widened ¼ inch with a a slot only ⅞ inch wide. However—to take standard operative conditions—the conduit engineer is working with small dimensions and, of course, has no way of tying the slot rails rigidly together as a unit except by bracing them from below on the yoke by rods from the sides. In hot summer weather these rods often expand sufficiently to cause the slot to get tight, while in winter the slot rails are forced toward each other by ice forming between the interstices of the block paving. Hence tight slots constitute a constant hindrance to smooth running and are avoided only by the greatest vigilance. In one single day during the winter of 1906–7 in New York no fewer than 800 cars out of 1,800 were disabled from this cause. If the trouble were confined merely to the destruction of the plow, which is relatively inexpensive, it would not be so serious, but the plow is heavy and necessarily held so firmly on the truck that a tight slot usually disables also the truck and other parts of the car.

With regard to the troubles connected with keeping in alignment the conductor bars in the conduit, it is only necessary to point out that on Manhattan Island the task involves endeavoring to keep in alignment to the fraction of an inch bars enough to stretch from New York to Buffalo, and located not out in the open where they can be easily seen, but in a conduit which is dark and too small to admit of the passage of a man. Moreover, the drifting of snow into the conduit in winter, with occasional setbacks of sewage or salt water during a high tide or after a heavy rainfall, adds to the difficulties of such work and tends to render conduit operation extremely expensive. Such reasons as these, therefore, account for the slowness of the extension of the system even in communities where the density of population and of travel would seem to justify the investment.

With regard to conditions in 1907, in testimony given before the New York Public Service Commission, Mr. Charles F. Uebelacker, then acting as chief engineer of the receivers of the Metropolitan Street Railway system of New York City, stated that the use of the underground conduit system greatly increased the cost of carrying passengers. The cost of installation was much larger, as well as indeterminate, since obstructions in the shape of pipes, etc., and the cost of relocating them could not be estimated in advance with any accuracy on account of the lack of correct maps of such construction. The expense of operation was also largely increased by the trouble experienced with the bare electrical conductors in the underground conduit, where they are subject to a great deal of moisture and can not properly be inspected. Mr. Uebelacker also stated that the plow was a great source of trouble, as it had to be made very narrow in order that the slot in which it moved should not be wide enough to catch the thinnest wheels of an ordinary light vehicle. Every time that a disabled car was pushed in, the expense of repairing the car and the cost of the delay on the road in getting the schedule of running time straightened out was considerable. Another cause of extra expense was the collection of snow in the conduits. Mr. Uebelacker stated that the expense for an overhead-trolley system in a large city would be about 16 cents per car mile, compared with 19 cents for an underground conduit trolley.

For some of the reasons here indicated and others involving the general financial circumstances, the maintenance of the conduit system of the Metro-

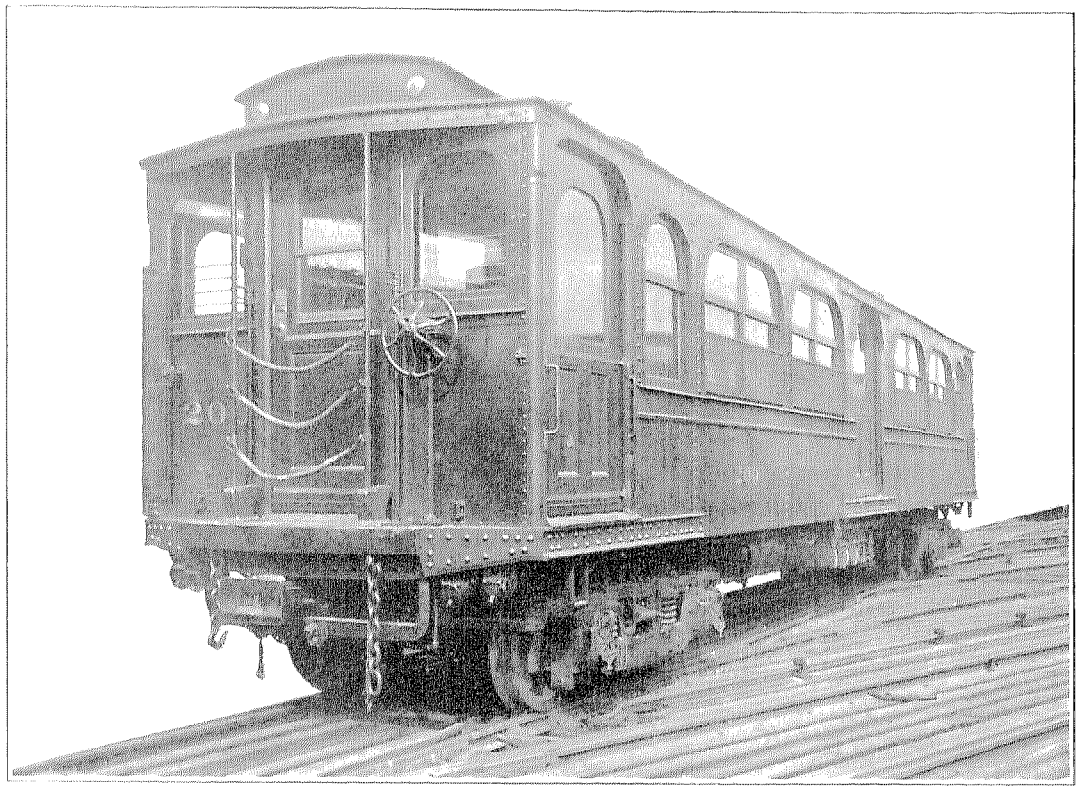
politan Street Railway in New York had not been adequate, and the receivers who were appointed in September, 1907, have since carried out various and direct improvements. The standard construction now followed by the Metropolitan system in all reconstruction and new work relative to trackage included in this report embodies a modification of the conductor employed originally when the cable lines were first built. Cast-iron yokes, spaced 5 feet apart and upward, embedded in concrete, support the track rails at their ends, and the Z-bar slot rails in the center. No wooden ties are used. The conductor rails are a special flange T-section supported in the trough by suspended insulators spaced 15 feet apart, accessible for renewal and inspection through handholes located in the pavement at every third yoke. The slot rail and track rails are connected with tie-rods between each pair of yokes so that the entire span is tied together laterally at intervals of 2 feet 6 inches. The slot rail rests on shoulders cast on top of the yokes and bolted through their bottom flange to the top flange of the yoke with a bolt on each side of the yoke web. Two methods are employed for fastening the track rail to the ends of the yokes, depending upon the height of the rail section. With the 7-inch rail used in streets paved between the tracks with asphalt the rail is bolted through the web to the ends of the yokes with three 1-inch bolts. Where the 9-inch rail is used in streets where the space between the tracks is paved with cobblestones, however, the rails are hook bolted over the bottom flanges with four bolts passing through the top flange of the yoke, on which the rail rests in a shoulder seat.

## VI.

### THIRD-RAIL SYSTEMS.

At the time of the last report considerable work had been done in the utilization of the third rail for conveying current to electric-railway tracks, chiefly on elevated lines. There were several sections, however, employed in surface work, as, for example, by the New York, New Haven and Hartford system on its Berlin division in Connecticut; by the Grand Rapids, Grand Haven and Muskegon road in Michigan; and by the Albany and Hudson road, between the two cities named in New York state. The newer developments of this class of work are chiefly connected with subway operation and with the electrification of lines on railroads hitherto dependent upon steam locomotives.

*Third rail in New York subway.*—One of the most notable instances of third-rail equipment during the census period is the Interborough Rapid Transit Company, which operates the elevated and subway lines in New York City. Each of the tracks constituting the subway system is provided with a contact third rail. There are consequently on the West Side 4 contact rails from New York City Hall to West Ninety-sixth street, and 3 thence to One hundred and forty-fifth street, 2 from One hundred and forty-fifth street to Dyckman street, and 3 from Dyckman street to the northern terminal. From Ninety-sixth street, where the East-Side system branches off, there are 2 contact third rails to Mott avenue, and 3 from Mott avenue to the northern terminal at One hundred and eighty-second street. Each contact rail is insulated from all contact rails belonging to adjacent tracks, so that in case of derailment or of accident necessitating interruption of service on a given track trains may be freely operated on the other tracks, having their separate and independent channels of electrical supply. For example, the section of the subway between Reade street and Nineteenth street, equipped with 4 tracks, has the contact rail for each track, together with direct-current feeders that supply it from substations electrically insulated from all other circuits. Of each pair of track rails, one is used for the automatic block signaling system, and is therefore not a part of the negative or return side of the direct-current system. The other 4 track rails, however, are bonded, and together with the negative feeders constitute the track return or negative side of the direct-current system. The contact rail is of special soft steel, to secure high conductivity, its resistance being not more than eight times the resistance of bare copper of equal cross section. The rail weighs 75 pounds per yard; the length generally used is 60 feet, but in some cases 40-foot lengths are employed. Contact rails are united electrically by 4 bonds, aggregating 1,200,000 circ. mils. section. These bonds are of flexible copper, covered by special malleable iron fish plate, which insures alignment of the rail, and their terminals are riveted to the steel by hydraulic presses. Each length of rail is anchored at the middle point and a small clearance is allowed between the ends of the adjacent rails for expansion and contraction, which is not great, however, in the subway, owing to the small change of temperature. The contact rail is carried upon block insulators supported upon malleable iron castings, and castings of the same material are used to secure the contact rail in position upon the insulators. The Interborough company has provided a guard in the form of a plank 8½ inches wide and 1½ inches thick, supported in a horizontal position directly above and carried by the contact rail, to which it is secured by supports. This type of guard was developed on the Wilkes-Barre and Hazleton Railway (Pa.), and tried for nearly two years before it was adopted in the subway, where it has now practically eliminated any danger from third-rail contact on the part of employees or passengers, even should passengers have to leave the trains and walk through a section of the tunnel while the rails were charged. The adoption of this guard necessitated the use of a collecting shoe, differing radically from that used upon the Manhattan Elevated Railway and upon elevated railroads



HUDSON AND MANHATTAN RAILROAD—STEEL CARS USED IN TUNNEL.

HUDSON AND MANHATTAN RAILROAD—INTERIOR OF CAR.

in Chicago, Boston, Brooklyn, and elsewhere employing the unguarded third-rail system. This shoe is held in contact with the third rail by gravity reinforced by pressure from two spiral springs, and the support of the shoe includes provision for vertical adjustment to compensate for the wear of car wheels.

*New York Central.*—After extensive experiments with various types of third rails on the experimental track near Schenectady, the New York Central Railroad adopted for its electrical zone an undercontact third rail differing from others previously in use. This rail, weighing 70 pounds to the yard, has a resistivity between seven and eight times that of copper. The rail is suspended from a curved arm or bracket of iron at standard distances of 11 feet, and held in the supporting space by insulating blocks and a special clip, the blocks being in two pieces 6 inches long and interchangeable. Between the supporting brackets the upper part of the rail is covered by a fiber sheathing or else one of wood. The latter is in three parts, nailed together except at the joints where the third rail is bonded and at the feeder taps, where they are mortised. The rail is not mounted rigidly in these insulators, but is given a little play for expansion and contraction, except at certain points where it is anchored. To secure the same clearance that would be permitted with a top-contact protected type of third rail, such as that used on the Long Island Railroad, the third rail on the New York Central required a location of from ½ inch to ¾ inch farther out, but to secure a wider clearance it was decided to place the rails 1½ inches farther from the gauge line, or a total of 29 inches. With a suitable shoe arranged to pass automatically from the undercontact to the top-contact rail, and vice versa, the difference does not prevent an interchange of equipment. The undersurface of the New York Central third rail is 2¾ inches above the top of the service rail, while the upper surface of the Long Island third rail is 3½ inches above. This difference can be taken up automatically by the spring pressure due to the shoe sliding on its under or upper surface. The principal reason for adopting the undercontact rail on the New York Central is that it can be more thoroughly protected, and hence is safer than the ordinary type of contact rail, for as there are no projecting live edges or bolts, and no slots between the third rail and its cover, the only possibility of reaching the third rail is from beneath upward. There is also less strain on the insulators, as the pressure from the shoe acts against instead of with gravity, and the rail is more sheltered from the weather and less liable to corrosion, while the contact surface is more thoroughly protected from the deposit of sleet and snow. The construction is self-cleaning, and as there is a greater space than in other types between the lower portion of the third rail and the tie there is less probability of an accumulation of snow, ice, and refuse, and consequently less leakage.

*Long Island Railroad.*—The electrification of the Long Island Railroad over a large part of its main division has been accompanied by the adoption of third-rail methods. Direct current at a potential of 600 volts is led directly to the third rail from the different substations, and in this way is carried considerable distances, great care being taken to insure the safety of pedestrians. The third rail is laid with its center line at the standard distance of 27 inches from the gauge line of track and with its top 3½ inches above the top of the track rail. This arrangement makes it possible for cars of the Pennsylvania Railroad, the Interborough Rapid Transit system, etc., to use this track, as well as permitting proper clearance for steam equipment, especially the steel hopper cars now in general use. This third rail is laid on sleepers or cross-ties which extend at regular intervals beyond the line of track, and is supported by vitrified-clay insulators. It is covered protectively throughout its length by a wooden sheathing. Brackets of steel attached to the rail are bolted firmly to short wooden uprights outside the rail, and to these by separate bolts is attached a second set of strong brackets supporting a 2-inch plank at a height of about 4 inches above the rail. Wherever the rail comes out in front of stations a special side sheathing is attached to both sides, rendering contact with it practically impossible for passengers. Another feature in connection with the protection of pedestrians at stations is that a running guard similar to the one covering the third rail is carried along the outside edge of the platform, thus preventing the passengers from coming into contact with the collector shoe on the motor cars. At either side of a grade crossing the rail terminates in a broad sloping shoe, called a "nose piece," similar to that placed on switches and crossings in the New York subway or on the Manhattan Elevated, this piece being considerably within the line of the protecting wire fence which now incloses the entire right of way. Each break is spanned by a heavily insulated wire cable passing underground in a concrete duct situated at a depth at which repairs on the crossing are not likely to interfere with it.

*West Shore Railroad.*—The electrical equipment of the West Shore Railroad, completed in 1907 between Utica and Syracuse and operated by the Oneida Railway, includes a third-rail system adapted to 600 volt direct-current service. For this purpose the third rail used is of the bullhead type, of the same section as that used in the New York City zone of the New York Central Railroad, and adapted for underrunning contact. It weighs 70 pounds per yard, supplied in 33-foot lengths, with such conductivity that no auxiliary feeders are required. The joints are made by ordinary 2-bolt splice bars with bolts ⅞ inch in diameter. The center line of rail is carried 32 inches outside of the gauge line of track, and its lower surface is 2¾ inches above the top of the running rail. This permits the passage of all cars belonging to the New York Central

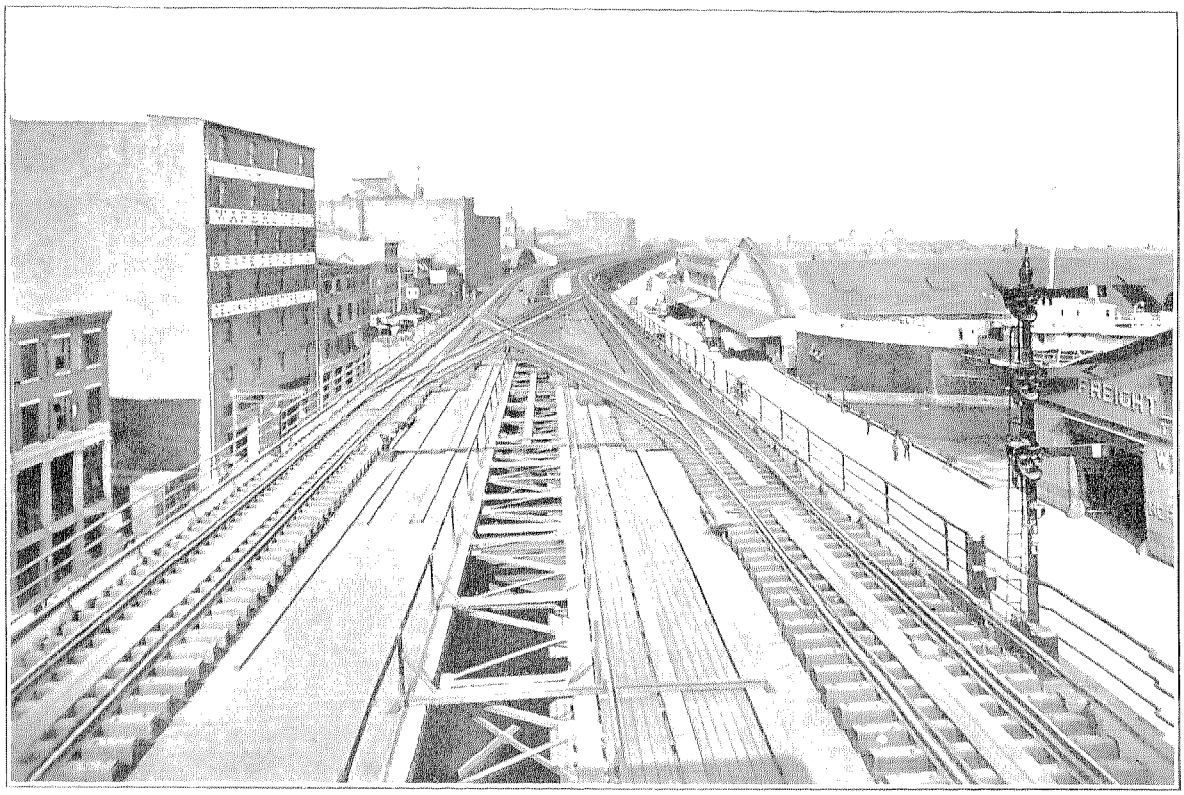
system and foreign cars, except a very limited type of coal cars with low truss rods. Electric locomotives and motor cars designed for use on the New York Central tracks can also be run over these West Shore tracks without changing the position of the third-rail shoe. At each yard a cast-iron tell-tale "gate" is provided, to ascertain if there is any projection on the tram that would interfere with the third rail.

The third rail is normally located between the tracks on tangents and on the high side of tracks on curves. The supporting brackets on the straight track are located 10 feet apart, or on every fifth tie, and are of tough gray cast iron, of the same curved pattern as in the New York Central construction, for undercontact of the upward pressing shoe. These brackets are held to the tie by 3 lag screws 4½ inches long and ¾ inch in diameter. A great deal of study was put on the question of the proper material for the insulating blocks for holding the third rail in the brackets. To secure good insulation, thorough vitrification is necessary, but a perfectly vitrified block is brittle. The problem was thus found to involve formulas for the mixing of clay and porcelain as well as methods of drying and burning the pieces, and the result was the material termed "semiporcelain." Two sizes of blocks are used—one for holding the rail at the inclines where a shallower insulating block is required, and the other at the other points, and each insulator is held to its bracket by a forged steel bolt which passes around the insulator and through a lug on the top of the bracket.

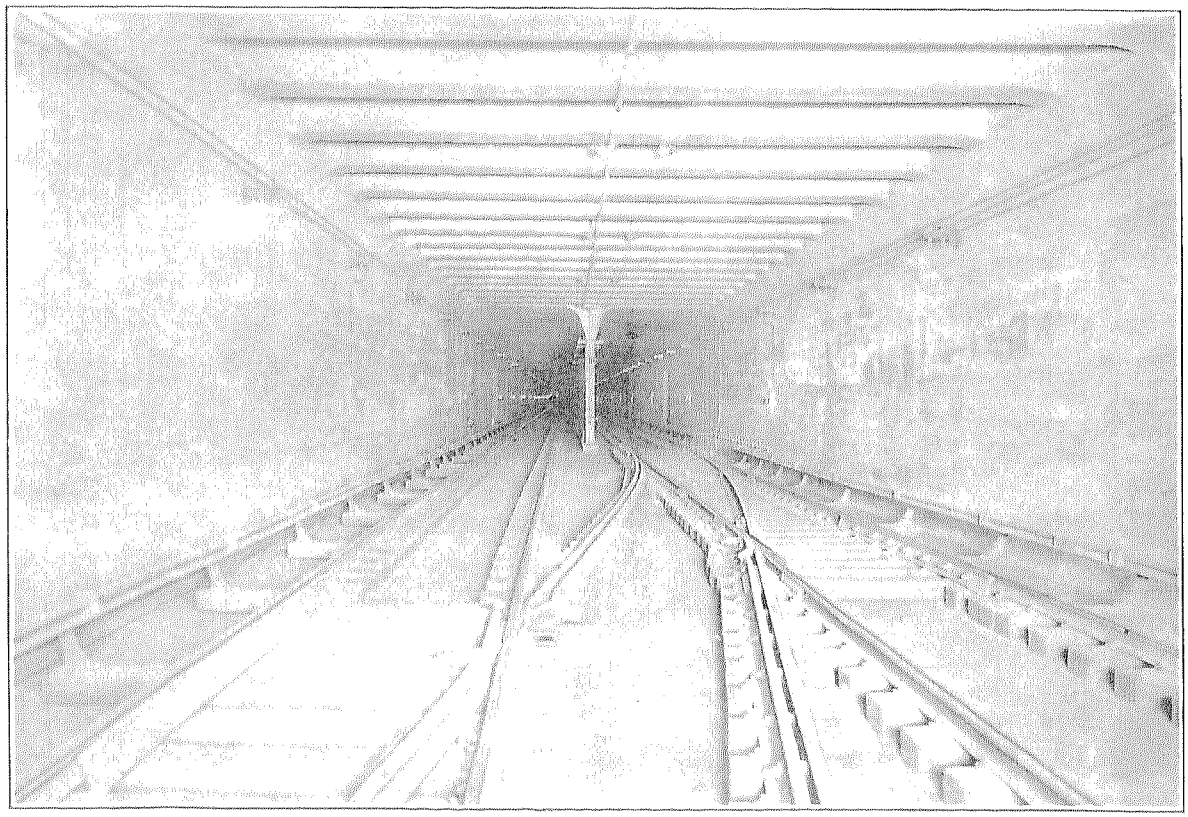
Two types of protective covering are used, namely, a 3-part wooden covering like that on the New York Central, and a single piece of fiber covering, which has been considered preferable. The wooden sheathing is longleaf yellow pine in three parts, top and two bases, held together by 3½-inch diamond-pointed drive screws, and treated with a coat of ordinary paint applied to the outside of the cover before it is placed over the rail. The indurated fiber sheathing is molded for straight track work in sections 43½ inches long, so that it takes three sections to cover the third rail between two brackets. The joints on straight track are covered by 2½-inch lap joints of the same material, but at the bonds a wider section of covering is used, permitting the fiber sheathing to cover the bonds and the joints.

*Pennsylvania Railroad.*—The electric division of the Pennsylvania system from Philadelphia to Atlantic City, known as the West Jersey and Seashore Railroad, with the exception of about 4 miles of main line, is operated with the third rail. The two third rails necessary to the two tracks are on the inside—that is, between the tracks. At stations a fence is placed between the tracks, and wherever there is an opening in the fence to permit passengers to cross from one side to another the third rails are discontinued and connected by underground cable in the same manner as at all the road crossings. At public streets or roads the side fences that separate the tracks from the abutting property turn inward to the tracks, where they meet a crossing cattle guard. The third rail never continues across a public highway, stopping 5 feet back of the property line, but with contact shoes on all cars a train is able to maintain continuous connection with the source of power. Precautions for protecting passengers are taken at all stations. In front and for a considerable distance beyond each station in both directions the third rail is covered by a guard and directly opposite the platform there is an additional covering on the side. The cars have contact shoes on both sides, and the shoes on the side opposite the third rail are charged as well as those which touch it. When at a station a piece of wood slanting down over the shoe from the side of the truck affords a covering and thus protects the shoe from above, while the station platform itself also projects in such a manner as to cover the shoes. Wherever the electric road parallels public streets, as in Camden, Vineland, and Millville, the third rail gives way to overhead trolley, and when the trolley is in use the contact shoes are not charged at all, but by a switch in the car are disconnected from the circuit. In Atlantic City, from the terminal to the point where the tracks go upon the elevated structure, the third rail is protected all the way.

The third rails employed are of Pennsylvania Railroad standard cross section in lengths of 33 feet weighing 100 pounds per yard, and having a conductivity about equal to that of a copper rod of 12,000 circ. mils. This type of third rail was used in order that it might be interchangeable with the track rail. The insulators carrying the third rail are of reconstructed granite 10 inches in length, 5½ inches broad at the base, with an effective depth from the bottom of the rail to the tie of 3½ inches and are spaced about 8 feet apart. They are held in position by a metal center cup screwed to the long ties by means of lag screws, which method of screwing prevents any strain on the insulator when the ties are depressed by the passage of trains. The third rail is anchored at intervals by means of metal clamps screwed to the underflange of the rail in such a position as to engage the insulators on either side. The top of the third rail is 3½ inches above the top of the track rail and 26 inches distant from the gauge line of the adjacent track rail. The approaches of the third rail are made of cast iron and the rail is bonded with concealed ribbon bonds with soldered copper terminals, compressed into 1-inch drilled holes in the rail, two bonds to a rail joint, each having an area of 15,000 circ. mils. As already noted, jumpers are used at all grade crossings, and wherever continuous third rail is impracticable. At such points the cable is drawn into a black bituminized fiber tube laid in solid concrete protection, and terra-cotta covers are employed to protect the cable terminals. The




PHILADELPHIA ELEVATED AND SUBWAY—PORTION OF ELEVATED THIRD-RAIL TRACK.



PHILADELPHIA ELEVATED AND SUBWAY—VIEW OF TRACK IN SUBWAY TUNNEL.

third rails are arranged in such a manner that each track may be isolated from the other, but normally the third rails are electrically connected midway between the substations through a combined switch and fuse box, thus obtaining the combined conductivity of the third rails. There are also section insulators opposite each substation, so that in the event of an accident on any part of the system only a short section of third rail will be dead. A notable point is found in the fact that the third-rail system was adopted for both terminal stations, where there were a number of platforms, and the preference was made on the score of fewer difficulties being encountered in its installation than would have been the case in that of an overhead trolley.

*Third-rail conductivity.*—The conductivity of the third rail depends upon its composition, and special formulas have been used with the object of increasing conductivity. The specific resistance in steel is proportional to the percentage of manganese and copper which it contains. The standard track rail contains from four-tenths of 1 per cent to five-tenths of 1 per cent carbon and as high as seven-tenths of 1 per cent manganese, giving it a specific resistance from ten to twelve times that of pure copper. The following statement shows the composition of special third rails, from which it will be seen that the ratio of resistance of the rail compared with copper has been greatly reduced so as not to be more than eight times as great.

*Composition of special third rails.*[1]

| MATERIAL. | Manhattan Railway. | New York Subway. | Albany and Hudson. |
|---|---|---|---|
| | PERCENTAGE. | | |
| Carbon | 0.073 | 0.10 | 0.090 |
| Manganese | 0.340 | 0.60 | 0.440 |
| Sulphur | 0.073 | 0.05 | 0.080 |
| Phosphorus | 0.069 | 0.10 | 0.088 |
| Ratio of resistance compared to copper | 7.700 | 8.00 | 7.250 |

[1] Standard Handbook for Electrical Engineers.

*Contact shoes.*—The question of third-rail maintenance depends to some extent not only upon the composition of the rail but upon the kind of shoe used to make contact with it. As a rule, the rail shows a very small amount of wear even with heavy service. Tests taken to ascertain this wear show that the passage of the 2,000,000 third-rail shoes over a given special soft rail caused the wearing away of only 0.006 inch. As already noted, third-rail shoes are of two general types, those making downward contact and those making upward contact. The current capacity of the shoe, especially at high speeds, is much in excess of any form of overhead trolley or sliding current collector, and tests indicate that the electrical energy that can be collected from a single shoe at a speed of 35 miles per hour is 2,000 amperes and from the same shoe at a speed of 70 miles per hour 500 amperes. The cast-iron shoes generally used are easily and cheaply renewable, on acount of the large wearing surface exposed to contact with the rail; and the life of one of them is in excess of 25,000 miles. Some interesting data were collected by the Interborough Rapid Transit Company for the year ending December 31, 1907, as to results with the two types of shoes employed on the subway and the elevated sections of the system. Results were as follows:

| | Subway. | Elevated. |
|---|---|---|
| Average life in contact-shoe miles | 45,720 | 56,008 |
| Average cost per 1,000 contact-shoe miles | $0.02322 | $0.01241 |

*New York Elevated third rail.*—The third rail on the elevated division of the Interborough Rapid Transit Company is of the double-link suspended-plane overrunning gravity type, which has been in successful use since 1901. The subway shoe is of the two-pair type for running over the head of the hooded contact rail in the underground section of the subway and over the head of the contact rail on the viaduct.

*Fuses.*—The Interborough company makes a practice of inspecting closely all contact shoes to the extent of the gauging of their height, trying all the bolts, and testing the inclosed shoe fuses. Its type of third-rail shoe fuse is another example of the development of a special device to meet subway conditions. It was essential that such fuses should be inclosed and should be capable of opening and terminating short circuits without any disturbance or any danger of throwing passengers into a panic by noise or flame. To meet these conditions a type of cylinder-link fuse was developed in which a maximum radiating surface is secured with a minimum volume of metal for any given current volume. This fusible link is inclosed in a fiber tube surrounded by porous filling, as in the ordinary inclosed fuse construction. It was demonstrated that fuses constructed with this form of fusible link properly inclosed would operate without disturbance even in handling direct short circuits from the third rail to the structure, where every other type of link inclosed in casing of relatively the same dimensions would explode with great violence. Some idea of the current to be handled by such fuses may be formed from the fact that rushes of current through the fuse in excess of 18,000 amperes were observed during the tests, while the potential drop of the circuit was practically negligible, the potential on the line being approximately 625 volts.

When it became necessary to provide equipment for the subway division, tests were conducted on fuses of larger capacity up to 600 and 800 amperes continuous load. The cylinder link was adopted also for this purpose. The first equipment for the subway called for fuses of 400-ampere capacity. After a year, however, it was found that the tremendously heavy traffic and the rapid acceleration of trains frequently blew the fuses when there was no trouble on

the line. The equipment over the entire system was therefore changed to fuses of about 650-ampere capacity. Originally the fuses were mounted on the beam supporting the third-rail shoe. It was found, however, that the vibration to which this beam was subject had a detrimental effect upon the fuses, and the result was that the shoe fuses are now mounted on a spring-supported block carried on the shoe beam, the springs consisting of two single-leaf semielliptics.

## VII.

### SUBWAYS AND TUNNEL SYSTEMS.

*Subways in New York City.*—One of the most interesting and important developments of electric street-railway traffic since the preparation and publication of the last report of 1902 has been the development of the subway systems. New York City has been the center of this important departure from the previous practice of building railways either on the surface of the streets or on elevated tracks. At the time of the last report the Manhattan Elevated Railway in New York City was in process of changing from operation by steam to that by electricity. At the present time the results with underground traffic have already been such as to render difficult, if not impossible, the construction of any more elevated railways within the limits of Greater New York.

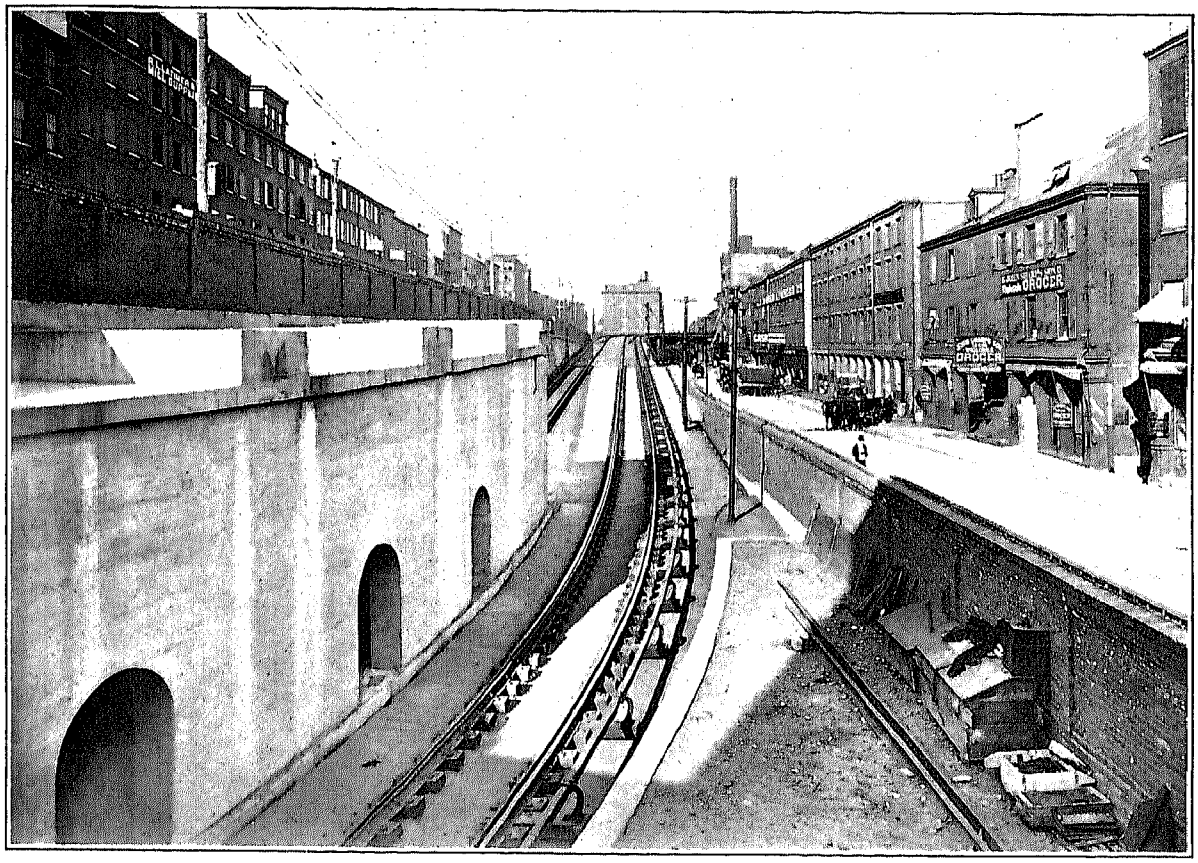
The Interborough Rapid Transit subway system went into operation as recently as October 27, 1904, but its traffic has grown to such an extent that during the year under report no fewer than 166,363,611 fare passengers were carried. At present a number of schemes for the continuation of the present system and the creation of others are under contemplation, while the Interborough system has been pushed northward beyond the confines of Manhattan Island, and has been carried under the East River into the very heart of the Borough of Brooklyn. In addition to this the Hudson subway system has been carried under the North River to the main-line terminal of the Delaware and Lackawanna Railroad system, and other tunnels have been constructed for the Pennsylvania Railroad traffic under the Hudson between the Jersey shore and Manhattan Island, and eastward again from Manhattan Island across to Long Island. These projects had not yet been put in operation at the time of this report.

The creation of the Interborough underground system was a work of many years, and the completion of the subway marked the solution of a problem which, as has been well said, "for over thirty years baffled the earnest desires of the people of New York City, in spite of the best efforts of many of its foremost citizens." As early as 1868 legislation was enacted making possible the construction of an underground railway from the city hall to the Harlem River, and a company was formed which, like numerous successors, struggled without result with the various difficulties encountered, and met only failure and loss.

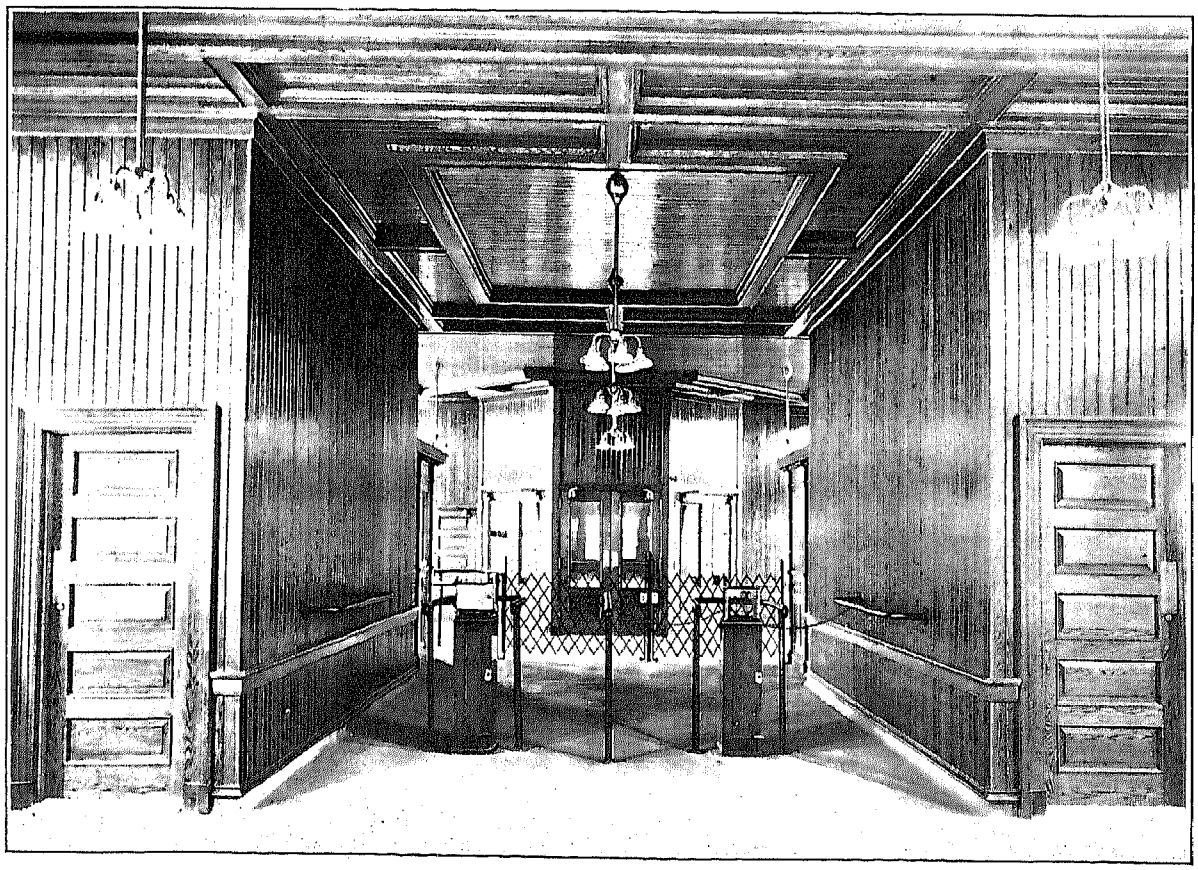
In 1891 the city itself secured the passage of a rapid-transit act under which the Interborough subway has been built, but which as originally passed did not provide for municipal ownership. It was not before 1900 that under the rapid-transit act then in force, a board was created to prepare general plans and to submit the question of municipal ownership to the electorate of the city. The city was authorized in case of a favorable vote to issue bonds not to exceed $50,000,000, at 3½ per cent interest, for the construction of the system, with $5,000,000 additional for private property rights along the route. As soon as the public had declared itself in favor of such a plan steps were taken by the rapid-transit commission to secure a contract for the construction of the system, the amount to be paid by the city for the construction being $35,000,000, and an additional sum of $2,750,000 for terminals, station sites, etc., leaving about $15,000,000 for equipment. The lease from the city to the contractors who agreed to operate the system was for a term of fifty years at an amount equal to the annual interest upon the bonds issued for the construction and 1 per cent additional, the 1 per cent during the first ten years to be partly contingent upon the earnings. It was agreed that the construction of the initial system should be completed in four and one-half years. This result was not reached without a great deal of trouble and anxiety, on account of financial difficulties. In the spring of 1902 the Interborough Rapid Transit Company was formed, as the operating and corporative representative of the Belmont interests, to which Mr. McDonald, the contractor, assigned the lease or operating part of his contract with the city. Incidentally it may be said that, in order to secure the advantages of harmony and union between the traction interests of the city, a further step was taken, in January, 1903, by which the Interborough acquired the Manhattan Elevated Railway system by lease for nine hundred and ninety-nine years.

The subway route as adopted finally reached from the terminal near the city hall to Kingsbridge on the northwest and to Bronx Park on the northeast, while subsequently by adopting the Brooklyn extension the line was carried down Broadway to the southern tip of the island, and thence under the East River to the Flatbush avenue terminal, in Brooklyn, of the Long Island Railroad system. As at present constructed the road may be considered a straight stem from the heart of Brooklyn through to Kingsbridge, with a fork or spur beginning at Central Park and extending northward to Bronx Park. Fully 75 per cent of the road has been built beneath the surface; the northern portion, however, comprises large and important stretches of viaduct and open cut.

*Types of New York construction.*—Five types of construction were employed in building the road, namely,



PHILADELPHIA ELEVATED AND SUBWAY—INCLINE BETWEEN ELEVATED TRACK AND SUBWAY.



PHILADELPHIA ELEVATED AND SUBWAY—VIEW OF SUBWAY STATION.

the typical subway near the surface, with flat roof supported between tracks by steel bulk angle columns and I beams for the ceiling and sides; flat-roof construction of reenforced concrete supported between the tracks by steel columns; concrete-lined tunnel; elevated track on steel viaduct; and cast-iron tubes under the Harlem and East rivers. A notable feature of the whole system is the use of four tracks, the two outer for local or way traffic and the two inner for express traffic, with island platforms at the express stations so that passengers can change readily from train to train, these island express platforms being connected with the local platforms by overhead bridges within the subway or by short transverse tunnels under the track.

The motive power of the entire system is electrical, current being derived by the motors from a hooded third rail over which the contact shoes slide. The standard type of car employed has a length of 51 feet and a seating capacity of 52 passengers, with inclosed vestibuled platforms and sliding doors at the ends instead of the usual gates. Modifications of this type have been suggested and tried, but without material change up to date. A large number of the earlier cars were of wooden framework around the steel framing, but the tendency has been steadily toward the substitution of all-steel cars. The rolling stock of the road comprises motor cars which carry two motors, one geared to each axle, and trail cars that carry no motive power. An express train of eight cars, to conform to the schedule speed adopted, requires a normal power of motors on the train of 2,000 horsepower, with an average accelerating current at 600 volts of 325 amperes in starting from a station stop. All the car-controlling devices are placed outside the car body in a special insulated steel compartment, so as to lessen any possibility of accident to the public from contact, etc. Cars are lighted electrically and a separate independent system is operated for the lighting of the subway and stations, so that the subway shall not be left in darkness in case of any accident to the motive-power service to the cars. A very elaborate system of signals embodying the highest development of the automatic system is also used.

The electrical energy for the whole system is furnished from one of the largest power houses in the world, on the Hudson River at the foot of Fifty-ninth street, whence the current is distributed to a number of substations in different parts of the city, where the current of 11,000 volts from the power house is manipulated as direct current to the motors at 500 volts.

It may be noted that the length of road from Brooklyn Bridge by subway to One hundred and eightieth street, New York City, is 13.46 miles, and from Brooklyn Bridge to Two hundred and forty-second street, New York City, 14.17 miles, this being a common length of journey, while the longest continuous ride is from Atlantic avenue, in Brooklyn, to Two hundred and forty-second street, New York City, a distance of 17.5 miles, one of the longest hauls for passenger traffic in the world for the rate of 5 cents. In discussing this subject and the various methods by which the subway might be improved in capacity and convenience, Mr. Bion J. Arnold, special consulting engineer to the Public Service Commission of the first district of the state of New York, says:

> The subway system has now been in operation long enough to demonstrate that, in order to make this method of transportation self-sustaining upon the present flat-fare basis, the income should average at least 1 cent per passenger mile. *In other words, with a uniform fare of 5 cents the average length of ride should not exceed 5 miles.*
>
> The analysis resulting from the study of the passenger movement on the individual trains proves that the average length of travel on the express trains is now 5½ miles, or slightly above the critical average, whereas the average length of ride on the local trains is but 2 miles. It is apparent that as the subway is extended and the outlying districts become more thickly populated the average length of the long-haul rides will become greater, and that unless the fare for these longer rides is increased, it will be necessary to cultivate the short-haul business and increase the profit from that source if the present 5-cent flat fare is to be retained.

*Hudson River tunnel system.*—As far back as 1879 a brick tunnel was pushed under the Hudson River by Mr. D. C. Haskins, reaching a distance of 1,200 feet; ten years later it was carried forward 1,800 additional feet; and it was completed in 1907 for the Hudson and Manhattan Railroad Company, whose system went into operation in February of 1908, so that the transportation figures are not included in the statistics of this report. It is proper, however, to note the details of a system built in the census period 1902 to 1907. The part of the route thus open consists of a twin-tube tunnel extending from Hoboken, N. J., to Twenty-third street, New York City, and it is proposed to carry it through to Herald Square and Thirty-fourth street, and eventually to the Grand Central Depot on Forty-second street. The tunnels under the river are made of steel rings, bolted together and set in place, as the boring shield, working in compressed air, opened the way for them. In most places the steel rings have a coating of concrete so that the interior of the tunnel is smooth. Each tube has an interior diameter of 16 feet 3 inches, and the cars are made to conform in general shape to the bore of the tunnel. The tubes are entirely separate from each other, in fact about 30 feet apart for most of the distance under the river to the Hoboken terminal, and are connected with the Delaware, Lackawanna and Western Railroad, so that passengers from either station may reach the tunnel cars or leave them directly without emerging to the open air. Eight-car trains, electrically propelled, are used in the tunnels, with third-rail direct-current system of transmission similar to that employed in the New York City subway. The cars have large sliding doors in the middle as well as at either end, and the platforms are so arranged at the terminal stations that passengers enter and leave the cars at the same

time. Another unusual feature is that the cars have upright stanchions as well as straps for the use of passengers standing. The doors are operated by compressed air, and no signal bells are used.

These cars are absolutely fireproof, while at the same time the weight has been kept as low as is consistent with safety. To secure fireproof qualities unusual precautions were taken. The entire car body, including door and roof-head lining, is made of steel; the floor is of monolith cement laid on steel with ¼-inch finish of carborundum cement used as a substitute for maple strips; and the seat backs and cushions are covered with a metal fabric instead of rattan. All conduit wires are covered with asbestos and are placed in iron conduit pipes; the magnet coils of the control equipment are insulated with mica and asbestos instead of the usual covering of cotton tape; and the contact shoes, which are of the hinged type, have directly over each one of them an inclosed fuse, protected by an asbestos-lined wooden box, the base of which fuse is mounted on springs in order to reduce the vibration, prolong the life of the link, and insure its more efficient operation.

When the last door of the train is securely closed the motorman receives an electric flash signal and starts the train. The automatic adjustment is such that the signal to start can not be given so long as any door in the train is open even the fractional part of an inch. The air in these deep tunnels under the bed of the river is good, as the ventilation is automatic, each train acting as a piston to force out the air ahead of it and to draw a fresh supply from the surface as it proceeds.

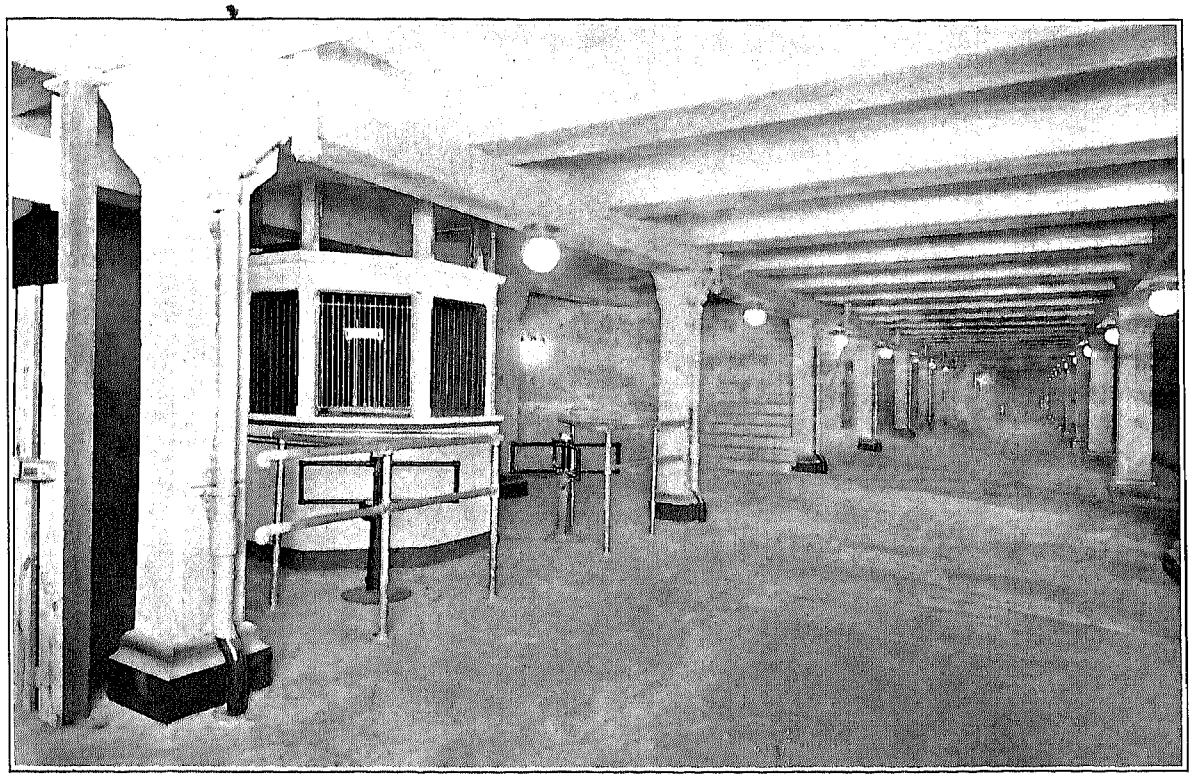
The Hudson and Manhattan Railroad Company, in addition to the installation of a thoroughly modern block-signal system, has installed in its tunnels an emergency signaling system with provision for cutting off power from the contact rail, similar to the method employed by the Interborough Rapid Transit Company in the New York City subway. It consists of the regular fire-alarm equipment with relay connections by which the direct-current circuit breakers in the substation are tripped by the same electric impulses that give the alarm. In case of an accident in one of the tubes a train hand, by breaking the glass front of the emergency box and pulling the hook, not only cuts off power from the third rail, but at the same time reports the location of the trouble by means of annunciator gongs in the substations, from which power is supplied to the section, as well as in the train dispatcher's offices, and in the office of the general superintendent. Further, to reduce risk from fire and smoke and to insure an absolute minimum of danger to passengers, the Hudson and Manhattan Railroad Company has used in the construction of the guard or hood over the third rail, Jarrah wood, specially imported from Australia. The tests made by the engineers of the system show that this wood possesses very remarkable fire-resisting qualities, admirably adapting it to such a purpose.

There are four sections proposed of this Hudson River tunnel system, of which section 1 just described is known as the north tunnel. Section 2 extends from Cortlandt street, New York City, to Jersey City; section 3 is a transverse tunnel, running along the Jersey shore of the Hudson River for a mile and a quarter to connect the terminal in Jersey City with that in Hoboken; and section 4 is a branch line running from Jersey City to New York City. At the Cortlandt-Fulton street terminal of the system in New York a huge 22-story steel structure has been erected, known as the Hudson Terminal Building. From the train platforms in this building, two stories below the street level, the passengers may proceed by underground and underriver routes to any part of Greater New York. The cost of the system when fully completed is estimated at about $70,000,000.

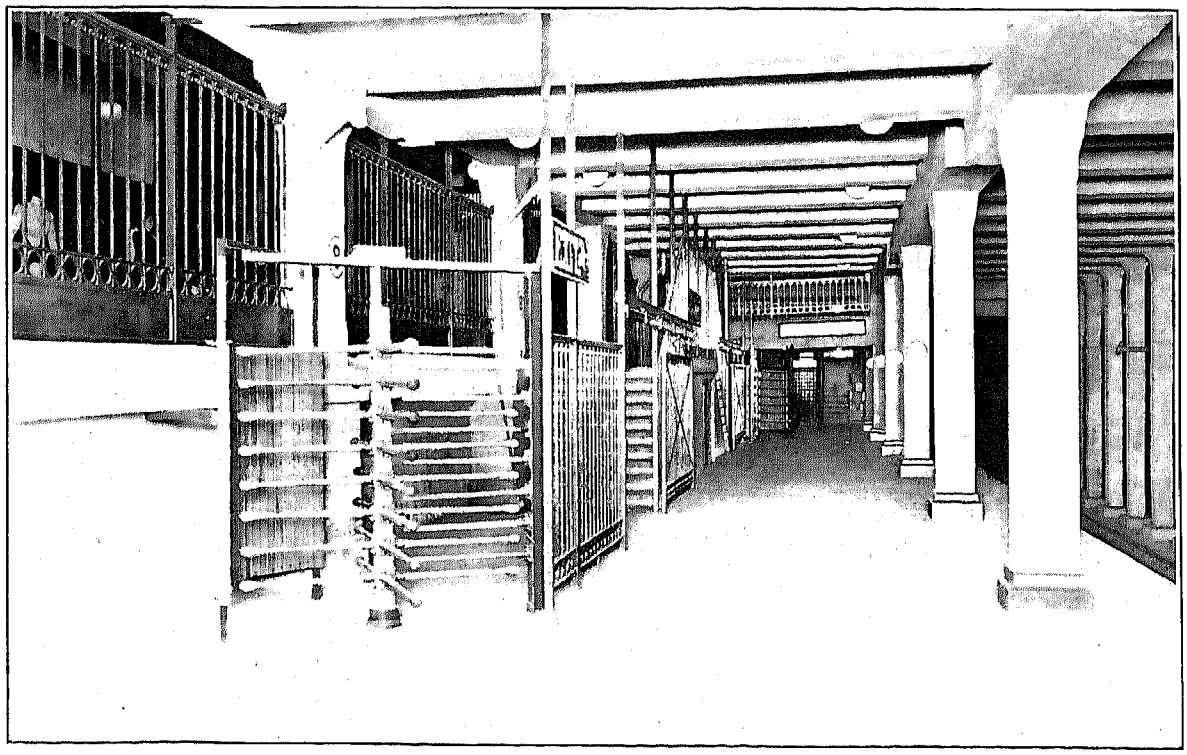
*Subways under East River, New York.*—A third subway system is that which has been built across the East River from the Grand Central Station to Long Island City, following the line of Forty-second street. This is a twin-tube tunnel, of which the tubes are similar in dimensions and general construction to those which are now in use as part of the Interborough system from the Battery at the southern extremity of Manhattan Island across to Brooklyn. This tunnel was built under an old franchise granted many years ago, but has not yet gone into use, although it has been offered to the city at a price of $7,000,000.

Independent of all this subway work, and also intended for electrical operation, is the tunnel system of the Pennsylvania Railroad. Hitherto that system has ended at the Atlantic seaboard with a terminal on the New Jersey shore, but is now completing a huge terminal depot in the heart of Manhattan Island near Herald Square. From the New Jersey shore to the New York shore two single-track tubes have been driven, so large that they can carry cars of the heaviest trains, and having an internal diameter of 23 feet, with heavy steel shell and deep flanges, and an interior lining of 2 feet of concrete. The concrete is carried up at the sides to the level of the window sills of the cars, so that a broad pathway which the passengers can traverse is afforded for use in case of a sudden interruption of the train service.

*Boston subway system.*—The Boston subway system, which has been in operation for some years, has recently had an addition in the Washington Street subway, built by the Boston Rapid Transit Commission and leased to the Boston Elevated Railway for twenty-five years. This new tunnel runs under the heart of the business district of Boston, and is a little more than a mile in length, being 5,676 feet between portals. The cost, including the approaches and the equipment of stations, was something over



PHILADELPHIA ELEVATED AND SUBWAY—TICKET OFFICE AND ENTRANCE TO SUBWAY.



PHILADELPHIA ELEVATED AND SUBWAY—TICKET OFFICE AND ENTRANCE TO DEPARTMENT STORE.

$10,000,000. It is estimated that when in full operation it will increase the capacity of the Boston Elevated Railway Company system in the downtown district about 175 per cent. The Tremont Street subway was the first rapid-transit tunnel built in the United States, and this latest addition benefits by the experience derived from that and similar work in other parts of the country. The construction of the tunnel varies in different places, being adapted to the constantly changing conditions of the streets and buildings above it, although it is a great improvement over the Tremont Street subway in that it is almost straight in its alignment. In some parts vaulted concrete roofs are used, held together by tie-rods, and in other places the roof is spanned by steel girders with concrete roof arches between. There are seven stations along the tunnel, four being for southbound trains only, three for northbound trains, while the State Street Station serves as a transfer point for passengers between northbound trains and trains in the East Boston tunnel. The platforms of all these stations are 350 feet long, to permit the use of 8-car trains of the type of rolling stock in use on the elevated structures. At the large State Street Station, besides the stairways, there are five escalators for the accommodation of the public. Lighting is done by incandescent lamps, with three independent sources of supply. To keep the tunnel free from water, pumping chambers are installed at three different points. In each chamber are two pumps—a small one for ordinary conditions of the most severe weather and a larger one for use in case of extraordinary circumstances, the larger pump cutting in automatically should the water come in too rapidly for the smaller pump to keep it down. There are also four fan chambers situated along the length of the tunnel, each with two fans, capable of exhausting 25,000 cubic feet of air per minute. The foul air is drawn out of the tunnel between stations through concrete ducts in the ceilings, and the fresh air enters at the several passenger entrances, insuring a pure supply at all times.

All the steel construction throughout the tunnel has been protected from rust and fire by concrete; all the woodwork is encased in sheet bronze; all destination and direction signs are made of enameled metal; and the ticket offices of sheet copper. In other words, a minimum of wood is used. Provision also is made for public and company telephone booths constructed of fire-proof materials.

*Philadelphia subways and elevated.*—One of the most important additions to street-railway systems of this character is the Market Street Elevated Passenger Railway, installed by the Philadelphia Rapid Transit Company, under franchises dating back to 1901 and 1902. This new system comprises both subway and elevated lines, extending from a terminal at Sixty-ninth street west of the city boundary in Delaware County eastward to the ferries on the Delaware River. At Sixty-ninth street a passenger station connects the Market Street line with other electric-railway systems, reaching rural portions of Delaware, Montgomery, and Chester counties. The power house, repair shop, etc., are also located at this point. The first section of the line runs on private property, with retaining walls to the western city line, and thence by 2-track elevated structure in the center of Market street to the new Schuylkill River Bridge built by the company. This bridge is located 100 feet north of the center line of Market street, and is reached by reverse curves and an incline with the subway, running east under the bed of Market street to the city hall and the Delaware River. The bridge and the subway, as far as the Philadelphia city hall, have four tracks—the two inner for trains operated on the elevated railway and the two outer for surface cars from West Philadelphia. At the city hall the tracks diverge, the two eastbound and the two westbound passing to the south and the north of the city hall, respectively. The tracks for the surface cars terminate in a loop on the east side of the city hall, passing under the through tracks, so that all these cars from West Philadelphia return westward after passing around the city hall. The two tracks for the elevated trains continue on the East Market Street subway to Front street, thence north by curve and an incline on private property between Front and Water streets, and by elevated railway on Arch street to Delaware avenue, proceeding south on that avenue to the eastern terminus at South street. The Delaware River ferries at Market, Chestnut, and South streets have stations on the Delaware Avenue elevated.

The subway itself is 26 feet 6 inches wide inside, and at the highest point 14 feet 5 inches from the base of the rail to the roof. A third rail of the underrunning-contact type supplies electrical energy to the elevated and subway trains, while the surface-line cars that enter the subway are operated by overhead trolley. There are 7.41 miles of structure and 17.2 miles of single track. The stations, of which there are 18, including the eastern and western terminals, are 350 feet long in the subway (except one, 364 feet) and provide for 8-car trains. As in New York City, connections have been made at various points with department stores and other buildings, and all entrances and exits of this kind are open day and night. The run through from Sixty-ninth street to Second street takes twenty-seven minutes eastward, while westward the heavy grade adds one minute. Between the city hall and Second street the run through is seven minutes, or less than half the best time possible by the surface cars.

Electrical energy is supplied from the power house to the tracks through two substations conveniently located. The subway is profusely lighted with 16-candlepower incandescent lamps, affixed generally

every 30 feet, but every 20 feet around the city hall loop, and every 25 feet in the 4-track tunnel west of city hall. The station platforms are supplied with lights on the basis of 32 to 38 square feet per lamp, and the lighting is done by 25-cycle alternating current for regular service and direct current at 550 volts for emergency service.

The elevated-subway service requires from 80 to 100 cars. In the slack hours 14 trains of 2 cars each are in use, while during the rush hours 14 trains of 5 cars each are operated. A steel-framed car of the design developed and used by the Boston Elevated Railway has been adopted, with slight modifications. Each car has entrances at the middle as well as at the ends. Woodwork is used only for the interior finish, which is of mahogany. Owing to the requirements of the ordinance that stations should not average more than one-half mile apart, it was not deemed feasible to attempt a greater schedule speed than 15 to 20 miles per hour, this being based also on station stops not to exceed twenty seconds each. It was further deemed advisable by experts, in view of the heavy grades, to make each car a motor car, instead of using trailers, so that on one truck of each car are mounted two motors rated at 125 horsepower each. The multiple-unit system of car control is used, whereby the whole train is controlled by the motorman on the front platform of the first car. The controller is so arranged that it returns automatically to the dead point should the motorman for any reason take his hand from the handle. The over-all height of the car, that is, from the top of the rail to the top of the roof, is 13 feet, giving room for the clearance between the top of the car and the subway roof.

An elaborate system of signals has been installed, and the road is also protected and operated with the aid of a complete telephone system, a telephone being in each ticket booth as well as at intervals all along the line.

An interesting feature of the system is the Schuylkill River Bridge, finished in 1905. This bridge, which was considered more desirable for the subway than a tunnel, is 576 feet long, and carries the 4 tracks with a clearance above the mean high-water line of 26 feet 4 inches.

The complete line was thrown open to public travel on August 7, 1908, although a portion of the system had been open for some months, as many as 1,286,161 passengers, paying or transferred, having been carried in December, 1907. Traffic practically doubled in 1908, reaching a total of 2,588,502 passengers in December of that year. The cost of construction of the subway and elevated line is reported as $17,708,250, inclusive of cars, car equipment, power house, signals, and everything complete.

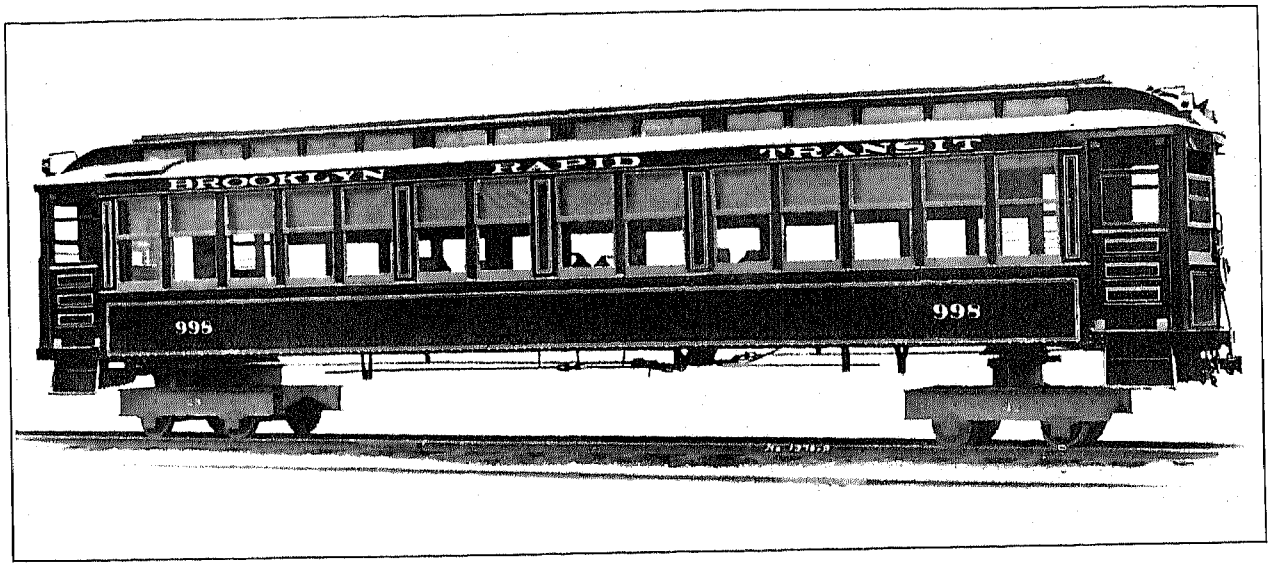
## VIII.

### CAR CONSTRUCTION AND LATEST TYPES.

*General development.*—The general statistics as to the number and kind of cars in use are given in Table 38, from which it appears that a total of 83,641 cars were in use in 1907 as compared with 66,784 in 1902, a gain of 25.2 per cent for the period. The table brings out the interesting fact that the passenger cars increased by only 9,726 during the period, or only 16.1 per cent, while other styles gained notably. The increase in combination passenger, express, and freight or mail cars was from 239 to 567, an increase of 137.2 per cent, and the effect of interurban development was indicated in the enormous increase in express, freight, and mail cars from 1,114 to 5,669, a gain of 408.9 per cent. These various types of cars, as well as others of the work and service class, are discussed in the statistical portion of the text with relation to Tables 38, 39, and particularly Table 40, which shows the distribution by states and geographic divisions.

The development of the street car was very fully discussed in the report of 1902, in which the construction and engineering details of the various types of cars then in use were explained. The chief feature of the intervening period has been the great improvement of the convertible and semiconvertible types of passenger cars, the introduction of a type strictly new so far as relates to the collection of fares, and the greater resort to steel as a material of construction. The use of the convertible and semiconvertible car has become essentially a measure of economy for modern street-railway systems, and commends itself for many important economic and managerial reasons. One of the problems of large street-railway systems is the provision of adequate cars for the service, with car barns in which to store them during the periods of idleness. If open or closed cars only were employed there would not only be no necessity of providing an extra set of cars with all the incidental items of maintenance and repair, but also no need of a large additional amount of car-barn space involving both additional labor and insurance and the acquisition of costly property at central points for car circulation.

*Convertibles and semiconvertibles.*—Between convertible and semiconvertible cars there is considerable difference. In the convertible type of car the lower panels as well as the upper sashes can be raised in the roof pockets, or else the sides can be detached and stored so that when the car is made fully open it becomes like cars of the regulation open type with side entrances, approached from the running boards. In the semiconvertible car, however, the lower panels are fixed; the sides of the car remain




STEEL CAR, BROOKLYN ELEVATED, NEW YORK.

INTERIOR OF STEEL CAR, BROOKLYN ELEVATED, NEW YORK.

intact and are not disturbed; but the window space may be entirely clear of the sashes when desired. The car may be thus half open, but the extent of the openings is limited. In connection with semiconvertible cars three methods are employed for the disposal of windows. In one type the windows are entirely removed at the beginning of summer and replaced as winter comes on. This of course necessitates much handling and provision for storage in the car barns. In another type the windows are dropped into wall pockets in the car, and in a third they are stored in roof pockets when not in use. The third method, it is claimed, is preferable, as the roof pockets do not occupy space needed for other purposes and maximum interior width of car is obtained; the window sills may be as low as desired; a single movement only is necessary in handling the sashes, and the wall pocket, accumulating dust and rubbish, is dispensed with. In the second type, on the other hand, it is somewhat difficult to raise sashes out of pockets within the panels, while such pockets place the window sill at an undue height because of the necessity for accommodating the full sash there. In summer time, however, a low sill is desirable, which, in some instances, is secured by dropping one section of the sash into a wall pocket and a small upper section into a pocket behind the designating letter board.

The window system of the semiconvertible car utilizing roof pockets is designed for both curved and straight sided construction. It consists simply of a pair of sashes which are guided into the pockets in the side roofs by means of trunnions moving in a metal runway. The bolts of the window locks form the lower trunnions of the larger sash and the upper trunnions of this sash are fastened upon plates screwed firmly to the sash frame. In its lowered position the larger sash is held tightly against the upper by sash springs which are compressed by parting strips and press the upper trunnion of the sash into notches formed in the runway. On being raised the trunnion slips easily out of the notches and the runway keeps the sash a little apart, so that there is no friction, except that given for short distances by the light sash springs against the parting strips. A slight turn in the runway just as the upper trunnion engages the hook at the top of the upper sash brings both sashes together. From this point upward the sash runways are double the width of those in the posts, as the trunnions which are cast upon the hooks of the upper sash also move in the same runway. The purpose of the trunnion in the upper sash is simply to drop into notches when this sash is lowered and thus hold it firmly and prevent rattling. The curve of the runway in the pocket locks the hooks of the upper sash to the trunnion of the lower, so that the sash can not become disconnected in the pocket. The window locks used with this system have a steel core in the brass bolt which prevents its bending if the sash is dropped from one stop to another. Besides the stops which hold the lock bolts when the sashes are in the pocket, there are five stops to each runway, the upper part of each stop having ample inclination or slope, so that even if the sashes are carelessly dropped the bolts can not fail to catch.

*Steps for cars.*—As will be noted from the table, a large number of distinct or separate open and closed cars are still in use, and in many cities, such as New York City, the difference has been maintained. In such cities the gross number of cars in use would have been greatly increased above the figures shown by the table but for the tendency, which has been strongly manifested, toward increasing the length and carrying capacity of cars. This increase in the size of the cars has necessitated heavier equipment of motive power, and these larger motors in turn have raised the cars to such an extent as to make the single step of undue height from the ground and inconvenient for people of short stature. This high step has resulted in many accidents and made the car slower than formerly in taking on and letting off passengers. It is said, however, to be impossible to construct an open car for double trucks with 33-inch wheels and carrying 4 motors, with the top of the floor less than 36½ inches from the rails. To divide this height by one step by making the distance between rail and step 19½ inches, and that between the step and the car floor 17 inches, is obviously awkward, and the difficulty has led to methods for double-step construction for open cars. In one leading open type the object has been accomplished by substituting for the usual thick timber sills Z-irons, the middle web of which forms the upper step. In this manner the Z-iron does for the open cars exactly what the drop platform does for the closed cars in reducing the height of the step; the lower step or running board is only 16 inches above the rail, from the board to sill step is 13 inches, and from the sill step to the car floor 7½ inches. These heights make it unnecessary for passengers to use the side handles, except to steady themselves and give them a short easy flight of steps which they can descend without stopping to swing around. Iron plate with corrugated surface forms the treads of the sill steps, preventing slipping in wet weather. They project over the web slightly, giving the step a width of 7 inches.

*Types of interurban cars.*—The development of interurban railroads has brought out many different types of large cars which serve for operation within the city limits as well as outside. The popularity of the larger types of cars, such as those 55 or 60 feet long, is shown in the fact that out of 17 roads examined in Ohio during 1906, 13 had cars 50 feet in length or over; 3 had cars at least 60 feet long; and on 9 of the roads 3-compartment cars were used for local as well as limited service. It will be readily understood that such large cars weigh from 40 to 60 tons. On several roads the smaller cars were kept for the

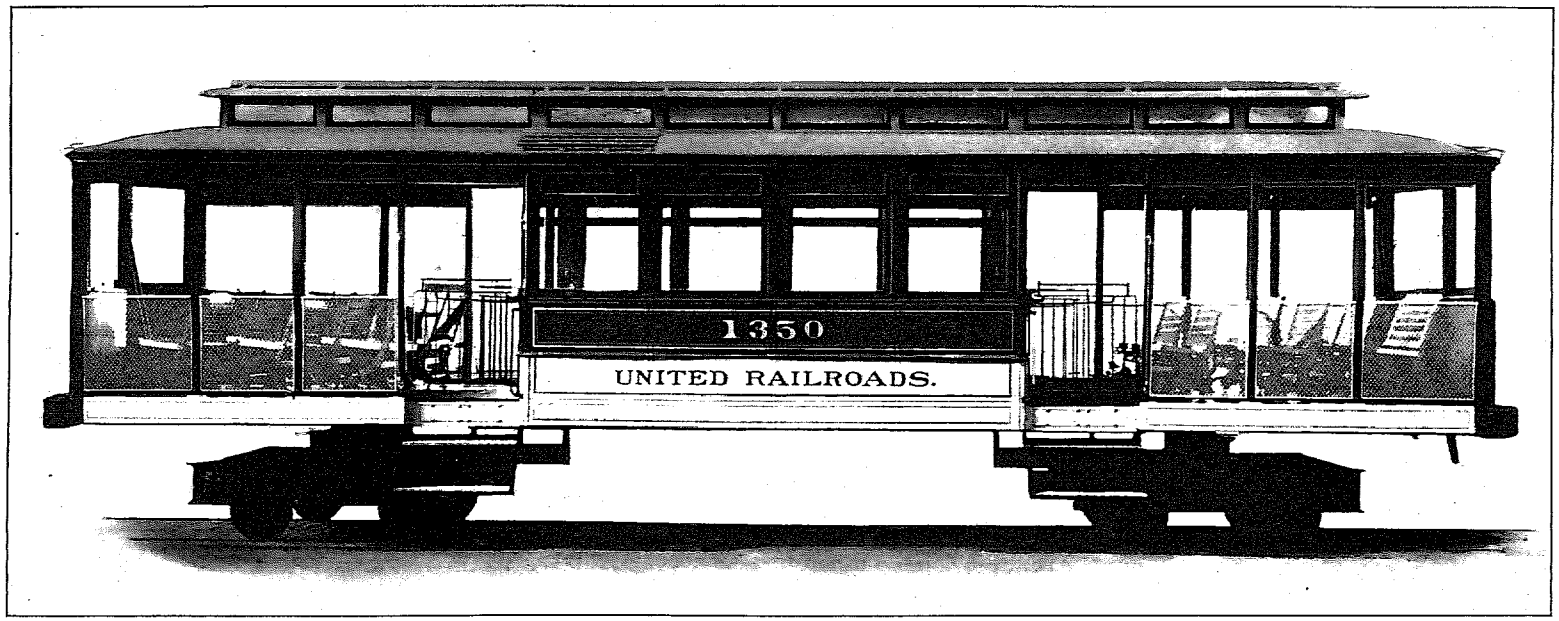
local runs and the longer cars for the "limited" runs, i. e., runs on which are made a definite, limited number of stops. It has been the aim of traction managers generally to secure as wide a car as possible, in order to furnish comfortable seats on each side, wide enough for two passengers; but the developments in this direction are frequently thwarted by local conditions. The Toledo, Port Clinton and Lakeside Railway Company entering Toledo, Ohio, has cars 9 feet wide, but 2 of them can not pass on the same street. The Cincinnati, Hamilton and Dayton Traction Company has many "devil strips" only 3½ feet wide between the tracks, with the result that the cars of the Interurban Railway and Terminal Company and the Cincinnati, Milford and Loveland Traction Company are only 8 feet 1 inch and 8 feet 3 inches wide, respectively. Cars built for the limited service on the Fort Wayne, Van Wert, Lima and Toledo lines are not less than 62 feet over all, and weigh 45 tons.

With such cars the question of steps has again involved various problems. It has been necessary to design steps that will not extend too far out beyond the side of the car and will at the same time keep the rear platform wide enough for safety. The use of heavier equipment has often rendered desirable a third step, especially in country sections where the tracks are elevated. The Dayton and Troy Electric Railway Company (Ohio) has equipped all its cars with a step which is dropped downward at each stopping point; and the Stark Electric Railroad Company (Ohio) goes so far as to provide each car with a small stool or box which the conductor is supposed to place on the ground at each stop, as is done by a Pullman porter in heavy steam-railroad work. This, however, is an innovation which is not likely to go far in electric railways. A tendency has been shown to build the floors of platforms of cars at the same level as the car floors, so that the sills can run through from bumper to bumper. In many instances the rear platform alone is dropped, usually about 6 inches. The bottom of the sills of the car with a dropped platform is usually from 40 inches to 43 inches above the rail. This makes necessary only two steps of from 11 inches to 13 inches, the last step being about 17 inches above the rail. Where the platform is on a level with the car floor, however, three steps are often used. The platforms are usually about five feet long. On some of the older cars the rear platforms are open, but closed vestibules are preferred, and the newer cars have been equipped with them. The rear platforms of the interurban cars of the Detroit United Railway are of the open type, similar to the open platforms of the regular city cars, and have a safety gate on one side.

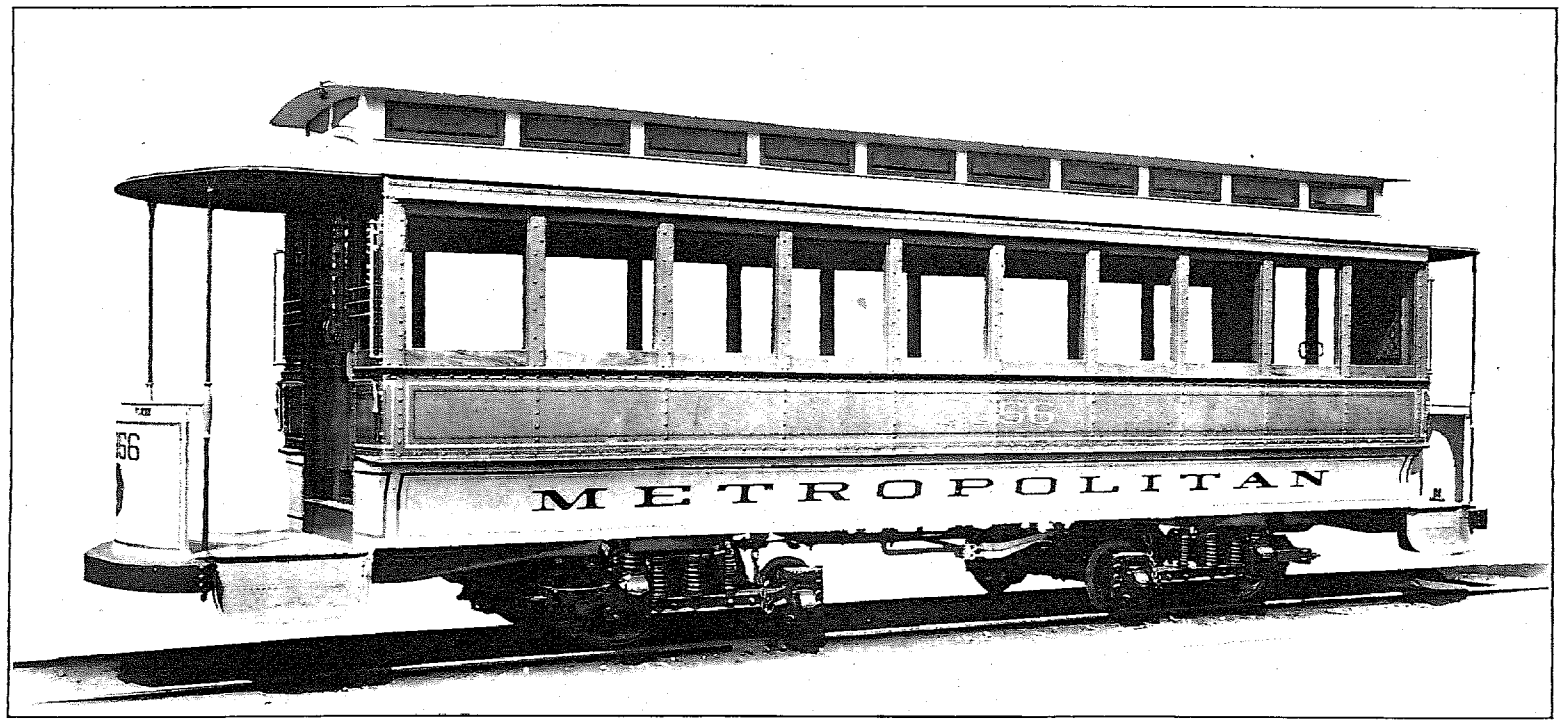
All the passenger cars on the interurban roads inspected in Indiana and Michigan during 1906-7 had two compartments and some had three. The limited cars of the Indiana Union Traction Company and the regular cars of the Detroit, Ypsilanti, Ann Arbor and Jackson Railway (Mich.) (now the Detroit, Jackson and Chicago Railway) were the only ones without baggage compartments, and in general construction, with one exception, all the cars were patterned after steam coaches, with steam-coach type of hood and side windows to raise instead of drop into wall pockets. The exception was the interurban car of the Terre Haute Traction and Light Company (lessor of the Terre Haute, Indianapolis and Eastern Traction Company) (Ind.), which resembled the usual heavy type of car for city service. The roof was of the monitor type, the side windows dropped, the letter board was absent, and the ceiling lower than usual on interurban cars. These cars are intended for double-end operation, while the interurban cars of all the other systems inspected are designed to be operated in one direction only.

*Weight of cars.*—When the interurban cars were first developed the managers were not particularly in favor of carrying baggage because of the delay and space consumed. It was found, however, that on the interurban limited cars, offering quick passage from town to town, a great deal of the passenger traffic was made up of traveling salesmen, to whom such service would be of no use unless they could take their trunks and sample cases with them. Hence the baggage compartment became necessary, and at the same time the smoking public demanded accommodation. Out of these necessities arose the development of the 3-compartment car which is now general, owing to the desire not to reduce more than possible the seating or passenger-carrying capacity. The heaviest cars thus developed reach a weight on the Indianapolis and Northwestern Traction Company (lessor of the Terre Haute, Indianapolis and Eastern Traction Company) (Ind.) of 82,000 pounds, and on the Fort Wayne and Wabash Valley Traction Company (Ind.) of 80,000 pounds. The weight appears to be about equally divided between the body and the trucks with their equipment. Thus, of the total 76,000 pounds for the cars of the Indiana Union Traction Company, the body weighs 38,000 pounds.

*Car seats.*—On a large number of interurban roads, as, for example, in Ohio and adjacent states, the seats are made stationary, this arrangement, of course, being possible only with single-end cars. The cane seat is preferred on many of the lines on account of its cleanliness and durability, and is largely adopted for local service, while high-back, roll-top, plush-upholstered seats are preferred by a number of roads for long-distance service. Several roads use plush seats in the main passenger compartment and leather seats in the smoking room—leather or pantasote being used in many of the later smoking compartments. Chair seats, which were used at one time by a number of roads on the limited service, have been given up on account




STEEL CAR, SAN FRANCISCO, CAL.



of the reduction in seating capacity. Wicker chairs are frequently found in the smoking rooms of limited cars. The passenger compartments on the roads in Indiana and Michigan are often equipped with reversible or walk-over seats.

*Trucks and wheel base.*—As already noted, the weight of the cars has greatly increased and with it the weight of the trucks, so that each truck exclusive of the motors now weighs from 10,000 to 12,000 pounds. The interurban cars on all the roads examined in Indiana and Michigan in 1906 were mounted on trucks of the M. C. B. type, and the latest cars of the Fort Wayne, Van Wert, and Lima Traction Company (Ohio) (lessor of Ohio Electric Railway Company), the Lake Shore Electric Railway Company, and the Cleveland and Southwestern Traction Company (now the Cleveland, Southwestern and Columbus Railway Company) use the heaviest type of M. C. B. truck with 7-foot wheel base. Both forward and rear trucks are usually of the same type, each of the four axles carrying a motor. With the increase in the weight of the truck has come an increase in the length of the wheel base. A few years ago the wheel base for trucks for interurban cars was usually about 6 feet, but at the time of this report a usual length of wheel base was 6 feet 6 inches, or 6 feet 10 inches. This has not, however, caused any difficulty in taking curves, but as curves on high-speed interurban roads have been generally reduced, it has been necessary to design the underside of the car so as to provide for the greater swing of the truck. With increase in weight and length there has also come increase in speed, which has tended to increase the diameter of the wheels, since with the larger wheel it is not necessary to increase the speed ratio to attain these higher speeds, and an easier and superior riding effect is believed to be obtainable. The 36-inch wheel is now looked upon as standard by high-speed roads, while some have introduced 37¼-inch, and the Dayton and Troy Electric Railway Company has gone to the extent of using 39-inch on its limited cars. Rolled and forged steel wheels have been introduced and favored on many of these roads, but steel-tired and cast-iron chilled wheels also have their advocates and are frequently to be found.

Owing to the unsuitable tracks and special work encountered at city entrances interurban roads have often been compelled to keep down the size of their wheel flanges. This difficulty has led a number of city roads and city authorities to consider the matter when new tracks have been laid, and the Cleveland Electric Railway Company in its new work has aimed to permit the interurban cars to use flanges 1¼ inches deep, which gives a good margin of safety where steel tires are used. The heavier cars have brought in also heavier axles and larger journals. The Stark Electric Railroad Company (Ohio) with 34-ton cars and 50-horsepower motors uses a 6-inch axle with a 7-inch gear seat; the Scioto Valley Traction Company (Ohio) with heavy equipment uses 6½-inch axles; and the tendency is toward heavier axles. The question of braking has been an important one with interurban cars and has seen many improvements. Straight air brakes are now used almost universally. The Scioto Valley Traction line has its cars equipped with both straight and automatic air brakes to provide for regular train operation; and the Dayton and Muncie line uses a storage air system which is also the practice of the Detroit, Monroe and Toledo Short Line Railway Company (Mich.).

*Gears.*—Solid gears are being used by the majority of interurban roads in Ohio, and the others are adopting them as rapidly as possible, while in this respect interurban practice in Indiana and Michigan is said to have entirely departed from city-car practice. On all the roads visited in 1906 solid gears were used, the use of split gears having been abandoned. The gear and pinion are usually either 5 inches or 5½ inches face, and the diametrical pitch is usually 2½ inches.

*Steel street-railway cars.*—At least as early as 1902 steel street-railway cars developed from the earlier types of car designed for passenger and freight service on steam railroads. The widespread adoption of the steel car, brought to a commercial basis in 1897 in the movement of ore, coal, and other heavy materials, introduced also the steel-underframe car; and early in 1900 the construction of such was begun, so that at the present time steel-underframe merchant cars and all steel coal and ore cars are standard types on most of the great trunk-line systems of this continent. Subsequent to this development came the type of passenger cars in which steel was substituted for wood, as far as economically practicable, and in 1903 these steel underframes were constructed for a number of elevated-railway cars. The question then arose as to whether an all-steel car could be built of little greater weight than the wooden car, and the experiments in this direction have resulted in the use for regular service on elevated, subway, and other lines of all-steel cars, the weight of which compares very favorably with that of wooden cars of the same capacity and dimensions. The process of development brought with it two specific forms of construction, one absolutely fireproof, and the other semifireproof, or noninflammable. The fireproof car necessarily embodies construction in which there is practically no material that will burn, and though it is more expensive in first cost, it is perhaps less so in cost of maintenance. The design of the semifireproof cars involves the steel underframe, permitting the use of cement or other noninflammable form of floor, together with a steel superstructure lined or sheathed with some fireproof material, including noninflammable treated wood. Experience obtained with these various forms of construction shows that the all-steel car costs from 25 to 40 per cent more than the usual wooden type; and the semifireproof car built with steel underframe and with

steel superstructure costs from 20 to 30 per cent more. On the other hand, the life of the steel car is estimated to be at least two or three times as long as that of the wooden car, while in case of accident the steel equipment has superior qualities of safety and resistance, so that, considered from the standpoint of accidents alone, it should save many times its cost in safeguarding passengers in case of collision, etc., and in thus decreasing accident claims. It is a fact of common experience that a great many passengers traveling on the elevated and subway roads, where wooden and steel cars are intermingled in the make-up of trains, seek the steel cars by preference on the sole ground of greater safety.

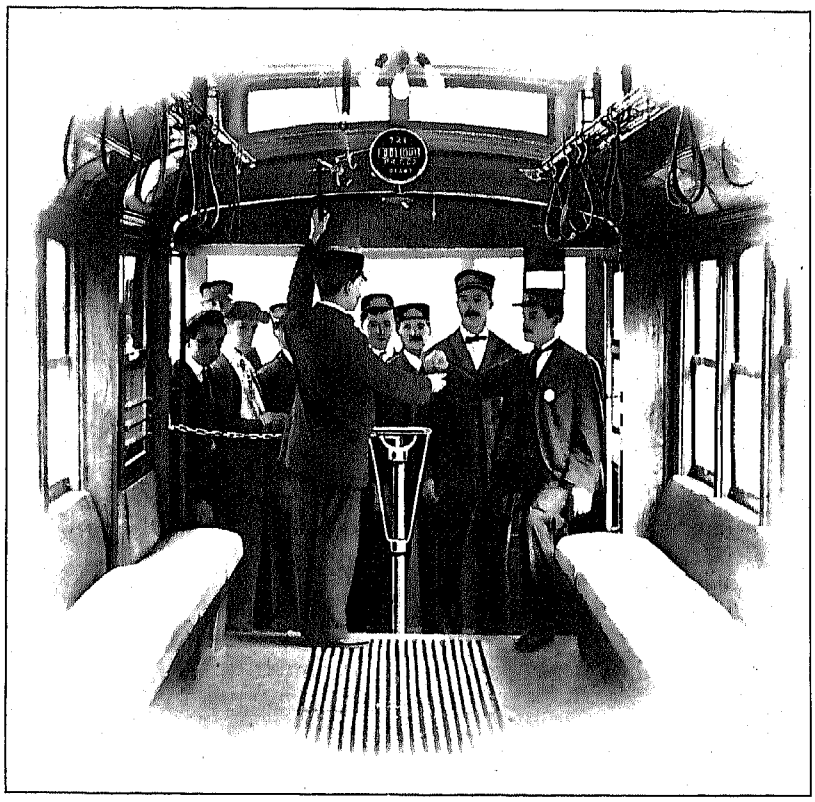
A considerable variety of all-steel cars and of the semifireproof steel cars have already been built for electric-railway work. In a car or two built for the Metropolitan surface lines of the New York City Railway Company no wood at all is used in the construction of the car, except for part of the window sash and for the roof and floor matting strips, and these parts are treated with fireproof compound to render them noncombustible. This car, though of all-steel construction, is modeled so closely after the standard double-truck wooden cars of the New York City surface lines that it is difficult from external appearance to distinguish between the two. The car body is 28 feet long; the over-all length is 37 feet 1 inch; and the weight of the car body with motor and trucks is about the same as that of the wooden type of car. The steel underframe is made of angle-shaped sills, connected by pressed-steel channels. The platforms are built up of four channel members bolted to the body underframe; the floors and the sides are of steel plate; the side posts of channel section continuing from the bottom of the side sill to the top of the eaves. The carlines are bent up from angle steel, continuous from side post to side post, and the side posts are strengthened longitudinally by angle-iron bridge members. The lower set of outside panels, running from the guard rail to the bottom of the side sill, are riveted horizontally under the guard rail and vertically at each post, so that a single panel can be replaced in case of damage. The platform hoods are made of steel plates bent to shape in three sections, riveted at the joints. The seats and backs are formed of sheet steel, pressed to shape, stiffened with angles, and covered with carpet. These seats are held in position by overlapping cleats without the use of bolts, and are removable.

In 1906 some all-steel combination cars were supplied to the United Railroads of San Francisco. They are of the so-called California type referred to in the report of 1902, designed particularly to meet the varying climatic conditions of the region. These cars have a central closed section and front and rear open sections, and one of the problems was to preserve the strength of the car in utilizing the new material. These cars have a length over all of 40 feet 6 inches, the middle closed section being 13 feet 2 inches. The underframe, side sheets, and outside finish to the eaves of the closed section, and the platform posts in the open section, are of steel in the form of rolled or pressed plates. The interior finish, such as doors, windows, sash, and deck moldings, is of wood; and the floor itself is of steel plate covered with one course of wooden flooring, while the lower and upper deck ceilings are of sheet steel. The carlines and purlines are made of rolled angles. The underframe consists of rolled-steel center sills, with a side-sill construction built up of Z-bars and pressed angle plates. The openings for the steps adjacent to the closed section are strengthened by placing reinforced angles along the sides of the step openings, extending past the body bolster.

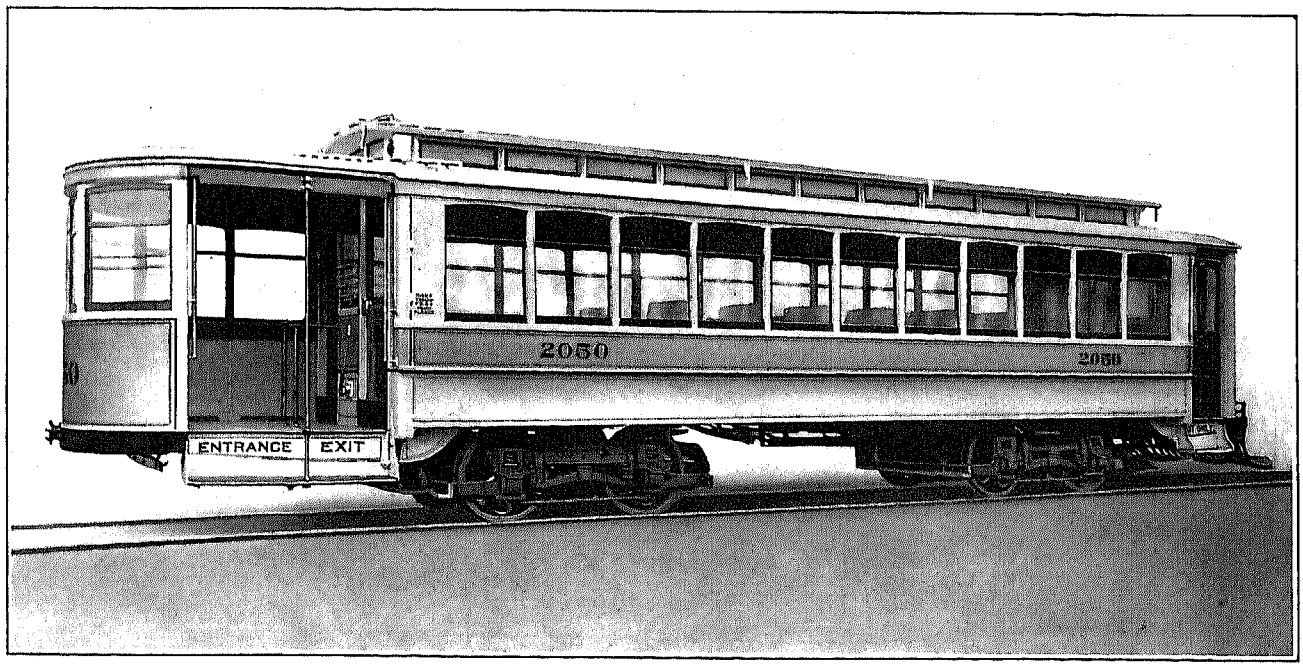
The cars for the Market Street Elevated Passenger Railway lines of the Philadelphia Rapid Transit Company are of steel throughout, with noncombustible flooring composition, and are practically shock proof and fireproof. They have a length over all, including platforms, of 49 feet 7¼ inches. The outside sheathing is of cold-rolled steel, and the longitudinal underframe consists of deep fish-belly side sills of cross bearings and connections in girder form, and is covered with corrugated-steel plates and a monolithic-flooring composition. The interior finish is of mahogany and the roof is constructed of tongued and grooved poplar with canvas covering. The seating arrangement provides 4 longitudinal seats for 9 persons each, and 8 cross seats in the center of the car for 2 persons each, resembling in this respect the type of subway and elevated cars now familiar in this country.

The all-steel cars of the Boston Elevated Railway Company are what is known as the "easy-access" type, and are 46 feet 7½ inches long over platforms, and each provides seating capacity for 48 passengers. The only wood employed in their construction is that in doors and floor mats. The underframe is built entirely of steel; the center sills are made of channel and the end sills of pressed-steel shapes. The car is provided at each end with antitelescoping plates on the top and bottom of the platform supports. The corner and door posts are special shapes of pressed steel and the double posts are T-section metal; the window sills, casings, and sashes are made of steel shapes and all the panels are steel plate, the top plates running the full length of the car; and the steel roof supports are so shaped as to form the camber in the roof. All-steel construction is carried out in the vestibule as well, and the ceilings of these compartments are made of steel plate with an overhead pocket lined with "transite" for the reception of switches. No bulkhead doors are provided, but there is a steel finish at each end of the longitudinal seats, which are formed of steel plates supported by angles bent to shape. A wooden mat is laid upon the monolith floor.

Another type of all-steel car is one built for street surface lines of the Brooklyn Rapid Transit system. It follows in general design the semiconvertible wood



PHILADELPHIA, PA., PREPAYMENT CAR, PLATFORM AND FARE COLLECTION.




TYPE OF PREPAYMENT CAR OF PUBLIC SERVICE CORPORATION, NEW JERSEY.

and steel cars adopted by that company as standard. The steel body has a length over all of 42 feet 6 inches, a total width of 8 feet, and a total weight of 20,460 pounds, which is about the same as that of a wooden car of the same dimensions. The cross seats have a capacity of 48 persons. The car is built with cross framing of 5-inch standard channel beams, with steel side plates fastened to the beams with angles. Steel plates fastened to the cross framing form the base or first course of the flooring, and this is covered with wooden flooring and with the usual center aisle mat.

In 1904 the Interborough Rapid Transit Company of New York City adopted an all-steel car, the first contract being for 200. The general dimensions differed but slightly from those of the wooden car, the total length of wooden cars over body corner posts being 42 feet 7 inches and of the all-steel cars 41 feet 1½ inches, while the length over buffers and drawbars is the same, being in both instances 51 feet 5 inches. The floor framing is made up of two center longitudinal 6-inch I-beams and two longitudinal 5-foot by 3-inch steel side angles extending in one piece from one platform end sill to the other. The end sills are angles secured to the side and center sills by cast-steel brackets and in addition by steel anti-telescoping plates placed on the underside of sills and riveted to them. The floor is of galvanized corrugated sheet iron laid across the sills and secured to longitudinal angles by rivets. This corrugated sheet holds the monolithic fireproof cement flooring, on top of which are attached long floor strips as a wearing surface. The platform flooring is of steel plate, to which a rubber matting is cemented. The side and end frame of the car is composed of single and compound posts made of steel T-angles, while the roof frame is of wrought-iron carlines and purlines. The sides of the car are double, composed of steel plate on the outside riveted to the side posts and belt rails, and lined with electrobestos. The outside roof is of fireproof composite board covered with canvas. The head linings are of fireproof composition faced with aluminum sheets, and the moldings throughout are of aluminum. The wainscoting is of transite board and aluminum, and the window panels and interior finish are also of aluminum, lined with asbestos felt. The seat frames and the cushion frames are of steel throughout. Later steel cars such as those of the Long Island Electric Railway Company and those used in the Hudson tunnels are modifications, with various improvements, of types described above.

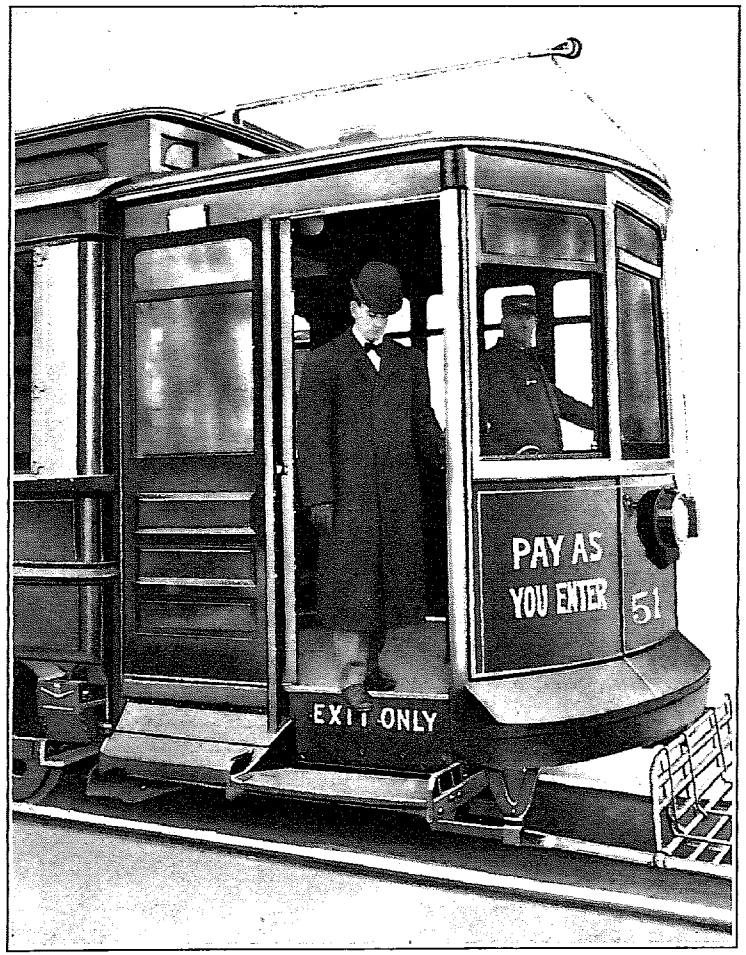
*Pay-at-the-gate cars.*—During the last few years there has been a notable development of cars designed for two distinct and specific purposes, both of which lend themselves to modified forms of construction. One of the purposes was that of reducing the number of accidents in getting on and off cars, and the other purpose was that of introducing a more exact and scientific method of fare collection. It is necessary in discussing such cars to refer to them more or less by name. The "pay-as-you-enter" system originated in Montreal, Canada, and the first cars of that type were placed in operation on the lines of the local street railway in 1904. The principle which governed the design of the first of these cars was that the rear platform should be the pay office of the car—that is, that all fares should be collected on the platform at the moment of entrance to the car by the passengers. Naturally it became necessary that the car should be so arranged that the movement of passengers in and out could be controlled. Hence it was required that every passenger should be compelled to enter the car at the rear and to leave it at the front. The idea has been worked out in various ways, and in the more perfect types the car can be entered by the rear platform only, but exit can be made at either end. A dividing rail forms the passageway from the rear platform step to the entrance door of the car. The conductor stands behind the rail and collects each passenger's fare at the platform before the passenger enters the inclosed part of the car. The front platform is provided with an exit which is at all times under the control of the motorman. The position of the conductor on the rear car is advantageous in many ways. He is able, for instance, to collect the fares of every passenger entering the car, whereas, under the older methods many passengers were unable or unwilling to pay fares in crowded cars, and from 5 to 15 per cent of the earnings were thus lost to the company. The conductor is also able to prevent accidents at the platform steps, not only by assisting passengers to board the car and to alight, but by giving the proper signals to the motorman to start the car only when all the passengers are aboard or have alighted and are clear of the car. In like manner the motorman by his control of the front exit can minimize the chance of accidents at the front platform. The desultory signals by conductors from the interior of the car have always been a prolific source of accidents, and the presence of the conductor within the car has also rendered it difficult to make stops effectively and start up the car again promptly. The conductor has often been dependent upon the good-natured assistance of riders on the rear platform. Another source of delay with the old types of cars has been the conflicting movement of passengers entering and leaving the car, while the separate entrance and exits of the pay-as-you-enter type make it possible to collect and discharge passengers simultaneously and with the minimum of delay. Two general types of cars are found in use—double-end cars, which have the platforms alike, with arrangements whereby the slight changes necessary to establish the control system can be made in a few minutes, and single-end cars, which operate continuously in the same relative direction.

*Effect on fares and accidents.*—Data from various cities are interesting as regards both the collection of fares and the diminution of accidents. Cars of this type were introduced in Chicago in 1907, starting with 100 cars and increasing rapidly since that time. A report by President T. E. Mitten to the mayor of Chicago during 1908 stated that the fatal accidents were 1 to every 4,172,727 passengers carried, as compared with 1 to every 2,596,919 during the same period in 1907. Accidents other than fatal to passengers carried showed a decrease of over 54 per cent as compared with the same period in 1907, with the almost entire elimination of accidents in boarding or leaving the front platform. At Kansas City 5 cars were installed in June, 1908, and the general manager, in his accident report for November of that year, showed as compared with November preceding a decrease of 67.4 per cent in the number of accidents on the division using the cars. In New Jersey the Public Service Railway Company introduced 150 of the cars in April, 1908, increasing the number afterwards to 450, as they found that these cars not only carried the passengers with greater comfort and safety but reduced platform accidents. In Buffalo 50 cars were installed in January, 1908, and increased to 150, because the cars had decreased accidents, alleviated conditions due to crowding, decreased the number of regular cars necessary, increased the speed of the cars, and increased the revenues. Cars of this type are now operated with similar results in St. Louis, Mo.; Portland, Oreg.; Columbus and Cleveland, Ohio; Washington, D. C.; Des Moines, Iowa; Milwaukee, Wis.; Wichita, Kans.; etc.

*Type used in Philadelphia.*—A variation from this type of car is furnished in the cars adopted in Philadelphia, where what is known as the "pay-within" car has been utilized. At first a car called the "pay-as-you-leave" was patented for double-end operation. In this car the entrance was on the front end only and the exit at the rear, passengers paying their fares to the conductor on the rear platform as they left the car. The principal objections to this type were the increased length of platforms to 7 feet 1 inch, making the over-all length of the car 42 feet 2 inches, and the possible difficulty of collecting fares from passengers who had already reached their destination. There was also objection to the position on the front platform of the motorman, who was inclosed in a cab placed at the outside edge against the car-body bulkhead. From this position it was practically impossible for him to observe obstacles which might foul the car on the side next to the "devil strip." None of the plans proposed and thus developed up to the fall of 1907 met with the views of the company's management, and efforts were then renewed to design a car, satisfactory in other respects, into which the company's old standard cars could be converted at a small expense.

The outcome of this last effort was the "pay-within" car, which embodies not only the prepayment plan of fare collection, but the use of pneumatically operated sliding doors and folding steps designed to prevent accident in boarding and alighting. In this car, which is now in general use in Philadelphia, the entrance is from the rear platform only, and exit from the front platform, or—in emergencies—past the left side of the conductor on the rear platform. There is no bulkhead on either end of the car body, the entrance from the platforms being entirely unrestricted, except a center post on the rear platform, against which the conductor stands facing the rear of the car. In the top of this center post are the operating valves for controlling the movement of the doors and steps of the rear platform, while the door and step at the front platform are controlled by an air valve operated by the motorman and mounted alongside the brake air valve. The conductor, standing on the raised floor of the car body and facing to the rear, also commands a view of the platform and the rear steps. Passengers as they enter go to the conductor's right and pay their fares as they pass into the body of the car, receiving transfers or exchange tickets only at the time of paying the fare. The conductor does not leave his post, except in emergencies. The entrance and exit openings of the rear and front platforms, respectively, are closed by the pneumatically operated sliding doors, which move back into pockets formed in the sides of the car body. The platform step is interlocked with the door, so that when it is closed the step is folded up behind the platform sill, leaving no foothold whatever for a person who attempts to enter the car after the doors are closed. The bumper beams also are sheathed with sloping sheet-steel covers, so that there is no possible place for persons to ride on the outside of the car, inviting accident. The Philadelphia Rapid Transit Company, aside from advantage to itself, believes that in the introduction of this car it has provided one that is more comfortable, that reduces the overcrowding and shoving, insures better ventilation, with greater warmth and more coolness, according to the season of the year, and which materially lessens any possibility of accidents. In fact, the reduction in the number of accidents has been very gratifying, while regular passengers on the line have learned quickly to adapt themselves to the new system. The trainmen also are pleased with the improvement. Both conductor and motorman are completely inclosed from the weather. The conductor is relieved from worry about preventing accidents on the rear platform and his duty is accomplished with much less physical effort. In like manner the motorman is relieved from anxiety in watching the front step to prevent passengers from jumping off before the car has stopped. As to the effect on the collection of fares, receipts on lines equipped with these cars have shown an increase of about 8 per cent over a corresponding period of the previous year.

PREPAYMENT CAR USED IN BUFFALO, N. Y.—METHOD OF ENTRANCE.




PREPAYMENT CAR USED IN BUFFALO, N. Y.—METHOD OF EXIT.

*Car fenders and wheel guards.*—The statistical data on fenders and brakes will be found in Chapter IV (Part I) on Track and Rolling Stock, from which it will be seen that the use of fenders is very general. These data include wheel and truck guards. The data given in Table 44 show also a very large increase in the use of air brakes during the census period, due obviously to the resort to larger cars which are too heavy to be stopped quickly in a short distance by means of hand brakes. It will be noticed that a large number of cars are furnished with both styles of brakes as a precaution against the failure of one or the other to operate.

The subject of fenders and wheel guards is one of general interest in connection with street-car traffic, but is necessarily of greatest importance as regards cars operating within city limits. The most exhaustive study given the subject in recent years is that of the Public Service Commission for the first district in the state of New York. During the year 1908 a number of tests were conducted under the auspices of the commission at Schenectady, N. Y., and East Pittsburg, Pa. At the close of the year a report on the subject was presented in regard to which Commissioner Maltbie said that probably no series of tests had ever been made with such thoroughness and with so close approximation to actual conditions, and claimed that with proper fenders and wheel guards the number of fatalities due to the operation of street cars in New York could be considerably reduced. While financial considerations were not the principal thing to be considered, the expense of carrying out the recommendations of the subcommittee making the specific investigation would not exceed $300,000, as against which the companies operating surface lines in New York City had incurred expenses for injuries, damages, and legal expenses during the year 1906–7 amounting to over $3,500,000. According to the commissioner, it was admitted that a considerable portion of this sum could have been saved the companies by the introduction of proper fenders and wheel guards.

The report of its electrical expert as adopted by the commission recommended that all cars throughout Greater New York be equipped with automatic wheel guards, and that in a large section of Brooklyn, as well as in the boroughs of Queens, Richmond, and the Bronx, the cars be equipped with protective fenders as well. The investigation included 1,800 tests, during which no fewer than 38 fenders and 29 wheel guards were made the subject of rigorous experiment, dummies being used on the tracks to show the effect on limbs and body. No particular fender or wheel guard showed such efficiency as to warrant its preference over all others, but the tests indicated that many of them were superior to those already in use and less expensive to maintain.

The various devices submitted for test were designated in the report in a classification which follows, and which may well be accepted as a summary of the apparatus available at the time of the present census report:

PROJECTING FENDERS.

*Nonautomatic.*—A fender carried in a fixed position at a height above the track, predetermined, according to the characteristics of the permanent way.

*Automatic.*—A fender carried as close to the track as the characteristics of the permanent way will allow, and dropped to the track by a projecting piece in front of the fender coming in contact with the object to be picked up. This actuates a trip which may be either mechanically or air operated.

*Platform trip.*—A fender carried normally as close to the track as the permanent-way conditions will permit, and dropped to the track by the motorman actuating from the platform a mechanism which drops the fender (ready to pick up an object).

*Shearing-projecting type.*—A fender carried in a fixed position above the track, at a height predetermined, according to the characteristics of the permanent way. This type of fender embodies the characteristics of the steam-locomotive pilot with the triangular frame, the sides of which are intended to shear the object clear of the track.

WHEEL GUARDS.

*Automatic (mechanical drop).*—A wheel guard, the apron of which is carried as close to the track as the characteristics of the permanent way will allow, and which is forced to the track by a compression spring or other mechanical device, being released by the object to be picked up coming in contact with a trip which actuates the release mechanism.

*Automatic gravity drop.*—The characteristics of this type of wheel guard are the same as those of the automatic mechanical drop, with the exception that the apron, on being released, drops to the track by gravity.

*Platform trip.*—A wheel guard, the apron of which is carried as close to the track as the characteristics of the permanent way will allow and dropped to the track by the manual operation of a platform-actuated mechanism, including the compression-spring effect, as well as a platform-resetting feature. This method of operation is usually supplemental to the automatic feature of this type of safety device.

*Shearing-automatic (mechanical drop).*—A wheel guard, the triangular frame of which embodies the characteristics of the steam-locomotive pilot. The frame is carried on the pilot board or car sills, at a predetermined height above the track dependent upon the characteristics of the permanent way, and is forced to the track by a compression spring or other mechanical device upon being released by the automatic tripping mechanism coming in contact with the object to be removed from between the rails.

*Shearing-automatic (gravity drop).*—The characteristics of this wheel guard are similar to those of the shearing-automatic (mechanical drop) with the exception that the frame on being released drops to the track by gravity.

*Shearing nonautomatic.*—The characteristics of this wheel guard are similar to those combining the automatic features, with the exception that in this case the frame is carried in a fixed position from the pilot board at a predetermined height above the track dependent upon the characteristics of the permanent way.

# CHAPTER II.

## FARES AND TRANSFERS.

A discussion will be found in Chapter V (Part I), Traffic, of the data connected with the relation of population and passenger business, and with the adequacy of service and the income yielded. Before passing on to the subject of fares and transfers, it may be pointed out that the tables relative to physical equipment in Chapter III of Part I reflect the installation and use of much larger plants. Thus the generator capacity of 898,362 kilowatts in 1902 for the operation of a total of 66,784 cars showed a provision of 13.5 kilowatts per car. In 1907 the plant of 1,723,416 kilowatts for 83,641 cars of all kinds showed a provision of not less than 20.6 kilowatts per car, a very marked increase, which is explained in part by the resort to heavier cars of much greater carrying capacity, requiring more energy to move them. It should be remembered in connection with these figures that not all of the generator capacity can fairly be compared with the number of cars, since part of the output is sold for commercial light and power purposes. The statement that the cars actually required more propelling current per car mile is borne out by the statistics in Table 21, which show that the kilowatt consumption per car mile for railways that do not buy or sell current increased from 2.14 in 1902 to 3.26 in 1907. Part of this notable increase may be due to increased haulage of freight; but most of it results from the use of heavier, bigger rolling stock. Eliminating the freight mileage, it is found that in 1902 the 60,290 passenger cars made 1,120,101,944 car miles, or 18,579 car miles per car per annum. In 1907 the 70,016 passenger cars made 1,583,831,199, or 22,621 car miles per car per annum. The increase in car mileage per passenger car is obviously much below the increase in consumption of power. This change to heavier rolling stock, and the enforced increase in facilities for keeping it in motion, as well as the larger consumption of current in doing so, offer a partial explanation of the increase in net income of only 31.8 per cent in the period as compared with a gain of 68.9 per cent in the earnings from operation; and it is to be observed in this connection that the increase in operating expenses was 76.6 per cent.

Of the 9,533,080,766 passengers carried, 7,441,114,508 paid full fare for the trip; 1,995,658,101 were carried on transfers; and 96,308,157 rode free. The transfers were issued at 7,376 transfer points. Table 51 shows 4.70 fare passengers per car mile, while Table 187 shows 43.06 fare passengers per car hour; but this latter figure may be defective because of the comparatively rare use made of the car-hour unit by the systems reporting.

*City fares.*[1]—The miscellaneous income, not from operation, of operating street-railway companies is so small—less than $12,000,000 out of $429,000,000—that it is vital to the companies to protect their fare systems in every way and to render them as productive as possible. But there is still a wide variety of opinion and practice in dealing with this subject. Fares may be broadly divided into two groups, urban and interurban, but the suburban travel introduces also a number of varieties and local permutations. The standard practice on all the urban street-railway systems of the United States, as is well known, is to charge 5 cents as the unit cash fare for one continuous ride within the corporate limits of any city or town regardless of the length of the ride; and this applies equally to elevated roads, subways, and even to tunnels under rivers, such as that under the Hudson, between Manhattan Island and New Jersey. Very recently a few companies in Massachusetts raised their fares to 6 cents, on demonstrating their inability to continue in operation and give good service for anything less. In Cleveland the attempt to reduce the unit rate of fare to 3 cents resulted in bankruptcy, as noted in the chapter on franchises. As a matter of fact, the remarkable increase in all operating costs and prices of material has led to considerable discussion among street-railway companies as to a general increase in fare, and a restriction of processes that go on reducing the fraction which the corporation receives of the normal 5-cent fare—in itself a very convenient unit from various points of view, and still regarded by managers as preferable within cities to any fare based on a complicated system of zones with tickets and expensive inspection. The objections to the zone system are not, however, regarded as applying to interurban and suburban travel where the zone is very generally recognized, if the word be taken to cover somewhat more arbitrary boundaries than those employed in Europe with almost scientific regularity.

In several cities the 5-cent fare is reduced to 4 cents, if the passenger purchases tickets or tokens in quantities. The Indianapolis Traction and Terminal Company and the Milwaukee Electric Railway and Light

[1] See also "Rates of fare," p. 294, Ch. V of this part.

Company sell 6 tickets for 25 cents and 25 tickets for $1. Conductors are supplied with strips of both kinds of tickets. The Springfield (Ill.) Consolidated Railway Company sells 6 tickets for 25 cents on cars, and books of 25 tickets for $1 are sold at the company's general office. The ticket books are purchased in moderately large quantities by merchants and others who sell them to customers at cost as an inducement for trade. In Indianapolis 85 per cent of the gross passenger revenue is derived from ticket sales, and the sales of 25-cent strips are largely in excess of the sales of the $1 strips. In Milwaukee the percentage of ticket sales is almost as large, being approximately 80 per cent. Ticket sales in Springfield, Ill., aggregate 25 per cent of the total revenue. The Albany and Hudson Railroad Company sells 24 tickets for $1, good on the city lines in Hudson. In Spokane, Wash., the city lines of the Spokane and Inland Empire Railroad system sell 22 tickets for $1. In Auburn, N. Y., the Auburn and Syracuse Electric Railroad Company does the same thing, to the extent of 5 per cent of its total revenue. Syracuse, N. Y., sells 20 tickets for $1. Springfield, Mass., sells a 20-ride ticket for $1 and a 100-ride ticket for $5, the yield representing 6 per cent of the total passenger income.

The attempts made to force the companies to collect only a 5-cent fare for extreme distances, based on the argument that the broadening of city areas has brought a larger territory within the legal scope of such a rate, have not been generally attended with success. Thus a double or 10-cent fare between Brooklyn, N. Y., and Coney Island has been upheld as legal by the courts. The New York Public Service Commission of the First District made a similar ruling as to a fare of 10 cents collected by the Brooklyn Heights Railroad Company, on the ground that the rate was neither illegal nor unreasonable. The case is of general interest. The Flushing Association alleged that the company charged a second fare of 5 cents to passengers traveling in each direction between Ridgewood and Flushing, and maintained that such extra charge was illegal and in violation of the terms of the company's charter. In its answer the company denied the allegation of illegality and maintained that its franchises expressly authorize a fare of at least 10 cents, that such fare is reasonable, and that a reduction would involve such a loss as to be confiscatory. The opinion of the commission said:

> The fact that one may ride 20 miles for a single fare results from the elaborate system of transfers, some of which are made mandatory by the railroad law and some a voluntary arrangement between distinct though affiliated companies of the Brooklyn Rapid Transit system. The fact that combinations of these compulsory and voluntary transfers make possible a ride of 20 miles for 5 cents, does not in itself constitute a sufficient legal reason why the Flushing-Ridgewood line should be operated to its terminus for 5 cents. The evidence shows that the Long Island Railroad station is within a stone's throw from the terminus of the defendant's line at Flushing, and that in the morning rush hours the steam-railroad platform is covered with people waiting to go to Manhattan by the steam trains at 20 cents fare, while the defendant's trolley cars start out from the same point not more than one-half filled. It is therefore apparent that one reason why people do not travel more on the defendant's cars is because of the long time consumed in proceeding the 12 miles to the Brooklyn Bridge. There is no reason to believe that a reduction of fare would cause such an increase of business as would wipe out the deficit.

There are several types of fare for adults that are different from those afforded under the 5-cent system or the average ticket system, such as rates for workmen, postmen, etc. On one road, tickets under the workman designation are sold at $2 per 60 and are good for working girls, but carry no transfer privilege. In another instance books of 50 tickets sold at $1.50 are good from 6 to 8 a. m. and from 5 to 7 p. m. In another instance such tickets are good from 5 to 6.30 a. m. and from 4.45 to 5.45 p. m. In a third instance 8 tickets are sold to workmen for 25 cents, good from 5.30 to 7.30 a. m. and from 5.30 to 6.30 p. m. In several cases the tickets for postmen are subject to a discount of 50 per cent, often without any restrictions, but in some instances they must be purchased in strips of 20, while in others the users are required to be in uniform. It is a common requirement of city ordinances and franchises that municipal employees in uniform or badged shall be transported free, on the assumption that they are on duty. A variety of other cases appear where the 5-cent fare is reduced for one reason or another. In one instance clergymen are carried at half price—2.5 cents; and in another the privilege is extended to soldiers. One road reports the use of tickets sold in lots of 100 for $3.75, with a 90-day limit.

In one or two cities it has been a practice to issue tickets in lots of 150 for $2.50, good for merchants only, and, as a stimulus to trade, passengers are often able to travel free to or from a given store, the proprietor of which provides his customers with tickets bought in large quantities from the local company. An ingenious development of this practice of combining trade and traffic has been worked out, chiefly in New England, through the use of redeemable cash-fare receipts. The street-railway companies have nothing to do with the redemption of the receipts, which is arranged for by local merchants, who give cash refunds on cash purchases of $1 or more. In general, the refund is equivalent to the amount of car fare paid. An additional feature of the scheme is the award of cash prizes monthly to collectors of the fare receipts. The basic principles of the redeemable-fare receipt system, which naturally finds its best application in interurban work, are illustrated by the 5-cent fare receipt in use on the Norwich and Westerly Railway, a 24-mile interurban line in eastern Connecticut. This road is divided into seven 5-cent fare zones. Passengers upon entering cars at intermediate stations pay their fare through to a destination, and receive in exchange the proper number of 5-cent fare receipts, each

consisting of a transportation coupon with a redemption certificate attached. One coupon is collected and rung up at each fare limit, but the passenger retains the redemption certificate. Each of these 5-cent redemption certificates entitles the holder to a cash refund of 5 cents on any purchase of $1 made within ten days of date of issue at any one of the 26 stores in Norwich or Westerly listed on the back of the certificates. The passenger does not surrender the redemption certificate when redeeming it at a store, but after presenting it for cancellation retains it to send it at the end of the month to the company printing and issuing it in competition for cash prizes to the value of $75 each month. The scheme involves none of the features of a lottery, as the prizes are awarded to the persons sending in the largest numbers of redemption certificates, whether canceled or uncanceled.

A variation of this method is introduced in a strictly city system, where a single 5-cent fare is charged and transfers are issued. The Cape Girardeau-Jackson Interurban Railway Company has the redemption plan with prizes, as in the case of the New England companies referred to, but one purpose of the ticket is to decrease transfer traffic. Each passenger paying cash fare receives one of these fare receipts, which is good as a transfer if one of the intersecting lines on the receipt is punched, but this punching renders the receipt "not redeemable and not eligible for prizes," as is indicated on the reverse side by the punch mark. This provision is also counted upon to influence passengers to refrain from asking for transfer privileges for other than their own personal use. These redeemable-fare receipts are not issued to passengers who present in payment of fare tickets which are sold 6 for 25 cents. This particular form of fare receipt has therefore a fourfold purpose—stimulation of traffic, substitution of cash for ticket traffic, decreasing transfer traffic, and checking up conductors.

It will be seen from the above data that tickets are by no means unusual in street-railway operation within cities, although they find their widest application outside city limits. The extending use of "prepayment" cars, in which the fare is paid as the passenger enters, makes it particularly noteworthy that the experience of the past few years tends to show that to secure better results from this system tickets might be employed. The delay in making change at the vestibule not only slows down the schedule, but keeps people standing in the roadway barred from mounting by the crowd in front waiting for change. Thus the street traffic is also hampered, whereas the use of tickets might lessen, if not wholly eliminate, the troubles. At present New York City is a typical case of this kind, as the street railways are without a ticket system, except as applied to transfers.

Tickets for children, another example of the reduction of the unit fare of 5 cents, are issued on a large scale, although children can often travel at a reduced fare without ticket, or free, depending upon age. The ages at which reductions became operative vary greatly, as do the "fare-free" ages. On some roads no fare is asked for children under 8 years; on others the limit is as low as 2. The ages at which full fare is required generally range from 3 up to 12, though one instance of 14 is noted. These conditions apply in the case of cash fares. School and children tickets are issued in large quantities, yielding for the former, in the case of some two score companies giving data, an average rate of 3.02 cents and for the latter, in the case of 8 companies, 2.62 cents. Speaking broadly, it may be said that the 5-cent rate is cut in two, but there are many interesting variants. School tickets, subject to the rule that they are good on school days only, range in price from 2.5 cents to 4 cents. The 4-cent tickets are sold in lots of 25, and the road issuing them also issues a "students' commutation" ticket at $3.75. In one instance tickets are issued at 2.5 cents in lots of 50 for "school children under 18," for use between 8 a. m. and 5 p. m., while in another case, at the same price, the number is 20 or 40, and the age is 17. Most roads issue the tickets only on receiving a certificate from the principal of the school. On one road the coupon book of 50 tickets, not transferable, is good for one year; but in another case the tickets have to be used up during the month purchased, and on school days between 7 a. m. and 6 p. m. One rate in use is 33 tickets for $1, but the conditions vary, and there is a notable absence of standardization in the practice of the companies in dealing with this matter.

*Interurban fares.*[1]—The rates of fare charged on interurban electric railways vary greatly. In several states which have enacted 2-cent-a-mile fare laws, such as Illinois, Indiana, and Ohio, the basic rates naturally do not exceed the legal limit, and in other states, as a general rule, the basic rates are from 1¼ cents to 2½ cents. It may be said that ordinarily the rates are a little lower than steam-railroad rates, and these lower rates, together with the greater frequency of service, are the chief reasons why so many steam railroads paralleled by electric railways have lost to them, at least temporarily, so large a proportion of their local patronage. Where special facilities are afforded, as for example on the "limited" trains with a limited number of stops on the trip, it is customary to charge an extra fare, as is the practice on steam railroads. On the Terre Haute, Indianapolis and Eastern Traction Company the average one-way fare is 1.7 cents per mile, the average round-trip fare is 1.6 cents per mile, but an excess is charged for limited trains of 5 cents for every 20-mile section or its fractional part. The Aurora, Elgin and Chicago Railroad Company charges no excess fare on its "limited" trains, but it runs several parlor buffet cars, for which an excess of 15 cents is charged. On these cars light refreshments

[1] See also Table 170 and accompanying text, in Ch. IV of this part.

are served, and the 15 cents excess is credited against any such purchase made on the trip. In Ohio the Lake Shore Electric Railway Company charges 1.8 cents for one-way local fare, with 10 per cent reduction on round-trip tickets and 1¼ cents for commutation tickets. Its mileage books are sold at 1.6 cents per mile. It makes no extra charge for "limited" travel.

In the far West, where steam-road rates have always been high, basic rates of 2½ cents and even higher are in force. The Spokane and Inland Empire Railroad Company has a rate of 2½ cents per mile on its Spokane and Inland division, but on the Coeur d'Alene division the basic rate is reduced to 2 cents a mile. This company makes no extra charge for limited trains, but it runs chair cars on these trains, for which an extra charge of 25 cents a seat is made. On round-trip tickets it makes a reduction of 5 per cent. It sells a book containing coupons representing $20 worth of one-way fares for $16 and also books of commutation and school tickets at the rate of 1¼ cents per mile. The Pacific Electric Railway Company on some of its scenic routes charges as high as 8 cents per mile. The reason for this is the high cost of constructing and operating such lines as the section of the Alpine division, which reaches the top of Mount Lowe, 21.3 miles from Los Angeles. The one-way fare for this distance is $1.75 and the round-trip fare is $2.50. The rates on some of the other lines of this company, as, for example, between Los Angeles and Pasadena, are as low as 1¼ cents per mile.

The basic rates of interurban companies operating in New York and Pennsylvania are generally lower than those used by the interurban roads in the Middle West. The Utica and Mohawk Valley Railway, the Auburn and Syracuse Electric Railroad companies, and the Oneida Railway all use 1½ cents as a basis for one-way local fares, as does also the Lackawanna and Wyoming Valley Railroad Company. The Rochester, Syracuse and Eastern Railroad Company and the Albany and Hudson Railroad Company, however, use 2 cents. None of these roads charges excess fare on any train. The interchangeable mileage book used by the companies named which operate in the state of New York contains coupons for 500 miles and is sold for $6.25. The Lackawanna and Wyoming Valley Railroad Company sells a mileage book at the same rate. The Auburn and Syracuse Electric Railroad and the Rochester, Syracuse and Eastern Railroad companies sell commutation tickets at rates as low as ⅔ cent per mile.

Interurban roads, like city lines, issue school tickets, workmen's tickets, etc., subject to such reductions as have already been noted, and they have also a variety of miscellaneous rates and tickets for round trips, commutation, etc. Where reductions are made it is often a condition not to check baggage free, but to charge extra for it or to limit it closely. Commutation tickets are frequently sold on a liberal basis. One instance is noted of tickets in books of 100, 200, and 400 coupons of 5 cents each, at 15, 25, and 32 per cent discount to the purchaser and his family. On the Boston and Worcester Street Railway student tickets are sold in strips of 10 for 25 cents, or 50 per cent reduction, upon the certificate of the principal of the school. The Spokane and Inland Empire Railroad Company sells school tickets at 2½ cents each.

It is now the custom of the interurban lines to use tickets, but the practice is not universal. One may ride for two or three hours on some New England lines, such as those in the Berkshires, without purchasing a ticket, as, for example, from Pittsfield to North Adams or Williamstown; or from Springfield to Huntington. But it is recognized that the use of tickets aids in the collection and protection of income and helps the auditing department. On some lines an excess rate is charged for cash fares collected en route, to prevent passengers from entering the cars without first buying tickets at the stations. This excess charge is 5 or 10 cents, and in some cases is returned on presentation of the cash receipt. A great variety of tickets have come into use, usually in coupon sections, to match the divisions traversed, and many of the roads employ a duplex form as an audit check. Hat checks are used on some lines which carry both local and through traffic, where it is hard for the conductors to remember and identify passengers. The most original form of token or ticket used in this country is the small aluminum disk with a hole in it, like a Chinese coin, employed by the Municipal Traction Company in Cleveland as an equivalent to the 3-cent fare. This token virtually adds to the small currency in circulation in the community for trade purposes. Such tokens are not generally approved of by street-railway managers, as they are liable to be counterfeited on a large scale, and detection would be difficult.

*Transfer traffic.*—As noted elsewhere, 944 of the 945 operating companies reported the number of passengers, and 522 of them, or 55.3 per cent, issued transfers. These figures are in themselves a striking proof of the extent to which transfers are used. The vast majority of these transfers are issued free. The transfers are, of course, duplicates of fares, and their number would indicate that they were issued to 26.8 per cent of the fare passengers. The data in Table 187 show the New York City Railway Company with a proportion as high as 51.7 per cent. In Nashville, Tenn., an apparent ratio of over 50 per cent exists. This particularly high ratio results from the fact that in Nashville all the cars run into a central transfer station, a little out of the business center of the city, and a large part of the transfer passengers come from lines which do not pass through the business district in entering the transfer station. The transfer passengers ride an extra block or two to reach their destination after leaving their original car, in a manner

analogous to that in which transfer passengers from the shuttle trains on the Third Avenue Elevated in New York ride on the line to the Grand Central Depot and the Long Island Railroad.

A few years ago street-railway managers in general were enthusiastic over transfers because of their effect in building up traffic, but an entire change of opinion has resulted from the inordinate expansion of the system. Now it is being subjected to various checks devised to keep it within reasonable limits.

The open abuse of the free-transfer privilege has led to much legislation attempting to penalize and minimize dishonesty on the part of passengers and others. Chicago furnishes one of the most interesting cases in point. There hundreds of men, women, and children rode on the cars every day with transfers picked up or purchased in the street or in stores. At one point alone, according to a statement made by witnesses in court, each of a dozen newsboys had an income of from $1 to $3 per day through the sale of these slips. There were about 100 points where, during the morning and evening rush hours, these slips were exchanged or sold. Numerous factories were discovered where employees traded transfers on the premises in the morning and secured others for the return trip in the evening.

The ordinance governing the use of transfers issued by street-railway companies in Chicago was supposed to be broad enough to give ample protection against such trafficking, and in one important case the claims of the city and the company as to its validity were sustained in the supreme court. The law provides a penalty of from $5 to $100 for each offense of giving away, receiving for improper use, selling, bartering, or exchanging these slips. But the company did not always have full support in its efforts to check these abuses, until with the passage of the franchise ordinance under which the company now is operating, the city became a partner in the receipts. A change in the attitude of the public, the police, and the courts was soon apparent. The misuse of hundreds of thousands of transfer tickets every day was seen to be an important item, and the evil was taken firmly in hand. Warning of the penalty was given on the reverse side of the transfers, newspaper publicity was called in aid, and investigators were detailed to locate the points where violations of this ordinance were most numerous, and to report to the police department. Officers in plain clothes, accompanied by several investigators, began a series of raids under the direction of the company's secret-service and legal department; junction points were visited, and whenever arrests were made the patrol wagon was brought to the spot to make the raids more impressive. Many of the offenders were small boys and they were either taken to the juvenile court to be reprimanded or to their parents for prompt punishment. It was a rare case when the same boys had to be taken into court for severe punishment on a second charge. In nearly every case where adults were arrested for purchasing, giving away, or picking up transfers a conviction and fine were secured. When, as occasionally happened, the defendant was a business man of some prominence, the publicity in the daily press was something feared more than the fine. As a further step in the campaign, concerns employing large numbers of men were asked to aid in checking violations of this ordinance. For the most part they agreed cheerfully, and as a result placards were distributed and posted in many factories and stores warning employees against misuse of transfers on the premises, and quoting the section of the city ordinance under which prosecutions were threatened. These cards, printed in English, German, and Polish, bore the signature of the firm or corporation in whose place they were posted. Other notices prepared for display in the cars were worded practically the same as the reverse side of the transfer slips. Employees of the company were also asked to give information as to points where they discovered misuse of transfers, and conductors were forbidden to leave their transfers at any place where they might tempt improper use. The company and the city have both profited by the crusade.

*Registering fares.*—The use of fare registers on city cars is universal, and the registers are supplemented by systems of inspection and supervision at terminals or en route. Many of the city lines also register transfers as well as cash fares. The companies that register transfers and sell tickets usually have one dial for cash fares and another for all tickets. The New York City Railway Company does not register transfers, but the Brooklyn Rapid Transit system does. Other large roads registering transfers are the Detroit United Railway, United Railways Company of St. Louis, Indianapolis Traction and Terminal Company, and the Twin City Rapid Transit Company. It is believed that the whole business of a company is thus brought to a much stricter account.

The practice of interurban roads in registering tickets and cash fares presents some features of interest. Some companies use an indicating and recording register and ring up all cash and ticket fares collected, including mileage. Some use a register for city fares only. The Western Ohio Railway Company uses an indicating and recording register on its local cars, but on its limited cars uses no register of any kind. The Terre Haute, Indianapolis and Eastern Traction Company uses registers on some divisions, but on other divisions has its conductors make up their trip reports from tickets collected and the stubs of the duplex cash-fare receipts issued. The Boston and Worcester Street Railway Company uses two single registers in each car. On branch lines one register is used for recording cash fares collected in each zone and the other for recording tickets and transfers received. On the main line one register is used for recording all through tickets between Boston and Worcester, and the other records cash and local-ticket fares between intermediate points.

# CHAPTER III.

## USE OF ELECTRICITY BY STEAM RAILROADS.

*Classes of roads affected.*—One of the most notable and important developments of the census period 1902 to 1907 was the adoption of electricity on steam railroads. Previous steps in this direction had been tentative and almost entirely in the direction of substituting electricity for steam on elevated railroads within city limits. Now, however, main or trunk lines of steam railroads have entered the electric-traction field with definite purpose, so that the question no longer is one of the mere adoption of electricity, but rather of how far the new motive power can or will be substituted for the old. The classes of steam railroads affected by this momentous change are broadly three in number: (1) Electric divisions of steam railroads; (2) mixed steam and electric railroads; (3) electric railways owned and operated or controlled by steam railroads and treated as separate units in the general organization.

Roads of the first and third classes are included in the general tabulation of street and electric railways, but in order to make the statistics for 1907 comparable with those of 1902, the mixed steam and electric roads which form the second class have been included only in the general tabulation for 1907, in which tabulation they were included in the census of 1902.

The following list shows the roads of the first and second classes thus included in the general tabulation for 1907:

*Electric divisions of steam railroads and mixed steam and electric railroads included in the census of 1907.*

| STATE. | Class. | Name. |
|---|---|---|
| California | 1 | Coronado R. R. Co. |
| Colorado | 1 | Denver and Inter-Mountain Ry. Co. |
| Colorado | 2 | Colorado Springs and Cripple Creek District Ry. Co. |
| Connecticut | 2 | New York, New Haven and Hartford R. R. Co. (New Canaan branch).[1] |
| Illinois | 2 | Peoria Railway Terminal Co. |
| Massachusetts | 1 | New York, New Haven and Hartford R. R. Co. (Nantasket division).[1] |
| New Jersey | 1 | West Jersey and Seashore R. R. Co. (Camden and Atlantic City branch).[1] |
| New Jersey | 1 | West Jersey and Seashore R. R. Co. (Atlantic City and Longport branch).[1] |
| New Jersey | 2 | Cape May, Delaware Bay and Sewell's Point R. R. Co. (Reading Railroad). |
| New York | 1 | Fonda, Johnstown and Gloversville R. R. Co. |
| Rhode Island | 1 | New York, New Haven and Hartford R. R. Co. (Providence, Warren and Bristol branch).[1] |
| Virginia | 1 | Norfolk and Southern Ry. Co. (Virginia Beach division).[1] |

[1] No financial data—could not be separated from steam-railroad accounts.

Among steam and electric railroads of the second class, not included in the census tabulation, are the following:

| STATE. | Name. |
|---|---|
| California | Northwestern Pacific R. R. (North Shore R. R., electric division). |
| California | Los Angeles and San Diego Beach R. R. Co. (electric division). |
| New Jersey | Hoboken Manufactures R. R. (Hoboken Railroad, Warehouse and Steamship Co., lessor). |
| New York | New York, New Haven and Hartford R. R. Co. (New York division). |
| New York | Long Island R. R. |
| New York | Bush Terminal R. R. Co. |
| Ohio | Cincinnati, Georgetown and Portsmouth R. R. Co. |
| Ohio | Felicity and Bethel R. R. Co. |
| South Dakota | Chicago, Burlington and Quincy R. R.—Deadwood (S. Dak.) Central R. R. |

Some examples of the third class, namely, electric railways owned or controlled by steam railroads and operated as separate units, are the following:

| STATE. | Name. |
|---|---|
| Connecticut | New York, New Haven and Hartford R. R. Co. (street-railway department operated by the Connecticut Company). |
| Illinois | Coal Belt Electric Ry. Co. (owned by Missouri Pacific R. R.). |
| New Hampshire | Portsmouth Electric Ry. Co. (owned and operated by Boston and Maine R. R. Co.). |
| New Hampshire | Concord and Manchester Electric Branch of Concord and Montreal R. R. (owned by Boston and Maine R. R. Co.). |
| New Jersey | Ocean Street Passenger Ry. Co. (owned by Reading R. R.). |
| Ohio | Wellston and Jackson Belt Ry. Co. (operated by Hocking Valley Ry. Co.). |

Closely allied with the third class of electric railways owned or controlled by steam railroads are properties which are thus controlled through the agency of a holding or operating concern and which are operated as separate units. Examples of this class are:

| STATE. | Name. |
|---|---|
| New York | Long Island R. R. (steam).<br>Long Island Consolidated Electric Companies (holding company for several electric railways which are operated as separate units). |
| Massachusetts | New York, New Haven and Hartford R. R. Co. (steam).<br>New England Investment and Security Co. (holding company for a large group of electric railways operated as separate units). |
| Rhode Island | New York, New Haven and Hartford R. R. Co. (steam).<br>Providence Securities Co. (holding company for the electric railways of Providence and vicinity). |

In connection with the general subject of electric and steam railroad traffic the practice of electric railways in leasing tracks from steam railroads is of interest. According to the statistics obtained in 1907, 258.02 miles of track operated by electric railways were thus leased or operated under various agreements. These companies and the mileages are as follows:

*Companies leasing track from steam railroads.*

| STATE. | Name. | Miles of track leased from steam railroad. |
|---|---|---|
| Total | | 258.02 |
| Alabama | Sheffield Co | 0.50 |
| Florida | Amelia Beach Co | 1.00 |
| Illinois | Suburban R. R. Co | 2.00 |
| Illinois | Chicago and Milwaukee Electric R. R. Co | 3.22 |
| Illinois | East St. Louis and Suburban Ry. Co | 2.16 |
| Illinois | Keokuk and Western Illinois Electric Co | 6.14 |
| Illinois | Coal Belt Electric Ry. Co | 1.90 |
| Indiana | Louisville and Northern Railway and Lighting Co. | 4.62 |
| Iowa | Fort Dodge, Des Moines and Southern R. R. Co. | 37.70 |
| Iowa | Waterloo, Cedar Falls and Northern Ry | 20.39 |
| Kansas | Iola Electric R. R. Co | 1.00 |
| Missouri | St. Francois County Ry. Co | 2.09 |
| New York | International Ry. Co | 24.12 |
| New York | Ocean Electric Ry. Co | 0.36 |
| New York | Oneida Ry | 100.82 |
| New York | Schenectady Ry. Co | 11.30 |
| New York | Utica and Mohawk Valley Ry. Co | 12.98 |
| North Carolina | Asheville Rapid Transit Co | 2.41 |
| Ohio | Toledo, Port Clinton and Lakeside Ry. Co | 2.00 |
| Pennsylvania | Pottsville Union Traction Co | 3.40 |
| Pennsylvania | Lackawanna and Wyoming Valley R. R. Co | 1.78 |
| Pennsylvania | Wilkes-Barre and Wyoming Valley Traction Co. | 0.50 |
| Virginia | Norfolk and Portsmouth Traction Co | 0.32 |
| Virginia | Virginia Passenger and Power Co | 3.12 |
| Washington | Puget Sound International Railway and Power Co. | 6.19 |

As far as electric railways are in control, it is evident that the greater portion of this trackage is operated exclusively by electric power. In some instances, however, the steam railroads do not surrender entire possession of the track to the electric railways, and hence a certain but unknown amount of such trackage is operated by both steam and electric motors of one kind or another.

At the census of 1907 the electric railways reported a total of 105.06 miles of track operated by steam motive power. This total mileage is itemized by companies as follows:

| STATE. | Name. | Miles of steam trackage. | Used also for electric traction. |
|---|---|---|---|
| Total | | 105.06 | |
| Alabama | Birmingham and Gulf Railway and Navigation Co. | 11.00 | No. |
| Indiana | Evansville Suburban and Newburgh Ry. Co. | 3.25 | No. |
| Iowa | Waterloo, Cedar Falls and Northern Ry. | 20.39 | No. |
| Massachusetts | New York, New Haven and Hartford R. R. Co. (Nantasket division) | 0.43 | |
| Nebraska | Sioux City, Crystal Lake and Homer Ry. Co. | 4.50 | No. |
| New York | South Brooklyn Ry. Co | 2.05 | |
| North Carolina | Laurel Park Street Ry. Co | 1.50 | No. |
| Ohio | Ohio Electric Ry. Co | 42.00 | No. |
| Pennsylvania | Philadelphia and Western Ry. Co | 0.33 | |
| Pennsylvania | Pittsburg Railways Co | 8.06 | |
| Pennsylvania | Mt. Penn Gravity R. R. Co | 5.50 | No. |
| Washington | Puget Sound Electric Ry | 6.05 | |

It was impossible, in some of these cases, to determine definitely whether or not and to what extent this trackage was also used by the electric cars. It must not be understood, however, that the trackage shown for these companies represents the entire system, as only in the roads enumerated in Alabama, Nebraska, and North Carolina does the steam trackage represent the entire trackage of the company. Although the Evansville Suburban and Newburgh Railway Company of Indiana reported only 3.25 miles of steam trackage, at times steam traffic is operated over their entire line; and in like manner, although the Great Falls and Old Dominion line of Virginia does not return any trackage as steam, it is nevertheless true that steam traffic is at times operated over the entire length of the road. The steam traffic shown for street and electric railways does not represent all the traffic carried by steam motive power, as the locomotives of the Toledo and Western of Ohio and of other electric companies handle freight cars over their electric lines.

In connection with the steam trackage of street and electric railways it is interesting to note that several companies report steam locomotives as a part of their rolling stock. These are shown in the following statement:

*Electric railways reporting steam locomotives: 1907.*

| STATE. | Name. | Number of steam locomotives. |
|---|---|---|
| Total | | 92 |
| Alabama | Birmingham and Gulf Railway and Navigation Co. | 3 |
| California | Northern Electric Ry. Co | 3 |
| California | Pacific Electric Ry. Co | 2 |
| California | Los Angeles Pacific Co | 3 |
| Colorado | Denver and Northwestern Ry. Co | 2 |
| Idaho | Boise and Interurban Ry. Co. (Ltd.) | 1 |
| Illinois | Aurora, De Kalb and Rockford Electric Traction Co. | 1 |
| Illinois | St. Louis, Decatur and Champaign Ry. Co | 1 |
| Illinois | Sterling, Dixon and Eastern Electric Ry. Co | 1 |
| Illinois | East St. Louis and Suburban Ry. Co | 2 |
| Illinois | Rock Island Southern R. R. Co | 1 |
| Illinois | Bloomington, Pontiac and Joliet Electric Ry. Co | 1 |
| Indiana | Fort Wayne and Springfield Ry. Co | 1 |
| Indiana | Evansville Railways Co | 1 |
| Indiana | Evansville Suburban and Newburgh Ry. Co | 3 |
| Indiana | Fort Wayne and Wabash Valley Traction Co | 2 |
| Indiana | Indianapolis and Cincinnati Traction Co | 2 |
| Iowa | Interurban Ry. Co | 1 |
| Iowa | Waterloo, Cedar Falls and Northern Ry | 4 |
| Kansas | Union Traction Co | 1 |
| Massachusetts | Haverhill and Amesbury Street Ry. Co | 1 |
| Michigan | Detroit and Port Huron Shore Line Ry | 2 |
| Nebraska | Sioux City, Crystal Lake and Homer Ry. Co | 1 |
| New York | Eastern New York R. R. Co | 1 |
| New York | Fonda, Johnstown and Gloversville R. R. Co | 1 |
| New York | Keeseville, Ausable Chasm and Lake Champlain R. R. Co. | 1 |
| New York | Interborough Rapid Transit Co | 8 |
| New York | Brooklyn Union Elevated R. R. Co | 5 |
| New York | Marine Ry. Co | 1 |
| North Carolina | Laurel Park Street Ry. Co | 1 |
| Ohio | Ohio Electric Ry. Co | 2 |
| Ohio | Toledo, Port Clinton and Lakeside Ry. Co | 1 |
| Ohio | Toledo and Western R. R. Co | 1 |
| Ohio | Youngstown and Southern Ry. Co | 1 |
| Oregon | Portland Railway, Light and Power Co | 3 |
| Pennsylvania | Pittsburg and Butler Street Ry. Co | 1 |
| Pennsylvania | Philadelphia and Western Ry. Co | 1 |
| Pennsylvania | Pittsburg Railways Co | 4 |
| Pennsylvania | Mt. Penn Gravity R. R. Co | 1 |
| Utah | Ogden Rapid Transit Co | 1 |
| Virginia | Richmond and Chesapeake Bay Ry. Co | 1 |
| Virginia | Virginia Passenger and Power Co | 1 |
| Virginia | Great Falls and Old Dominion R. R. Co | 3 |
| Washington | Spokane and Inland Empire R. R. Co | 6 |
| Washington | Pacific Traction Co. of Maine | 1 |
| Wisconsin | Milwaukee Electric Railway and Light Co | 6 |

The companies reporting steam locomotives do not agree, however, with the companies operating steam trackage or leasing tracks from steam railways, as steam locomotives are often used by electric railways on construction or work trains, and are therefore not a factor in the traffic of such roads.

*The stage of transition.*—The adoption of electric motive power as a substitute for steam is shown by

this report to have entered upon a very interesting and important stage. The change from one method of propulsion to the other is determined by a great variety of conditions—some financial, some economic, and some of a social nature. Two of the governing factors in recent years have been the determination on the part of citizens in great cities to tolerate no longer the noise and smoke associated with the use of steam locomotives within urban limits, and the great desire of the railroads themselves to find better methods for handling their terminal traffic than are afforded by steam. A notable influence in deciding the trend of events has been the extraordinary development throughout the United States of interurban electric-railway systems, many of which under former conditions would have been operated by steam and others would not have existed. The general success of these systems in handling passenger and freight traffic, comparable with that of many long lines of steam railroads, has established beyond contradiction the ability of electricity to grapple with some of the hardest problems encountered in the field of main-line transportation; and both in Europe and America to-day the problem is being rapidly worked out, although along different lines of experiment and practice. The general results attained will best be understood from a consideration of leading typical instances.

*Methods of New York Central.*—Probably the most striking illustration of the change is that furnished by the New York Central and Hudson River Railroad Company in equipping its New York terminal with electric locomotives for through traffic and with motor cars for the suburban traffic. The electric zone of the New York Central is to continue for a distance of 34 miles on the main line from the Grand Central Depot to Croton, and for 24 miles out on the Harlem division, but up to date goes only to High Bridge and Yonkers. As they enter this electric zone, all the through passenger and mail trains drop their steam locomotives and are brought to the terminal by electric locomotives or motors. Each of these electric locomotives, hauling a total train weight of 435 tons, is capable of making the run from Croton to the Grand Central Station, without stopping, in forty-four minutes; or a train weighing 875 tons, drawn by two of the locomotives, averages from 60 to 65 miles an hour and can attain a speed of over 80 miles. The weight of these locomotives is 97 tons, with a total rated capacity, as a unit, of 2,200 horsepower, while the largest steam locomotives built, up to the end of 1907, weighed about 300 tons and gave a sustained output of 2,180 horsepower. On account of this limited output the cost of steam locomotives for a certain gross annual ton mileage may be even greater than the cost of the electric units replacing them. The electric locomotive of the New York Central has four driving axles, on each of which is mounted the armature of a direct-current electric motor of 550 horsepower; the maximum tractive drawbar pull is 34,000 pounds and the tractive pull per ton of engine weight 330 pounds. The locomotive has eight 44-inch drive wheels and four 36-inch truck wheels, a drive-wheel base of 13 feet and a total wheel base of 27 feet. The pressure of current supplied is 600 volts and the normal full-load current 3,050 amperes.

Current is derived from a third rail placed alongside the track in the manner noted elsewhere in this report, third-rail shoes, four of which are placed on each side of the locomotive, making contact with the rail. In the yards at the terminal, however, the large number of switches and crossings necessitates, in places, an overhead structure; and there additional contacts mounted on top of the locomotive are used.

The heavy traffic with the electric locomotives arrives at the New York Central Depot on one level and the large suburban traffic, for which motor cars and trailers are used, on a lower level. The first equipment of suburban rolling stock for the New York Central included 125 motor cars with 2 motors, mounted on the same truck, on each car, the machines being rated at 200 horsepower each. An average suburban train of the old steam type with locomotive and 6 loaded cars weighs 700,160 pounds, while the electric train of equal seating capacity, composed of 4 motor cars and 2 trailers, weighs 621,360 pounds, or a lighter weight, for the electric train, by 39.4 tons.

This pioneer installation was begun on the New York Central system in December, 1906, and has been in complete and successful operation since July, 1907. In discussing the subject before the American Institute of Electrical Engineers, in November, 1907, Vice-President Wilgus, of the New York Central Railroad, said: "The working, side by side, of both kinds of motive power has given unsurpassed opportunity for the observation of their comparative capacities and efficiency. The results are even more gratifying than were expected, and substantiate many of the claims of the superior capacity of electric equipment." Mr. Wilgus said also that the net result of all the economic advantages of electrical operation over steam, for the conditions existing on the New York Central, would, after including all elements of cost of additional plant, show a saving in the summer months of from 12 to 27 per cent, depending upon the character of the service, while even a larger saving might be expected under winter conditions; that because of less cost of maintenance of electric equipment and less idle time in the repair shops, the greater cost of extra charges and depreciation for the system was not only neutralized, but a net saving of 19 per cent on repairs and fixed charges over steam equipment was effected; that electric-locomotive inspection and lighter repairs, as compared with coaling, watering, drawing fires, repairs, etc., of steam locomotives showed a saving in time in favor of electricity of more than four hours per day, equal to 18 per cent; and that the electric locomotive, when busy,

was a much more nimble and efficient machine than the steam locomotive, showing an increase in daily ton-mileage of 25 per cent. The question of locomotive weight is a large factor in a comparison of relative economies in handling passenger traffic by steam and by electricity, and in the switch service at the Grand Central terminal 65 per cent of the total steam ton-mileage was due to locomotive or dead weight, while the electric-locomotive percentage was but 54 per cent—a saving for the latter of 11 per cent. In the regular schedule service Mr. Wilgus stated that the steam locomotives showed 51 per cent dead ton-mileage, as against 35 per cent for the electric equipment, a saving for the latter of 16 per cent. With regard to the speed advantages of electric locomotives it was pointed out that this advantage was perfectly apparent in the New York Central installations, where the increase in coal consumption for car ton-mileage in high-speed service, as compared with slow-speed service, was shown to be 165 per cent; whereas, under exactly the same conditions, the increased consumption of current for electrical equipment was only 18 per cent, an economic difference, in favor of electrical operation, of 147 per cent.

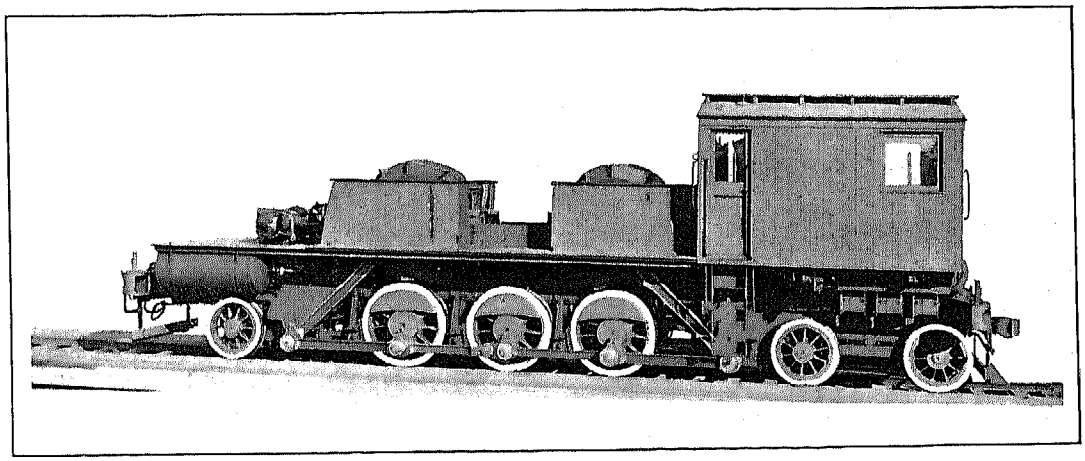
In connection with this radical change on the New York Central it should be pointed out that the adoption of electricity in the operation of the road has, in a sense, carried with it the complete reconstruction of the Grand Central terminal as a whole, with the building of a new double-level station for the reception and dispatch of trains; the reconstruction of cross streets over the depressed electrified tracks; the installation of power plants to supply the electrical energy; extensive systems of substations and transmission lines; and the development of a third-rail distributing system throughout the electrified zone. There has also been required the organization of an electrical department, with a chief engineer of electric traction, reporting to a responsible vice-president in general charge of the whole work.

*New York Central power plants.*—Two power plants have been built to furnish current to the electrical zone of the New York Central, one located at Port Morris, on the eastern side of New York City, and the other at Yonkers, on the Hudson River, feeding in from the western side. These stations are practically duplicates, each having an ultimate capacity of 30,000 kilowatts of electrical energy at full rating. The Port Morris station was put into service in May, 1906; the first train over the system was run in July of that year; and the first regular train entered the Grand Central station on December 11. Since July 1, 1907, all the New York Central trains in and out of the Grand Central Depot and the adjacent Lexington avenue temporary terminal have been electrically operated.

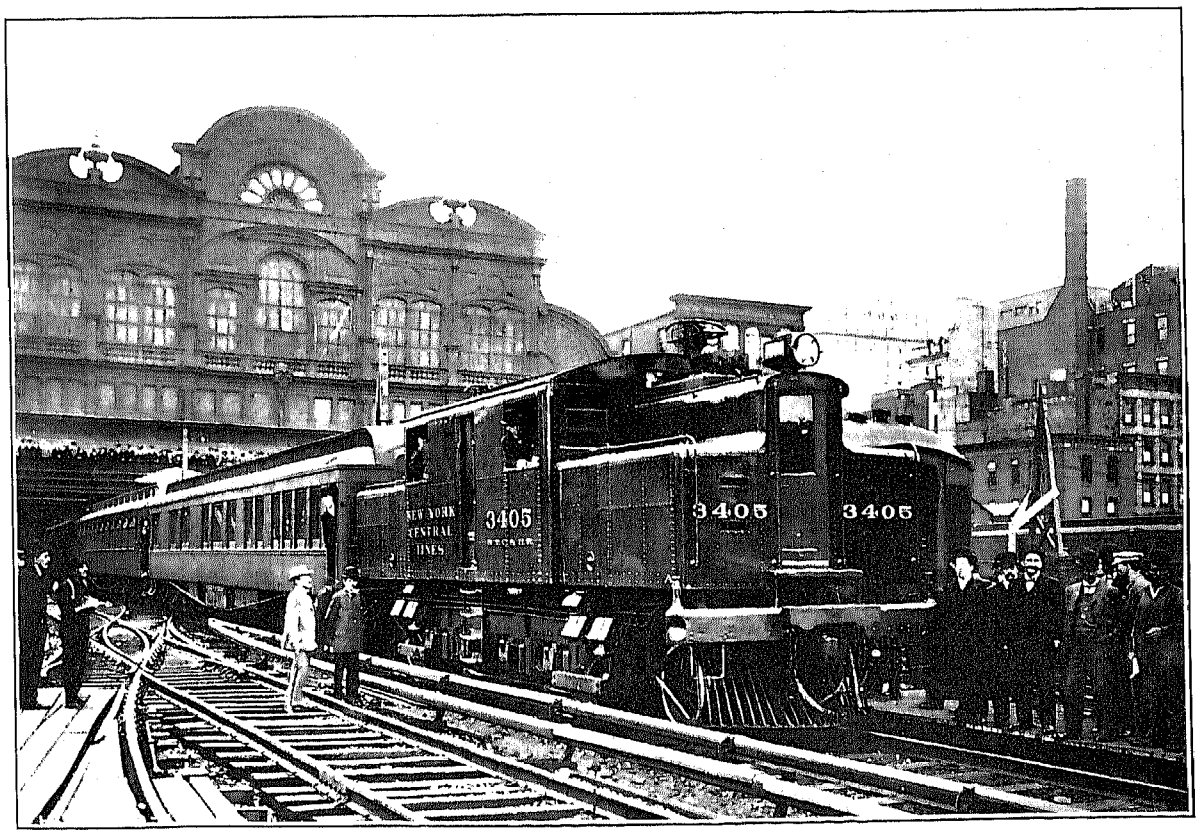
The Port Morris station, which may be taken as typical of both plants, is 237 feet long, 167 feet wide, and 105 feet high, with smokestacks 250 feet above the grates. The turbo-generator room is 231 feet 8 inches long by 69 feet wide, and the boiler room 88 feet wide. At each station all high-tension switching is accomplished in a separate switch house—the one at Yonkers being combined with a rotary-converter substation. The equipment at Port Morris includes four 5,000-kilowatt vertical turbo-generator units, 3-phase, developing alternating current at a frequency of 25 cycles and at 11,000 volts. Six such turbines constitute the ultimate station equipment; but it is an interesting fact that the requirements for electrical energy for train operation have fallen below the estimates, thus giving the plants, as they stand, a much greater capacity for caring for the duties imposed upon them than was anticipated. A typical midday load curve taken at the Port Morris power station on August 7, 1907, showed an average load during the day of 3,000 kilowatts. The minimum load was 1,000 kilowatts and the maximum load was 6,600 kilowatts, which occurred during the evening rush hours of suburban traffic. The corresponding morning peak reached a volume of 5,400 kilowatts. The morning and evening peak loads lasted about three and one-half hours each, while the minimum load lasted about five hours.

The plan of operation of the New York Central for the existing electrical zone is based upon delivery of current to 8 substations, equipped with three rotary converters, each of 1,000 or 1,500 kilowatt capacity, depending upon the local circumstances. Each substation, in addition to the provision of apparatus for receiving the high-tension current and converting it to direct current of 666 volts for delivery to the third rail, is furnished with a storage-battery equipment of sufficient capacity to operate the service with maximum train-load requirements for about half an hour. Each substation can be fed from either power station, and the transmission lines are so disposed that no ordinary accident can cut off a substation from one or the other source of power supply. It is obvious that in a great transportation system of this kind the precautions against interruption can not be too careful or too minute, and the system is designed to give the greatest possible protection against breakdown.

In order to provide against interruption in the substation itself, the following general principles of design were adhered to: The path of the current was made as short and straight as possible from the high-tension transmission line through the substation to the direct-current feeders; the wiring is as little exposed as possible, yet is readily accessible to the substation employees; all the machinery is on the same floor with the operating switchboards; the principal apparatus is under the direct control of the operator while standing at the switchboards; all the equipment is so arranged as to limit the effect of an accident to the spot where it occurs; the operator is safeguarded as much as possible, and the risk of accident to him is



NEW YORK CENTRAL SIDE-ROD ELECTRIC LOCOMOTIVE.




FIRST ELECTRIC TRAIN LEAVING GRAND CENTRAL STATION, NEW YORK, WITH DIRECT-CURRENT LOCOMOTIVE.

minimized; and finally, the substations are all of strictly fireproof construction. The whole system is interwoven with an independent telephone system, while there are also connections with the regular telephone system and exchanges within the electrical territory. The system, as a whole, from the busbars in the power house to the third-rail shoes on the trains, is an organized group of apparatus with systematic interrelation.

The circuits are carried in part overhead along the line of the road, but through the Park avenue tunnel, along the viaduct from the tunnel to Harlem, and through the Harlem depression the conductors are carried in steel pipe, while in crossing the Harlem River the conductors are cable-laid in the river bed.

*New York, New Haven and Hartford Railroad.*—Next in importance to the work done on the New York Central Railroad in the adoption of electricity is that done by the New York, New Haven and Hartford Railroad Company. While the New York Central has employed direct current, the other system has had resort to the alternating current; so that New York City itself affords examples of both methods, and an excellent opportunity for comparing them in operation and in results. The first electric zone of the New York, New Haven and Hartford Railroad, on which commercial service was begun on July 24, 1907, extends from the Grand Central Depot to Stamford, a distance of 33 miles, and the apparatus has been so devised as to operate upon the direct-current third-rail system near the city and on alternating current with overhead wires from Woodlawn outward. For the electrification of the system 35 locomotives, each furnished with 4 motors of 250 horsepower, normal rating, have been put into use. The motors, of the gearless type, wound and built for a normal speed of 225 revolutions per minute, are permanently connected in pairs and require about 450 volts at the terminals for alternating current and 550 volts for direct current. For local service, each of the locomotives handles a 200-ton train, with stops averaging 2 miles apart, on a schedule of 25 miles an hour, and in order to maintain this average speed the maximum speed per hour is about 45 miles. On through service, owing to the infrequent stops, one locomotive can handle a 250-ton train, while for heavier trains it is the practice to couple two locomotives together and operate them in multiple, 8 cars per locomotive being the maximum number allowed. For regular work over the alternating-current system the locomotives are provided with overhead pantagraph trolleys, and each of the two trolleys for such work is able to carry the total line current. Since the introduction of these locomotives, however, various changes and modifications have been made in six new ones, embodying the results of practice and looking to the improvement of the service.

The electrical energy for the service is generated at 11,000 volts, applied directly to the overhead lines of catenary-construction form, described elsewhere in this text. This catenary construction is carried by steel bridges over the tracks, and the current, at high tension, is taken off and received on the locomotive by step-down transformers, which reduce the pressure to the 450 volts required for the operation of the motors. The electric power supplied for the New Haven road is furnished from four 11,000-volt steam turbo-generators, three of which have an electrical capacity of 3,750 kilovolt amperes, single-phase, while the fourth unit consists of a 6,000 kilovolt ampere, 3-phase generator which can also supply single-phase current to the system.

A very interesting report on the operation of the road was presented before the American Institute of Electrical Engineers in 1908 by Mr. W. S. Murray, the electrical engineer of the railroad, who stated that, following the initial operation in July, 1907, local service from Stamford was established in October, and that finally, July 1, 1908, all through and local passenger trains were under electrical schedule between Stamford and the Grand Central Station. Mr. Murray found, by measuring the weight of all the trains in the New Haven service, that the average was 212 tons. If 75 per cent of the service could be handled by locomotives rated upon a basis of 200 tons trailing load, it seemed good engineering to consider that the correct locomotive unit size, and to use two units for the remaining 25 per cent formed by the heavier trains. Practice has shown that 73 per cent of the trains can be handled with single units. From statistics given of a day of heavy traffic it would appear that the electric mileage averaged 34 per cent better than the steam mileage. It is also pointed out that no fatality to the traveling public had happened since the service had been in operation by reason of the high-voltage current used. With regard to the general case as to the use of alternating current, as compared with the direct current and its bearing upon the question of cost, Mr. Murray says in his paper that he has intentionally omitted the discussion of operating costs of a direct-current versus an alternating-current system. But bearing in mind the fact that good engineering means making a dollar earn the greatest interest, it is his belief that in the electrification of steam roads to-day straight alternating-current traction is the agency through which that end can be gained. Experience shows that alternating current is the preferred agent for the transfer of electricity, where either distance or capacity is involved. A railroad involves both. "Granted, therefore, that alternating-current traction apparatus has received the trade-mark of practicability, what further argument does it need in its favor?"

*Equipment for the St. Clair tunnel.*—Another very interesting type of single-phase railway equipment is

that adopted for the St. Clair tunnel by the Grand Trunk Railroad. The tunnel was opened in 1890 to eliminate the transportation of cars by ferry between Port Huron, Mich., and Sarnia, Ontario. The tunnel is slightly over 6,000 feet in length, and previous to the adoption of electricity was operated by means of steam locomotives especially constructed to burn anthracite coal. Although these locomotives rendered satisfactory service, it was found desirable to substitute electric locomotives for them in order to remove the limitations of haulage capacity over the single track in the tunnel and to obviate the danger and inconvenience due to locomotive gases in the tunnel. The work on the tunnel was finished during 1907 and the locomotives went into service early in February, 1908. The tunnel is now clean, well lighted, and safe to work in, and trains of much greater length than formerly can be hauled, thus relieving the congestion in the freight yards on both sides of the river.

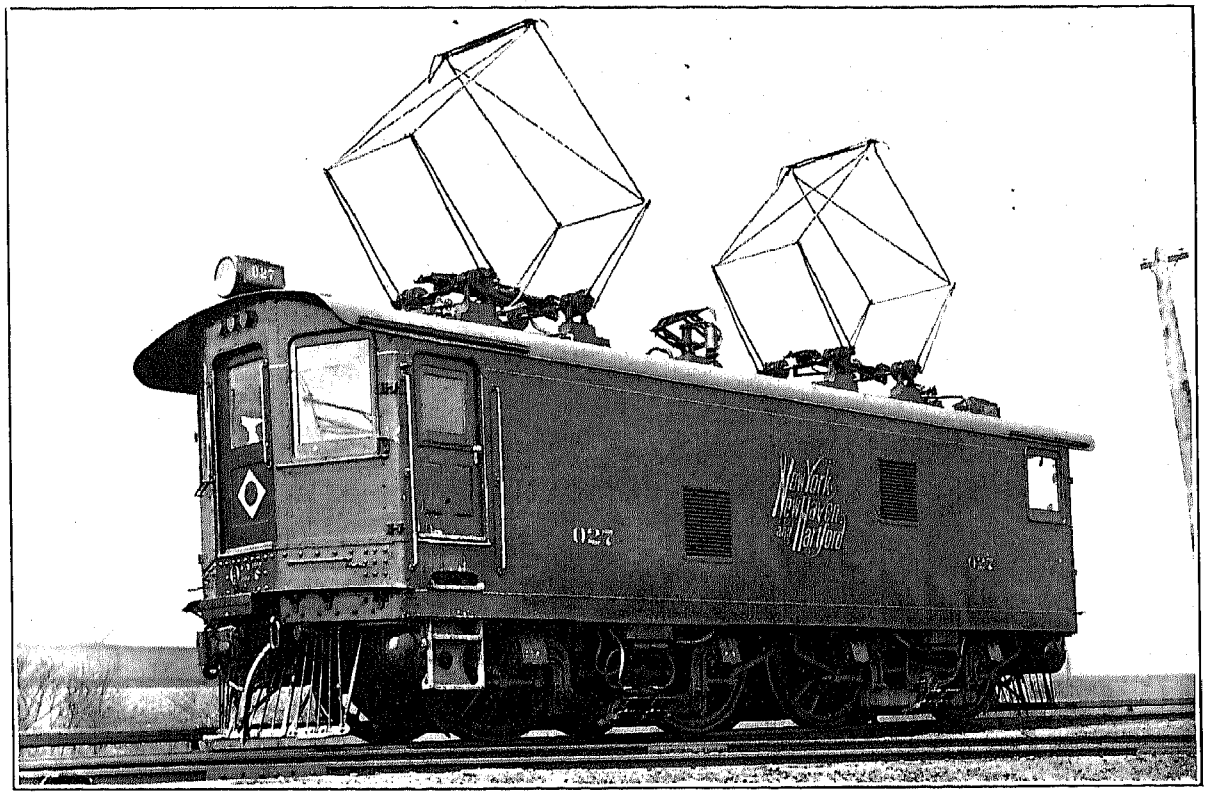
The power house is situated on the Port Huron, Mich., bank of the St. Clair River, and is equipped with two 1,250-kilowatt, 3-phase, 25-cycle, 3,300-volt steam turbo-generators. The high-tension voltage is applied directly to overhead lines and is stepped down by transformers for the motors. The trolley system is fed through a vertical shaft, which extends to the tunnel at a point just outside the power house, and no additional feeders are required. The overhead-contact conductor system is of the single catenary type, a messenger or supporting cable of ⅜-inch of heavy galvanized steel being suspended on the insulators fastened to the overhead bridges immediately over the center lines of the tracks. The working conductor is supported by the messenger cable at a height of 22 feet above the top of the rail.

The traction equipment comprises 3 locomotives, each built in two half units, so that each can be operated alone. Each half unit is driven by 3 single-phase conductively compensated series motors having a rating of 250 horsepower, so that the total power capacity of the complete locomotive is 1,500 horsepower. Each complete locomotive is designed to develop a drawbar pull of 50,000 pounds at a speed of 10 miles per hour and is operated at a speed not to exceed 30 miles per hour. It is estimated that each is capable of starting a 1,000-ton train on a 2 per cent grade.

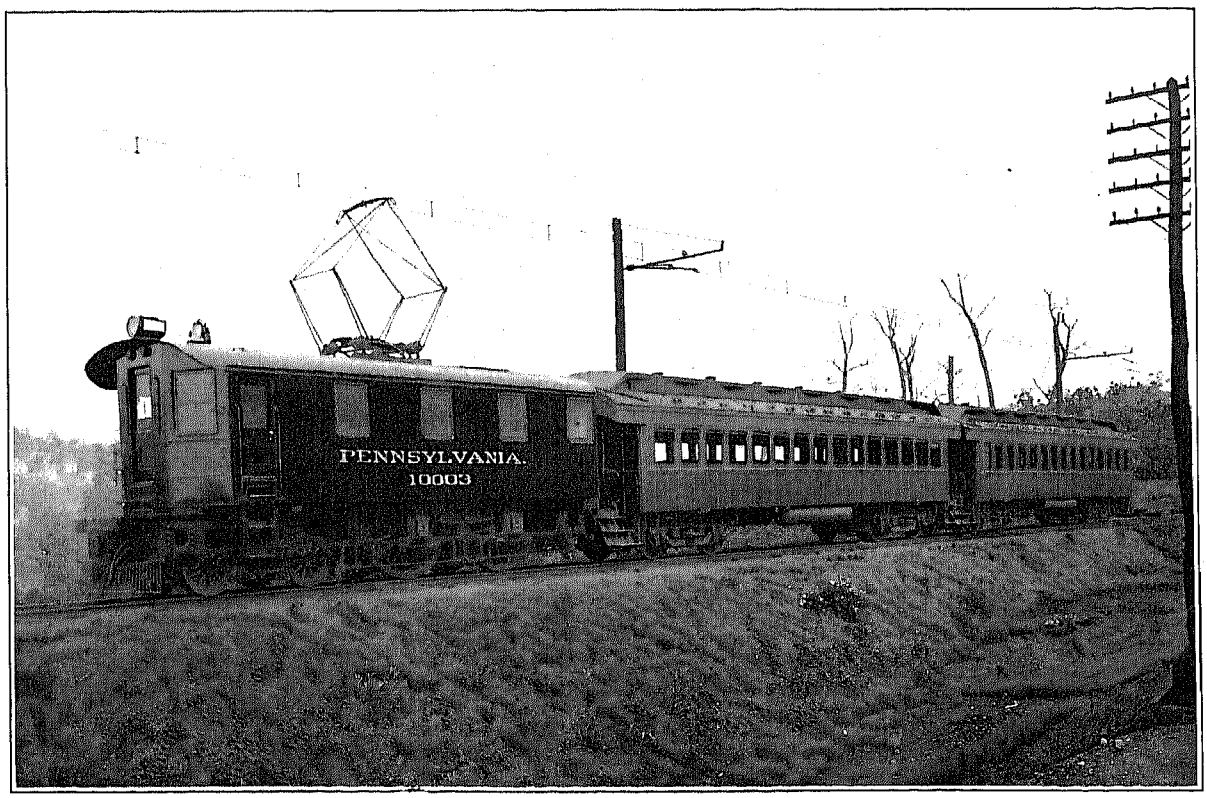
*Cascade tunnel of Great Northern.*—Another of the main railroad systems that has taken up electricity is the Great Northern, which has introduced 4 locomotives for hauling trains through the Cascade tunnel, which is somewhat less than 3 miles in length and has a uniform grade of about 1.7 per cent. These locomotives are of the 3-phase alternating type, with double truck, and 2 motors to each truck. Each locomotive is equipped with 4-wheeled trolleys, somewhat similar to those employed on street cars, 2 of which are used for operation in each direction, the rail being employed as the third or return conductor. The current is supplied to the overhead line at 6,600 volts and is lowered to 500 volts by the transformers on the locomotive for use at the motors. The gearing of the locomotive is such as to give a speed of 15 miles, which is maintained on the up grade and only slightly exceeded on the down grade. In the event of the satisfactory operation through the Cascade tunnel, other grades in the vicinity will also be operated electrically.

*Baltimore Belt Line tunnel.*—One of the earliest of the main lines of steam railroad to substitute electricity for steam was the Baltimore and Ohio system, which has now been in operation for some years, using the equipment in the Baltimore Belt Line tunnel. At first 3 locomotives, each weighing 96 tons and equipped with 4 direct-current motors rated at 360 horsepower, at 300 volts each, were employed, and were found to greatly ameliorate the conditions connected with the operation of the tunnel, as well as to improve the general service. As originally designed, these locomotives took current from an overhead trolley at about 625 volts, various forms of trolley being employed; later, however, it was deemed more economical and efficient to employ a third-rail system. The results obtained with the locomotives more than met the most sanguine expectations. It was found that one locomotive could accelerate a loaded train equivalent to 52 freight cars having a total weight of 1,900 tons. This acceleration was accomplished smoothly on a grade of eight-tenths of 1 per cent, and the train finally brought up to a speed of 12 miles per hour. The drawbar pull exerted during acceleration was 63,000 pounds, and the current taken at 625 volts during acceleration was 2,200 amperes, steadying down at constant speed to 1,800. It was finally decided to use even larger locomotives, which are now in commercial service and are among the most powerful in the world. On account of their extreme size they were built in two separate units of 80 tons each, each unit having 4 motors of 200 horsepower, giving a normal rating of 1,600 horsepower for the complete locomotive. At this rating each locomotive is capable of accelerating, on a level, a train weighing 3,000 tons with a current consumption of 2,200 amperes, or on a 1 per cent grade a 1,400-ton train, to a speed of 10 miles per hour, the current at this speed being 1,600 amperes. The free-running speed of the locomotive without train is about 24 miles per hour.

*Multiple-unit system.*—The work thus far considered in the transition on main lines from steam to electric power has dealt with the adoption of locomotive methods, in which, so far as the train is concerned, practically all the older ideas remain unchanged. In other words, with electric locomotives, as with steam, the train, in charge of a regular train crew and consisting of a given number of cars, is made up with the propelling power in a large unit at the head of the train. All the functions of propulsion relate to the locomotive, and the cars are simply so many trailers. On the through lines of the New York Central and on the




NEW YORK, NEW HAVEN AND HARTFORD ALTERNATING-CURRENT LOCOMOTIVE.




PENNSYLVANIA RAILROAD ALTERNATING-CURRENT LOCOMOTIVE.

service of the New Haven roads the locomotive system, identified with seventy-five years of practice, is essentially the same now as before the adoption of electricity; but on other roads and on electric divisions of steam railroads the transition has brought with it revolutionary changes rendering the service analogous to that of interurban electric-railway lines and to street-car practice in general. In other words, the motive power, instead of being concentrated in one unit at the head of the train, is distributed throughout the train in a number of smaller units; and a train is made up either entirely of motor cars or of motor cars interspersed with trailers; this being the practice on all the elevated and subway lines now in existence in this country. While, in the newer methods, the motive power is distributed throughout the train, it is usually, by means of the multiple-unit system, subject to the controlling operation of one motorman. This enables a train to be built up of any number of units, according to the exigencies of the load, the needs of traffic, and other conditions.

*Rochester division of Erie Railroad.*—One of the most important electric-railway developments in respect to the abandonment of the locomotive principle is that on the Rochester division of the Erie Railroad, where the change took place in June, 1907. It is believed to be the first system to install a single-phase alternating-current system of electric motive power upon a steam railroad of any kind, and also the first to apply several other important features, among which were the use of 11,000-volts working pressure commercially on a trolley-contact system, and a single-phase traction system receiving its current from a 60,000-volt transmission line.

The section of track thus equipped is 34 miles long, from Rochester, N. Y., to Avon, a distance of 19 miles, and continuing thence 15 miles over the Mount Morris branch. The railroad is entirely single track, with sidings at way stations 3 or 4 miles apart. The line is relatively straight, with long tangents, easy curves, and low grades, but it has a number of bridges, including one that is 700 feet long over the Genesee River, about 1½ miles south of Rochester. The track was laid originally with 68-pound rails, but for electrification was relaid with 80-pound rails. The roadbed is ballasted with gravel, and a single No. 00 protected copper rail bond is applied to each rail joint under the plate, one of the advantages of the high-tension single-phase system being that the relatively small current combined with the high impedance of the main circuit renders it unnecessary to resort to heavy bonding.

The old steam service between Rochester and Mount Morris comprised three round trips daily for passenger service, to which the electric system is devoted solely, the freight service, as well as the through trains between Rochester and Corning over the main line of the Rochester division, a distance of about 94 miles, being handled by steam as heretofore. Instead of the former three round trips per day, the electric service has given six complete round trips between Rochester and Mount Morris, and three more between Mount Morris and Avon. The flexibility of the service is shown in that the trains can be made up in any number of units from 1 to 4. The equipment permits of single-car trains traveling with one stop per mile over the entire road at an average speed of 24 miles per hour, or 1 motor car can haul 1 trailer, making stops about 2½ miles apart, at the same schedule speed. It has been found, too, that the electric trains can be depended upon to keep their running time better than the steam passenger and freight trains operated over the main line. A single passenger coach is frequently attached to a motor car and on such trains baggage, milk, or mail cars are regularly hauled. When 2 trailers are employed, 2 motor cars are required, making up a 4-car train, corresponding roughly to a regular locomotive train with its baggage car, smoking compartment, and other features. Since the service was introduced it has become very popular throughout the Genesee Valley and has been improved from time to time.

The motor cars initially employed, 6 in number, were 51 feet 4 inches over bumpers, 8 feet 9 inches wide over sheathing, and 13 feet 8⅝ inches in height above the rail. Four of these cars had two passenger compartments, and the other two a baggage compartment about 14 feet long, with a small smoking compartment, besides the regular passenger section—an arrangement which corresponds closely to that found in ordinary interurban practice described elsewhere. The electrical equipment of the cars which are electrically lighted and heated consists of 4 single-phase motors with a normal rating of 100 horsepower each.

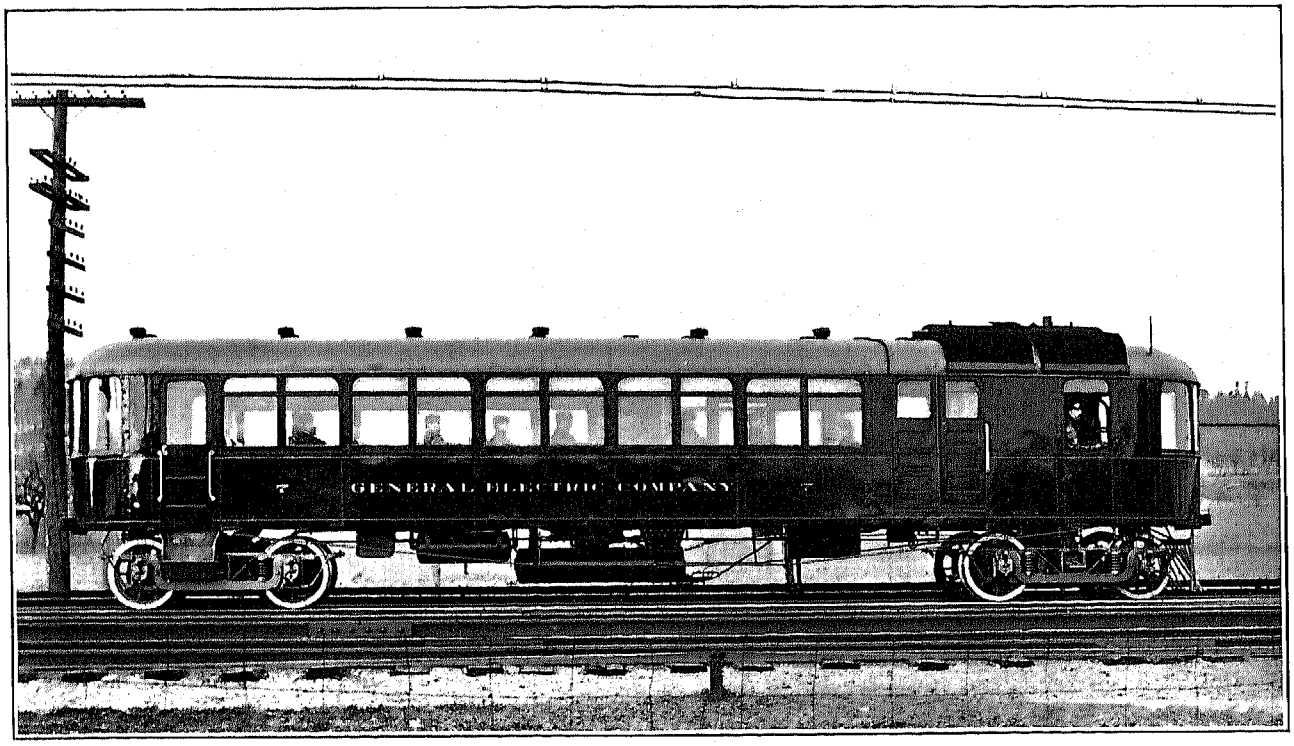
The circuits are carried by chestnut poles averaging 25 inches in circumference at the top, 42 inches at the butt, and most of which are about 33 feet long, although 40-foot poles are used where the embankments are narrow and steep, and for span construction. Nearly all the overhead construction is of the bracket type. The trolley, which is of the pantagraph form, is raised and held against the wire by means of springs and lowered by the application of air pressure through a piston working in a cylinder which forms part of its base. The electrical energy employed is generated at Niagara Falls in the plant of the Ontario Power Company, at the foot of the Great Horseshoe, and is transmitted at 60,000 volts, 3-phase, over the line of the Niagara, Lockport and Ontario Power Company, being received by a substation where the high-tension current from the transmission line is made available for single-phase distribution by means of three transformers of oil-insulated water-cooled type, each of 750-kilowatt capacity, from which the 11,000-volt current goes to the railroad line. Provision has been made so that in case of development an extension of 40 or 50 miles to another substation could be cared for.

During the time covered by the census period the daily electric train mileage was 500 miles on week days and 400 miles on Sundays. The schedule was somewhat irregular, but on week days approximated a two-hour service for twelve hours a day. The train crew of single cars consisted only of a motorman and a conductor, as on ordinary street cars, but two-car trains carried a brakeman in addition, and a brakeman was always carried when baggage was handled. The electrical division is, as has been noted, operated as a portion of the Rochester division, and has the same management, except that the electrical work is in charge of a supervisor of the electrical service. Although in 1907 the cars were operated, under ordinary conditions, over a period of only fifteen hours a day, current was left on the trolley continuously. Cars were brought in for inspection on an 800-mile basis and thoroughly overhauled; and it was found that about 10,000 miles of wear was secured from the pantagraph trolley shoes, which are lubricated with graphite and gasoline once a day. At first these shoes were of copper, but steel shoes have since been substituted.

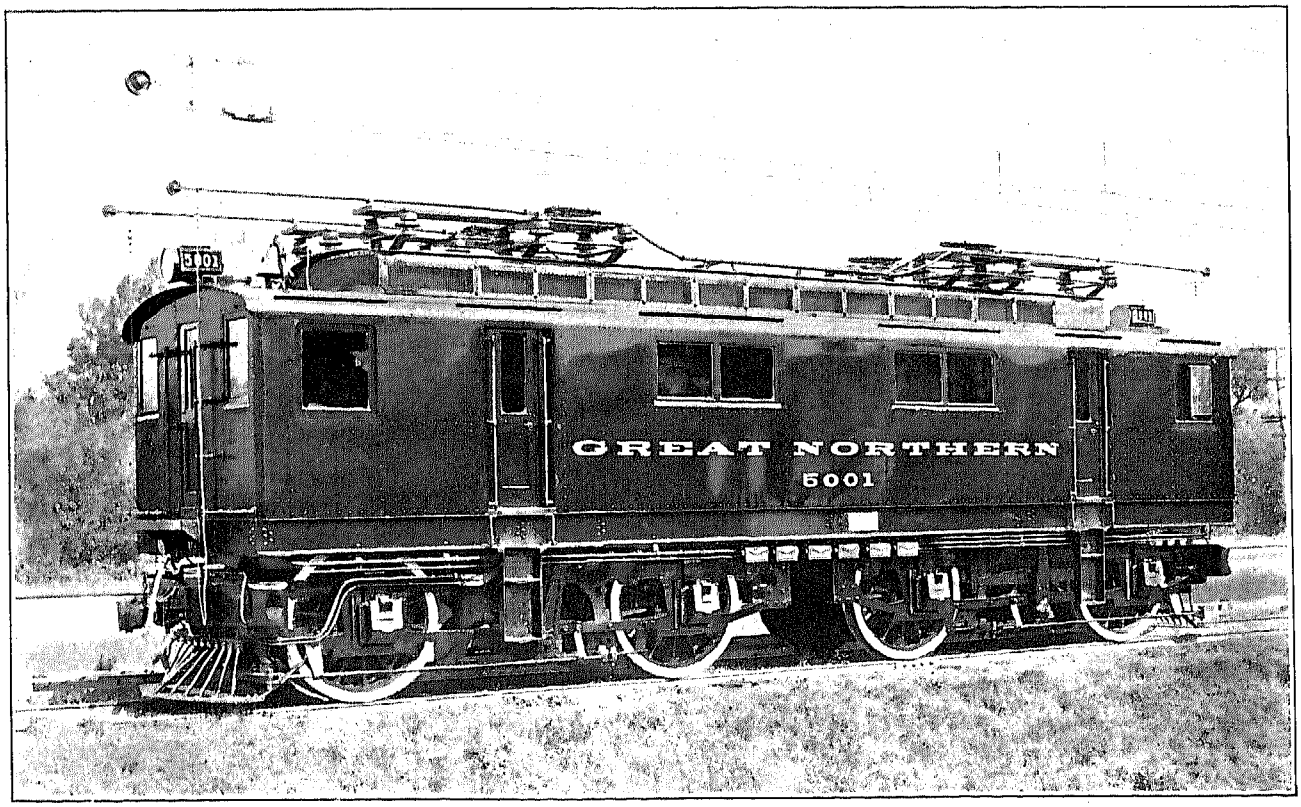
The electric division is operated and protected by a positive manual block-signal system, working in accordance with the code of the American Railways Association. There are in all 11 signaling stations, and the blocks are consequently about 3 miles long. The telephone instead of the telegraph or bell-signal system is used for communication between the signaling stations, so that there is no necessity for the towermen to be telegraph operators. The telephone is not employed in giving train orders, and where it is necessary, for any reason, to give orders of this kind, they are received by a motorman, engineer, or conductor at regular way stations from the telegraph operators at those points. The operation of trains is in charge of a chief dispatcher at Rochester, who supplies the motorman or engineer with train orders which, under ordinary conditions, block the train through. The block operators know the train schedule, and as the time for a train draws near each operator telephones the next operator ahead asking whether or not the block is clear. The first operator sets his signal in accordance with the reply, and if the block is clear, the second one sees that the stop signal is set for all possible trains. The signal, however, returns automatically to the stop position. Special trains over the circuit are blocked through in the same manner.

*Long Island Railroad equipment.*—Another extensive railroad system which has already adopted electricity over a considerable portion of its line is the Long Island Railroad, controlled by and forming an integral part of the Pennsylvania Railroad system, with which it is being connected by tunnels under Manhattan Island, the East River, and the North River. This electric system went into full operation during the census period, and has been steadily extended. At the close of 1907 the electric equipment consisted of 130 steel-motor passenger cars, 5 express cars, and 1 rotary snowplow, supplemented by 55 wooden trailers, which had been wired for electric lights and electric heaters. The electric express cars are provided with truck motors and controllers, identical with those employed in the steel passenger cars. These steel cars resemble closely those employed in the New York subway, and are 51 feet 2 inches long over bumpers and 8 feet 5¾ inches wide over the side sills; the motor and trail trucks have wheel bases of 6 feet 8 inches and 5 feet 6 inches, respectively; and the wheels of the motor truck are 36 inches and those of the trailer truck 30 inches in diameter. Two motors of 200 horsepower each are mounted on a motor truck, and are operated by means of electro-pneumatic controllers. The current is taken up as described elsewhere by means of the third rail and the contact shoes.

The power plant of the system, operated by what is known as the Pennsylvania Tunnel and Terminal Company, is situated on the eastern bank of the East River at Long Island City, and the output of the station is purchased by the Long Island Railroad for its electric-traction work. The power plant is designed for six 5,500-kilowatt turbo-generators, of which three were installed at the close of 1907, when there were approximately 19 miles of protected third rail to be fed with current. There were 6 substations; and 2 portable substations, which can be shifted to any part of the system. Between the power house and Woodhaven Junction there is a direct transmission line, partly underground and partly overhead, consisting of 5 circuits. At that point the transmission circuits go in three directions to the various substations, east, west, and south, being carried partly overhead and partly underground. The overhead circuits are carried part of the way on lofty steel towers and for the remainder of the distance on wooden poles. Very little trouble has been experienced with the overhead line. The underground high-tension circuits consist of 3-conductor, paper-insulated, lead-covered cables placed in a conduit system provided with manholes at frequent intervals. At two points on Jamaica Bay, where the line crosses to Rockaway Beach and Far Rockaway, and where steam trains are also operated, there are drawbridges which necessitate the use of submarine cables. Current is generated by the 3-phase generators, rated to develop 5,500 kilowatts at 175 pounds steam pressure. This current is received at the substations from the transmission lines and transformed and delivered as direct current to the third-rail system. These substations are equipped with storage batteries as provision against interruption of service. An interesting feature is the use of the portable substations, rendered necessary by the extremely heavy but infrequent loads incident to the service of the race tracks along the system during the season at Belmont Park and at the Metropolitan race




SELF-CONTAINED GASOLINE ELECTRIC LOCOMOTIVE.




ELECTRIC LOCOMOTIVE FOR GREAT NORTHERN RAILWAY.

track south of Jamaica. These two portable substations consist each of a 1,000-kilowatt rotary converter, with transformer, switchboard apparatus, and the necessary auxiliaries carried in a heavy steel car resembling a freight car in outward appearance. These substations are permanent, to all intents and purposes, and tap from the transmission lines enough electrical energy to take care of the unusual train movement at the points indicated.

*West Jersey and Seashore Railroad.*—The West Jersey and Seashore Railroad operating between Camden and Atlantic City is a division of the Pennsylvania system which was previously operated by steam, but which, since July, 1906, has been under electrical power. The distance is about 75 miles, including 65 from Camden to Atlantic City, and 10 from Newfield to Millville. The contract included the erection of a power house and 8 substations, one of which is located within the power house; the electrical equipment of about 150 miles of single track almost entirely with the third-rail system; the building of 71 miles of high-tension transmission line, in duplicate as a precaution of safety; and the electrical equipment of 68 cars. At the time the work was done the contract called for the electrification of a main line double-track steam railroad from terminal to terminal, of a greater length than any steam road previously electrified in this country; but it is to be observed that this work also included the radical departure from antecedent methods, namely, the abandonment of the locomotive principle and the adoption of the system of power distributed through the train.

The Pennsylvania Railroad Company has two roads connecting Camden with Atlantic City, and it is the longer of these that is now electrified, as there is a local traffic on this longer route which can be handled more economically and expeditiously by electric than by steam traction. From the Camden terminal to Newfield the road is laid with 100-pound steel rails of Pennsylvania Railroad standard cross section, and from Newfield to Atlantic City with 85-pound rails of American Society of Civil Engineers section. For the entire distance the road is equipped with a third rail, with the exception of a short stretch of track about 4½ miles in length from Haddon avenue to South Gloucester, at the northern end of the system, where the tracks pass through the city streets at grade, and are furnished with overhead trolley wires. At the southern end, about 2 miles from Atlantic City, a new right of way was secured and, after crossing a public thoroughfare on a new drawbridge, the tracks go above the Philadelphia and Reading Railroad on an elevated structure and enter the Atlantic City terminal on a descending grade. On the section of the line between Newfield and Millville, which is a single-track road, the overhead trolley has been installed and the line is equipped with 100-pound steel rails.

At the time covered by this report the express service to Atlantic City consisted of 3-car trains running on a headway of fifteen minutes in each direction, at a speed, on straight, level track, of 60 miles an hour, the running time being ninety minutes. The local service was provided for by 2-car trains between Camden and Millville, running at half-hour intervals, and single cars between Camden and Woodbury at ten-minute intervals. It is understood that the general service has been modified and extended since then, but these provisions give an idea of the flexibility of the service, which includes also baggage and mail cars, as required. Each car in the electric system is a motor car, no trailers being used.

The rolling stock called for by the first contract, as already noted, comprised 68 cars, of which 63 are straight passenger and 5 are combination baggage and mail. Each car carries two 200-horsepower motors with automatic multiple-unit control. The controllers are so arranged that, should the motorman for any cause release his hold on the controller handle, the current is cut off from the motors throughout the train, and the brakes are applied automatically. The cars are heated and lighted electrically, and have general dimensions of 55 feet 5½ inches over buffers, 44 feet 6 inches length over body and sills, a height from the top of the rail to the top of the roof of 13 feet 3$\frac{13}{16}$ inches, and a weight, fully equipped on the track, of 89,000 pounds. Each passenger car has a seating capacity of 58 persons.

Electrical energy is furnished to the system from a power house at Big Timber Creek near Westville, N. J., 5½ miles from the Camden terminal, where there is an abundance of water for boiler feed and for condensing purposes. It comprises three 2,000-kilowatt, 25-cycle, 3-phase, 6,600-volt turbo-generators, with the ordinary full equipment of station regulating and controlling apparatus. The high-tension 3-phase current is converted to direct current in the 8 substations at 650 volts, and thus delivered to the third rail; the equipments of the different substations vary in capacity according to the requirements of the section of the road that they supply.

*Electric traction on West Shore Railroad.*—A further exemplification of the change from steam conditions and the abandonment of the locomotive idea is furnished in the electrification of the West Shore Railroad tracks between Utica and Syracuse, N. Y. The electric equipment of the line was done by the Oneida Railway, which operates the electric rolling stock. The conditions here again are interesting, as illustrative of the pressure brought to bear upon the steam railroads by the invasion of competing trolley lines. A large number of independent trolley systems having sprung up throughout the state of New York, they soon brought a keen competition to bear upon the

steam railroads for two classes of business, the local passenger traffic and the light-freight traffic, while some of the contiguous lines were formed into a chain or system paralleling the tracks of the steam roads all the way from Albany to Buffalo. For strategic considerations and for the protection of their traffic, the steam railroads deemed it their best policy to secure some kind of control over these competing electric lines and adopt kindred methods, with the result that such steam roads or divisions, where the capacity of traffic was not fully utilized, have been electrified or are now going through that process. These old steam roads, thus changed, form a connecting link, so to speak, between the steam lines proper and the auxiliary trolley network. The electrification between Utica and Syracuse is an important piece of work of this character. The road was formerly double track under steam conditions, but to accommodate the different classes of service a third supplementary track has been provided between Clark Mills and Vernon, near the Utica end, to allow the faster units to pass the local trains. In like manner, between Oneida and Canastota, at the middle of the division, a fourth track has been laid to permit the electrical units to pass steam trains that may be held at that section, owing to the presence there of water stations and freight yards. The distance between the terminals is slightly over 44 miles, this mileage being composed of 2, 3, and 4 tracks, making a total of a little less than 106 miles, laid throughout with 80-pound rails.

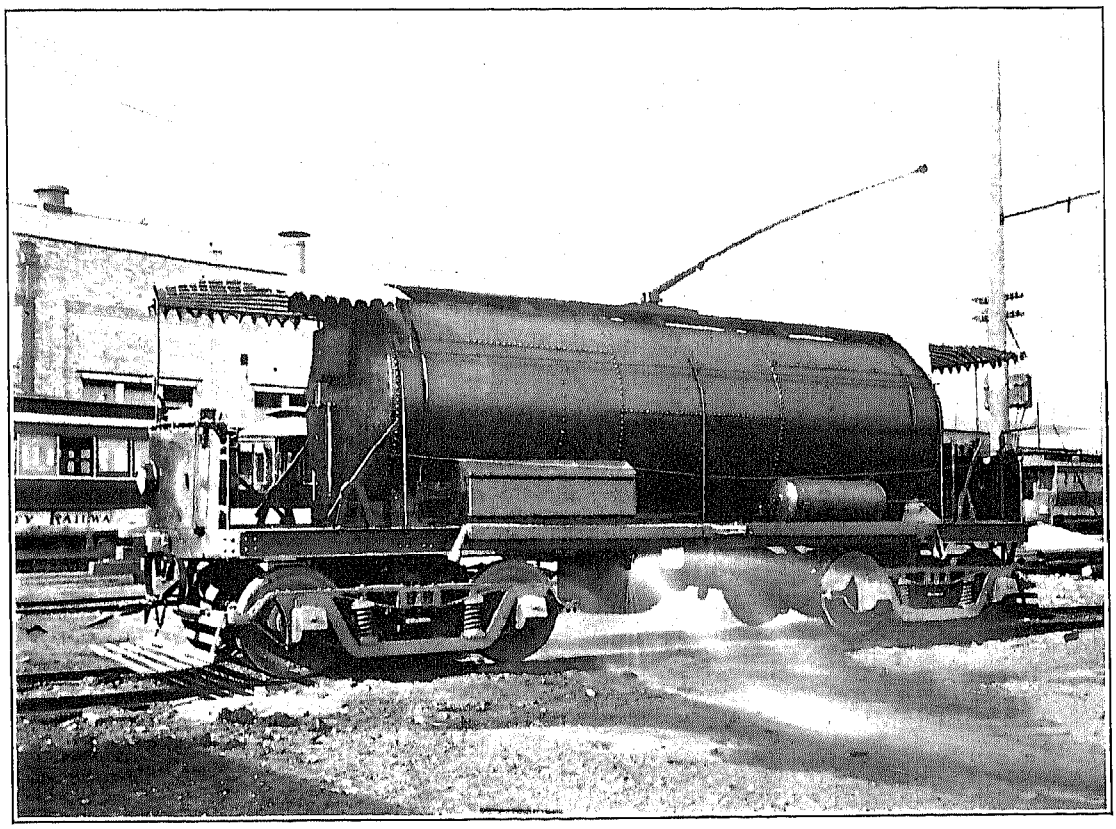
The new service, while subject to steam-railroad conditions, owing to the intermingling of trains, is novel in many respects, as the electric cars, after leaving the main tracks, run through the city streets and give practically a block-to-block service, like ordinary street cars. Moreover, under steam conditions, only two passenger trains were run daily in each direction between Syracuse and Utica, while the two trains of sleepers passing over the tracks at night were of practically no use to the residents of the cities traversed. Under the new conditions there is a fast limited service of cars or trains leaving each terminal hourly making two stops en route and completing the journey in one hour and twenty-eight minutes. There are local cars or trains which make a schedule speed of 24 miles an hour and complete the run in one hour and fifty-eight minutes, providing also an hourly service from each terminal, with as frequent stops as may be required by the passengers aboard. There is also a fast steam freight service.

The road started with an equipment of 15 cars, each having 4 motors of a capacity of 75 horsepower, the cars being made up into trains to suit requirements. Each car has a length, over buffers, of 49 feet; a width, over all, of 8 feet 9 inches; a height, from top of rail to top of trolley board, of 12 feet 11¾ inches; a weight of 79,780 pounds; and a seating capacity of 52 persons. As already noted elsewhere the line is equipped with a third rail for underrunning contact of the same nature as that employed on the electrified zone of the New York Central. Electrical energy is to be supplied to the system from transmission lines, at a pressure of 60,000 volts, by the Hudson River Electric Power Company, whose transmission system is 100 miles in length, extending from Spiers Falls to Utica. The high-tension 3-phase current is reduced in pressure and converted to direct current of 600 volts at 4 substations distributed along the line at an average distance apart of 10¾ miles.

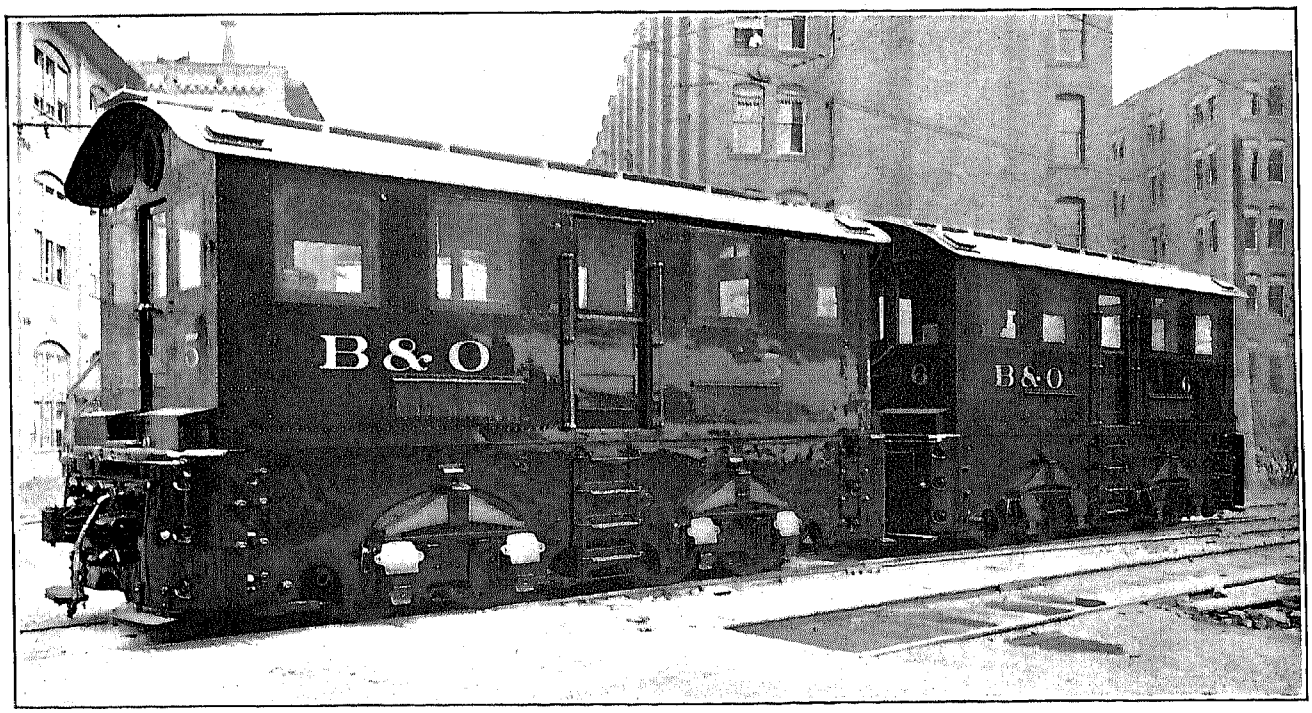
*Types of electric locomotives.*—The subject of electric-locomotive design is incident to the change that has been going on in the adoption of electricity by steam railroads, and various types have been noted in the course of this chapter. In order to get a clearer view of the steps taken, it may be pointed out that the first large electric locomotives, designed and built specifically for high-speed electric traction, as distinguished from those built for low-speed work, as on the Baltimore and Ohio road, were used in the New York Central service. These were a radical departure, in most respects, from any steam or electric machines previously built for such service. They had a long, rigid wheel base with four driving axles and a radial pony truck at each end; the motor armatures were built up solidly on the driving axles, while the motor field magnets and frame were supported on the locomotive framework. The driving wheels were only 44 inches in diameter, and were not connected with side rods or by any other means. In the original experimental locomotives of this type there were springs fitted on the side of the driving-axle boxes to absorb the side shocks, but in the locomotives built soon after, under contract, these were omitted.

The next general large type for high-speed work was that of the New York, New Haven and Hartford system, with two separate 4-wheel trucks, carrying a motor on each axle, designed for single-phase work. With the object of relieving the axles of the dead weight of the motor armatures, the latter were carried on pins set into spring pockets in the driving-wheel centers. These locomotives had driving wheels 62 inches in diameter as compared with 44 inches of the New York Central type, but no guiding wheels of any kind, the entire weight being available for adhesion.

Another development was that of the half-unit experimental single-phase locomotive, built in 1907 for the Pennsylvania Railroad, and tested at very high speeds on the West Jersey and Seashore line between Camden and Atlantic City. This type is the exact counterpart of the so-called Atlantic or 8-wheel type of steam locomotive, well known as the general standard for passenger service in the United States. It has two driving axles, wheels 72 inches in diameter mounted in the main frame and a swiveling



STREET SPRINKLER.




TWO UNIT TYPES OF 150-TON LOCOMOTIVES ON BALTIMORE AND OHIO RAILROAD.

4-wheel bogey truck in front, which carries 45,000 pounds, nearly one-third of the total weight. The motor armatures are supported on quills in spring pockets in the driving-wheel centers like those of the New Haven type.

These three general types have served as points of new departure, and modifications embodying more or less radical changes are already seen. The 12 new locomotives for the New York Central have swiveling bogey trucks at each end, instead of a radial pony truck, and the side-thrust springs on the driving-axle boxes, abandoned after their use on the experimental locomotives of 1904–5, have again been adopted. The manufacturers of these locomotives have also built a high-speed experimental locomotive, which was under test during the preparation of this report, and which is of yet another type, having two articulated trucks, each consisting of a pair of pony wheels, at each end and two driving axles in the center. The driving wheels are connected by side rods. The new models of the New Haven locomotives are distinguished by the addition of a single pony axle placed in front of the driving wheels of each motor truck. The addition of these pony wheels, which are equalized with the main driving wheels, has afforded a marked improvement in the riding quality of the locomotive, although making some reduction in the adhesion weight. The tendency, however, appears to be toward a sacrifice of adhesion weight in order to secure better riding qualities.

*The gasoline electric locomotive.*—An interesting type of locomotive for use on street and main steam railroads should be mentioned, which does not fall within any of the classifications mentioned above, namely, the gasoline electric car. In this car, which is illustrated in the report, a car body of suitable design is mounted upon bogey trucks. The forward truck is equipped with 2 standard electric-railway motors of 100 horsepower each. In the forward compartment of the car is placed the power plant, consisting of a gasoline engine and an electric generator of about 125-horsepower capacity. The power plant consists of an 8-cylinder, 4-cycle gasoline engine, 550 revolutions per minute, direct-connected to an 8-pole, 80-kilowatt, 600-volt commutator pole generator, with a direct-coupled 3½-watt, 32-volt exciter for the field magnets. There is no mechanical connection between the power-generating plant and the power truck. The energy is transmitted by means of electricity, the current from the generator driving the motors, which are controlled by a device similar to the controller on a trolley car, whereby the car can be started, accelerated, stopped, and reversed by the manipulation of the controller handle. This combination gives great flexibility of control and ease of operation, being simple and economical, and in its effect equivalent to a mechanical connection with a practically infinite number of gear ratios, but without change of gears. The speed of the car is from 50 to 60 miles an hour, and it can be stopped and reversed without stopping or changing the direction of the rotation of the gasoline engine. The car is arranged for operation either from the self-contained power plant or from 600-volt direct-current overhead-trolley circuits, and can also be adjusted to a third-rail circuit. The car is electrically lighted by 25-volt incandescent lamps and carries a 52-candle-power incandescent headlight. For these, current is supplied from the exciter when the main gasoline engine is running, otherwise from a 12-cell storage battery located under the car body. Automatic means are provided for switching the lights from one system of circuits to the other, and for charging the battery from the exciter. The car body is heated by a system of hot water operated on the thermo-siphon principle, the heat being obtained from the exhausted gases of the engine. This type of car, with steel construction, has been built and successfully operated for commercial service on one or two of the main lines of railroad.

*General effect on traction industry.*—It will be seen from the foregoing study of the subject that the adoption of electricity has already played an important part on standard railways, and on street and interurban railways where steam locomotives or steam dummies were previously employed. The records of the Bureau of the Census do not include specific data on this point other than those cited above, but a very careful investigation of the subject has been made by Mr. W. J. Clark, electric-railway expert of the General Electric Company, who has compiled two statements on this subject which are deemed appropriate to be given in this report and are reproduced below. It will be seen from the first statement relating to street and interurban railways, that since January, 1888, on 126 roads of that character, 558 steam units have been replaced by electric. It will also be seen, from the second statement of the partial list of the changes of equipment on standard steam railways, that on 24 roads approximately 863 steam locomotives have been replaced, making a total of 1,421 electric locomotives or motor cars in use where steam locomotives would otherwise now be employed.

*Partial list of steam locomotives and dummies replaced by electrical equipment on American street and interurban railways since January 1, 1888.*

| | |
|---|---|
| Alabama | Anniston Street Railway, 2; Bessemer Dummy Line Co., 2; Birmingham and F. C. Dummy Street, 2; Birmingham Railway and Electric, 16; Blountsville and Bangor Dummy Line, 6; Decatur and Trinity Belt Line, 1; East Birmingham Street, 3; Gadsden Land and Improvement Co., 2; Highland Avenue and Belt, 8; Mobile and Spring Hill R. R., 1; Mobile Street, 4; North Birmingham Street, 4; Oxford Lake Line, 2; Selma Street Railway and Dummy Line, 7; Sheffield Street, 2; South Calera Land and Improvement Co., 1; Tuscaloosa, 1. |

*Partial list of steam locomotives and dummies replaced by electrical equipment on American street and interurban railways since January 1, 1888*—Continued.

California.....California Railway (Oakland), 4; City (Pasadena), 1; Coronado, 9; Eureka Street, 6; Ferries and Cliff House, 10; Geary Street Park and Ocean, 4; Los Angeles and Redondo Ry., 12; National City and Otaya, 5; North Shore Ry., 8 (?); Pacific Coast Ry., 6 (?); Park and Ocean, 7; Presidio and Ferries, 5; San Diego, Old Town and P. B., 3; San Jose and Alum Rock Park, 4; Southern California Motor, 3; Temescal and Berkeley Ry., 6.

Colorado.....Colfax Electric, 1.

Florida.....East Florida Land and P. Co., 2; Pensacola Terminal, 3; Tampa Street, 3.

Georgia.....Atlanta and Edgewood Street Ry., 2; Atlanta Consolidated Street, 2; City and Suburban (Savannah), 3; Coast Line, 1; Columbus, 3; Metropolitan Street, 10; Milledgeville and Asylum, 2; Rome Street, 3; West End and Atlanta Street, 1.

Illinois.....Alton Improvement Association, 2; Rock Island and Milan Street Ry., 4; Union Street, 2.

Indiana.....Evansville, 2; Muncie Street, 4.

Iowa.....Ames and College, 1; Des Moines Suburban, 4; Lake Manawa, 5; Sioux City and Highland Park Ry., 3; Sioux City and Morning Side, 2; Sioux City Rapid Transit, 4; Twin City and Des Moines River Motor Street Ry., 2.

Kansas.....East Side Street, 3; Leavenworth Rapid Transit, 5; Riverside and Suburban R. R., 1; Topeka Belt, 2; Topeka Rapid Transit Ry. Co., 6; West Side Circle, 3; Wichita and Valley Center, 3.

Kentucky.....Winchester Street Ry., 1.

Louisiana.....New Orleans and Carrollton, 19; New Orleans City and Lake, 7; New Orleans Spanish Fort and L., 6.

Massachusetts.....Black Rocks and Salisbury Beach, 1; East Wareham O. B. and P. I. Street, 2; Hoosic Valley Street, 2.

Michigan.....Ann Arbor and Ypsilanti Street, 2; East Detroit and Grosse Points, 7; North Park Street, 2.

Minnesota.....Tower and Soudan Street, 2.

Mississippi.....Columbus Street Ry. and Power Co., 1.

Missouri.....East Fifth Street, 9; Interstate Consolidated Rapid Transit, 17; Kansas City, Independence and Park, 5; St. Louis Cable and Western Ry. Co., 8; Waldo Park, 6.

Montana.....Butte Consolidated, 5; Great Falls Street, 1.

Nebraska.....Lincoln Rapid Transit Co., 3; Metropolitan Cable, 10; Omaha Southwestern Street, 4.

New Hampshire.....Concord Street, 2.

New Jersey.....Atlantic City Ry., 5; North Hudson County, 10.

New York.....Brooklyn City, 29; Elmira and Horseheads, 2; New Brighton and Onondaga Valley R. R., 1; Seneca Falls and Waterloo R. R., 2.

*Partial list of steam locomotives and dummies replaced by electrical equipment on American street and interurban railways since January 1, 1888*—Continued.

Ohio.....Columbus and Cincinnati Street Ry. Co., 3; Pendleton, Mount Lookout and N. W. H., 4; Price Hill Inclined Pl., 2; Wellston and Jackson Belt Ry., 2.

Oregon.....Albany Street, 1; City and Suburban, 6; City and West Portland Park, 2; Mount Tabor Street, 3.

Pennsylvania.....Frankford and Southwark Philadelphia City Passenger R. R., 8.

South Dakota.....Watertown and Lake Kampeska, 2.

Tennessee.....East End, 4; Fountain Head, 3; Memphis and Prospect Park Ry. Co., 1; Nashville and W. U., 4; Overland, 6; Tennessee River and Waldens Ridge R. R., 3.

Texas.....Corpus Christi Imp., 2; Dallas and Oak Cliff, 4; Dallas Rapid Transit, 4 (?); Denison Rapid Transit, 2; North Dallas Circuit, 2; North Side Street Ry. Co. (Fort Worth), 2; North Texas Traction Co., 4; Waco Street, 2.

Utah.....Ogden and Northwestern, 2; West Side Rapid Transit, 4.

Virginia.....Roanoke Street, 2.

Washington.....Point Defiance Street, 3; Seattle City, 2; Spokane Falls and Montana, 2; Tacoma (eight lines), 40.

West Virginia.....Wheeling and Elm Grove, 5.

Total number of roads, 126.
Total number of steam units replaced, 558.

*Partial list of steam locomotives replaced by electrical equipment on standard railways in America.*

California.....Southern Pacific Co. (Oakland), 20.

Connecticut.....New York, New Haven and Hartford R. R. (New Canaan branch), 4; New York, New Haven and Hartford R. R. (Stamford to New York), 45.

Illinois.....South Side Elevated R. R., 46; Lake Street Elevated R. R., 40.

Maryland.....Baltimore and Ohio R. R. (Baltimore tunnel), 4.

Massachusetts.....New York, New Haven and Hartford (Nantasket branch), 8.

Michigan.....Grand Trunk R. R. (Sarnia tunnel), — (?)

New Jersey.....Pennsylvania R. R. (West Jersey and Seashore), 20.

New York.....Erie R. R. (Lockport and Tonawanda), 5; Erie R. R. (Rochester-Avon), 6; Brooklyn and Brighton Beach, 8; Brooklyn, Bath and West End, 7; New York and Sea Beach, 6; Prospect Park and Coney Island, 10; Brooklyn Elevated, 95; Kings County Elevated, 44; Sea View, 7; Brooklyn Bridge, 19; Manhattan Elevated, 334; Long Island R. R. (suburban service), 40; New York Central (New York terminal), 70.

Ohio.....Cincinnati, Georgetown and Portsmouth, 5.

Rhode Island.....New York, New Haven and Hartford R. R. (Providence, Warren and Bristol), 20.

Total number of roads, approximately 24.
Total number of steam locomotives replaced, approximately 863.

# CHAPTER IV.

## INTERURBAN RAILWAYS—ECONOMIC, FINANCIAL, AND SOCIAL FEATURES.

*Conditions of interurban development.*—One of the leading features, if not indeed the principal one, of electric-railway development during the period 1902 to 1907, was the extension of the interurban electric railways which are now to be found in almost every part of the country, and which in many instances, by the extent of their operations, rival main lines of steam railroad. In the report for 1902 considerable attention was paid to this development, of which the various elements were discussed for the first time. The radical nature of this advance and its bearing upon the street-railway industry are well indicated by the fact that the representative national body, the American Street Railway Association, has changed its name, and the better to represent and designate the field which it covers has become the American Street and Interurban Railway Association. While it is true that many of the interurban roads have a large city or community as a terminal or at some point along the line, their trackage lies very largely in rural districts and they often merely make connection with the existing local street-railway systems at the populated points they touch. One of the first effects of the application of electricity to street-railway traffic was to develop suburban passenger business and to build up widely scattered suburban districts. The secondary effect was soon made manifest in the operation of interurban electric railways, which, in knitting the whole community together, have done for vast rural regions what the street railway has done for the suburbs, and have benefited both city and country alike. One of the remarkable features of this development is the continuity of service afforded, enabling a passenger who wishes to travel cheaply to use the trolley almost without a break over long routes, so that to-day there are comparatively few interruptions to a trip of this kind between New York and Chicago, Boston and New York, Indianapolis and Chicago, Chicago and St. Louis, Louisville and Cincinnati, and other widely separated points.

*Length of journey possible.*—As the result of the work done during 1906, 1907, and 1908, one may now travel by trolley cars from Sheboygan, Wis., or Rockford, Ill., to Port Huron, Mich., Louisville, Ky., or to Buffalo, N. Y., with but one interruption in the service, and during 1908 a gap of less than 20 miles in the longest trip named was being closed. To go by these cars from Sheboygan to Buffalo one would travel not only over roads of the best possible construction built during 1907–8, but along routes of large interurban systems constructed chiefly or wholly in the present census period, with substantial roadbeds and comfortable cars. Starting from Sheboygan, the passenger bound eastward for New York state would travel to Milwaukee over the Milwaukee Northern Railway—one of the important roads included in this report, so progressive as to generate its electrical energy with the latest type, large gas-engine-driven units. From Milwaukee the trip south 75 miles to Evanston is made over the Chicago and Milwaukee Electric Railroad, which has an electric service over a double-track line in Wisconsin and over a four-track one between Waukegan and Evanston, and which at Evanston has a joint terminal with the Northwestern Elevated Railroad Company. The next link is a double-track surface line of the Chicago, Milwaukee and St. Paul Railway, in 1908, thus furnishing the elevated road with a surface extension between Evanston and the Wilson Avenue terminal. Arrived in Chicago, the passenger has many alternative routes by which to reach Hammond, Ind., where is located the terminal of the Chicago, Lake Shore and South Bend Railway, with a heavily built, high-speed, single-phase electric-railway system of modern design, built in 1907–8. Starting from Hammond, or from Pullman, Ill., the route of this line extends along the shore of Lake Michigan and continues across the state of Indiana, the passenger reaching the eastern terminus at South Bend, after having passed through a number of important points, including Gary, the new steel center. From South Bend to Warsaw, Ind., the passenger can continue his eastern trip over the Chicago, South Bend and Northern Indiana Railway and the Winona Interurban Railway system, the latter of which has recently built an extension from Warsaw to Peru, Ind. At this point, in the vicinity of Akron and Mentone, occurs the only short break, one of about 20 miles, which is now being closed. At Peru, Ind., limited cars of the Winona Interurban connect with the limited service of the Fort Wayne and Wabash Valley Traction Company, operating between La Fayette and Fort Wayne, and from Fort Wayne the Ohio Electric Railway system covers the ground to Lima. Arrived at Lima, either of two routes can be taken to Toledo, and from that city the limited service of the Lake Shore Electric Railway Company (Ohio) continues to Cleveland over a route

of 121 miles. From Cleveland the route lies eastward through Painesville, Ashtabula, Conneaut, and Erie, over the systems of the Cleveland, Painesville and Eastern Railroad Company, Pennsylvania and Ohio Railway Company, the Conneaut and Erie Traction Company (Pa.), and the Buffalo and Lake Erie Traction Company, at last reaching Buffalo.

*Ramifications of electric lines.*—The foregoing gives a clear idea of the extent of the journey that can now be taken entirely by means of trolley lines without resort to the steam roads. But the picture is not complete, as other systems of a similar character, built or under construction during the report period, would make possible a similar journey from Buffalo to St. Louis, Mo., while now the journey, with few breaks, might possibly be continued eastward to Manhattan Island itself. These various lines referred to have been presented merely as connecting links in a continuous journey, but as a matter of fact each system should be regarded as a large and complicated network spreading over extensive portions of the states traversed, and including almost every point of importance between Buffalo, Chicago, Cincinnati, and Detroit, with ramifications that touch Missouri, Wisconsin, Kentucky, and West Virginia.

While such trips as these include sections of the line finished since the present census statistics were compiled, very few, if any, sections belong to systems not already projected in the census period nor to companies organized for work long prior to the beginning of 1908. The financial depression of the latter year has stood seriously in the way of new work of this character, but during the year a considerable number of systems have been completed or links built between systems in existence. Thus, for example, about January 1, 1908, a line was put into service between Brazil and Greencastle, Ind., by the Terre Haute, Indianapolis and Eastern Traction Company, giving through service over a direct route 73 miles long. In Missouri an exceptionally substantial line was finished from Pittsburg, in the southwestern part of the state, to Joplin, in the center of the densely populated zinc district. In Michigan steps were taken to connect the Detroit, Flint and Saginaw Railway and the Detroit United Railway, between Flint and Frankenmuth, making possible electric-railway travel between Bay City and Detroit, approximately 100 miles apart; and the Michigan United Railways Company inaugurated service on a new line between Lansing and Mason, forming a link in its high-speed third-rail division between Lansing and Jackson, from which latter city the company has for a number of years operated a single-track third-rail line to Battle Creek, as well as several divisions using the overhead trolley.

From this survey of one or two different fields, it will be seen how rapid and far-reaching the interurban development has been. One of the most active years in the entire period was 1906, when such an extraordinary development occurred throughout the state of Ohio that by the end of the year there were in operation in the state at least 2,600 miles of strictly interurban lines, while the completion of the Western Ohio Railway extension between Lima and Findlay, Ohio, was the finishing touch to a system which linked together more than 4,000 miles of interurban road in the 5 states of New York, Pennsylvania, Ohio, Michigan, and Indiana. The completion of this link was followed by the institution of "limited" service from Dayton to Toledo, a distance of 162 miles, giving, in connection with other roads, a fast trolley trip from the central part of Michigan across Ohio, and from the eastern part of Ohio westward into a very large part of Indiana. In the state of Indiana several new roads were constructed, and others operated during the previous census period were extended. Thus, for example, the Terre Haute Traction and Light Company completed an extension southward from Terre Haute to Sullivan, a distance of 26 miles, while in the vicinity of Evansville, in the extreme southwestern part of the state, two other lines were completed, to Mount Vernon, Ind., and Boonville; the Winona Interurban Railway went into operation during 1906 between Goshen and Winona, a distance of 28 miles, and then pushed its line southward from Warsaw to Peru; and early in 1907 the extension of the Indianapolis and Cincinnati Traction Company eastward from Rushville was completed, forming part of the connected road between these two large cities. Interurban systems during the period 1906–7 were also built or put in operation between Fort Wayne and Bluffton, La Fayette and Logansport, Muncie and Portland, and a number of other points. Many of these lines were at first unrelated and unconnected, but ultimately became links or subdivisions in a close network.

*System of Illinois Traction Company.*—A typical system is that of the Illinois Traction Company, composed of some 20 subsidiary companies, organized in 1904, whose ramifications now include no less than 425 miles of main line interurban track exclusive of its trackage rights in cities and its local street-railway systems. Its longest direct line is from Danville, Ill., where it owns and operates the street-railway and electric-light company and other systems, to East St. Louis, a distance of 227 miles. Near the central point of the system, two lines extend northward from the main trunk. One of these, to the eastward, connects Decatur with Bloomington, 45½ miles northward, while the other extends from Springfield to Mackinaw, 57 miles to the

north, where it connects with the Bloomington-Peoria division, 37½ miles long. The three principal branches of the system—Peoria to Springfield, 74.7 miles; Danville to Springfield, 130.7 miles; and East St. Louis to Springfield, 96.6 miles, as well as the Bloomington-Decatur division, 45.5 miles—are each served with limited trains operated at high speed on a two-hour headway. It will be understood that the use of the word "limited" refers to the limited number of stops made, the idea being to insure a quick service by restricting the number of stopping points. The schedules of the limited trains are so arranged that the cars meet at Springfield for the through transfer of passengers, so that patrons of the system can ride by limited trains from Danville, at the Illinois-Indiana border, to East St. Louis, on the Missouri line, a distance of 227 miles, on any one of six trains a day, which make the run in nine hours and forty minutes, a speed which compares favorably with that of the regular main line of steam travel. The running time for the 96.6 miles between Springfield and East St. Louis has been three hours and forty minutes, but this is being shortened at least forty minutes. A limited train leaves Danville each day at 6 p. m., reaching Springfield at 10.55, where the passengers can secure a sleeping car which arrives in St. Louis at 4.10 in the morning. The limited trains between Danville and East St. Louis make only 40 stops, or an average of 1 about every 5 miles, which gives an idea of the manner in which the service compares with ordinary steam travel rather than with suburban trolley travel, with its stops at short intervals.

The tracks of this Illinois Traction system over a large part of the distance parallel long-established steam-railroad lines throughout a territory which is both agricultural and mining, and the system is of real importance to the coal industry of the region. There are, for example, 7 coal mines along the route, which have no other outlet than the electric road, while on the parallel steam roads there are 100 coal mines, which are also served by the electric traction system. The coal traffic on the electric system is heaviest during the five winter months, when on an average about 1,000 carloads of 30 tons each of commercial coal are handled monthly. The three coal-mining districts are Danville to Champaign, Springfield to Peoria, and Staunton to Springfield, and the aim of the traffic department is so to arrange shipments that each group of mines supplies coal for its own division, thus keeping the car mileage down to as low a point as possible. The company has developed its coal business to such an extent that by 1908 it had in operation no fewer than 365 coal cars, many of which are used to deliver coal along the right of way to dealers who unload on their own special sidings directly to their own wagons for house and factory distribution. This coal traffic as well as other freight and express business is done at night, so as not to hamper the passenger schedules. During 1907-8 the company took steps to develop the freight and express traffic by the construction of belt lines around the largest cities, by inaugurating an extension of siding tracks, and by an improvement in the electric facilities. Some idea of this class of service may be formed from the fact that no fewer than 15 motor cars, 40 trailers, and 25 grain cars of 60,000 pounds capacity each are in daily use. The longest through-car express run made over the system is from Peoria to St. Louis, a distance of 171.3 miles, over which route trains are operated daily, leaving either end at 8 p. m. and arriving at the other end at 7 a. m.

The older part of the Illinois Traction system—more particularly that included in the census returns—is of the familiar direct-current type, but all the new work, including the line between Peoria and Bloomington, and a line from Mackinaw, midway between those places, through Lincoln southward to Springfield, has been done by the most advanced methods of alternating-current traction with 3,300 volts single-phase current. At the time of this report about 15 per cent of the interurban mileage was thus operated by alternating current, but it is obvious that this intermingling of direct-current and alternating-current methods must bring further important readjustments of electrical conditions.

*Conditions on Pacific slope.*—Thus far consideration has been given chiefly to interurban systems in the Middle West and the East, but it is not to be inferred that the Pacific slope has escaped this remarkable development in methods of transportation. The Spokane and Inland Empire Railroad (Wash.) has been cited as an evidence of progressive spirit; and attention may be directed also to the Pacific Electric Railway Company, of Los Angeles, Cal., which, chartered in 1901, had at the time of the census report nearly 200 miles of standard-gauge track electrified, and over 24 miles of a gauge of 3 feet 6½ inches, this network being operated with 104 passenger cars, including 14 closed, 7 open, 72 combination closed and open, and 11 combination passenger and express, etc.; 34 express, freight, and mail; 13 work and miscellaneous cars; and 2 steam locomotives. This system is mainly a consolidation of various street-railway systems and now, through its interurban lines, connects Los Angeles with Mount Lowe, Pasadena, Santa Ana, Sierra Madre, Long Beach, Huntington Beach, San Gabriel, and Naples, besides operating urban lines in 7 of the towns and cities along the route. Considering also the Los Angeles Interurban Railway Company, which is operated by the same management, there is a total of more than 500 miles of standard-gauge track built, equipped, and operated as part of the network. The lines radiating to the north, south, east, and west of Los Angeles reach every suburban town of importance within 35 miles, traverse all the fertile valleys, and make accessible all the seaside and mountain resorts that are not only patronized by the population of the

region, but invite visitors from every part of the United States. The general literature of this system in volume and attractiveness compares favorably with that issued by standard lines of steam railroads. Aside from the regular and excursion features of its business the Pacific Electric Company has developed a large amount of freight and express traffic since 1902, in which year it had no freight or express cars in operation. Equally remarkable has been the growth in passenger traffic, which of course does not necessarily imply the development of interurban traffic. It appears, however, from the company's statements that of their passenger business 56 per cent was of the strictly interurban type.

*Methods of current supply.*—During the census period the development of interurban systems of the United States from the electrical standpoint was accomplished entirely by methods, outlined in the 1902 report, of utilizing high-tension alternating current transmitted to various substations along the route, where this current passed through transformers and rotary converters—aided sometimes by storage batteries—and was delivered as direct current to the consumption circuit and to the motors on the cars. Early in the present census period, however, a further step in electrical development was taken by the adoption of the single-phase electric-railway system, of which, toward the close of the period, the most striking example was found on the New York, New Haven and Hartford Railroad. From the rapid progress made in this development of this single-phase method it seems likely to become a predominant method in the interurban work of the future, although various attempts have been made to develop the high-tension current system by raising the voltage used by the motors on the cars. In almost every instance the standard voltage for direct-current interurban systems included in this report has been 550 to 600 volts—this limitation being due to what was considered both feasible for the motors and safe for the public. There are, however, now in operation in this country a few direct-current systems where the pressure has been carried as high as 1,200 volts.

An interesting example of this work is furnished by the Indianapolis and Louisville Traction Company, the first interurban road in the United States to employ this high-tension system as well as the first to give connection through this section of the country. This line, equipped during 1907, has lines extending from Seymour on the north to Sellersburg on the south, a distance of 41 miles, and operates through cars from Louisville, Ky., of which Sellersburg is a suburb, as far north as Indianapolis, a run, in an almost direct line, of 110 miles.

The connections between the two cities are as follows: The lines of the Indianapolis, Columbus and Southern Traction Company, extending from Indianapolis southward to Seymour, are operated at 600 volts direct current; the Indianapolis and Louisville Traction Company's lines, connecting Seymour with Sellersburg, operate with a 1,200-volt current; while the Louisville and Northern Railway and Lighting Company and the Louisville and Southern Indiana Traction Company, connecting, respectively, Sellersburg with Jeffersonville, and Jeffersonville with Louisville, are both operated at 600 volts direct, under which conditions the system penetrates to the heart of Louisville.

The Indianapolis and Louisville line parallels the tracks of the Pennsylvania Railroad for a considerable part of the way, and, owing to the fact that the steam trains are run only at long intervals, has secured a large portion of the local traffic. The prices charged for transportation by the electric road are also below those of the competing steam railroads, and as the 2-cent fare is in force throughout Indiana the facilities for cheap transportation have thus been materially increased. Terminal facilities have been secured in both Louisville and Indianapolis, so that the comfort and convenience of passengers is enhanced by enabling them to complete their journey well within both cities.

The direct current for the line is generated by two standard 600-volt railway generators connected in series, so that the current is delivered to the consumption line at 1,200 volts. The motors on the cars are of what is known as the commutating-pole type, the use of the greater number of poles permitting the higher voltage to be used without danger of burning out the motor, the four smaller or commutator poles being placed between the main poles of the motors. The commutating poles are permanently connected in series with the armature, an arrangement which insures a variation of excitation and commutating field strength in sympathy with the load on the motor. The exciting fields are connected and handled exactly as are those on a standard 600-volt equipment, such as will be found in most of the interurban systems included in this report. When operated on a 600-volt current the four motors are grouped in the regular series parallel relation, but when on 1,200 volts they are divided into two groups each of two motors in series. These groups are in series and in parallel for accelerating and for free running, respectively. The change from the 600-volt to the 1,200-volt is made through a special commutating switch designed for the purpose.

The Central California Traction Company has also developed more recently a 1,200-volt direct-current system of the same character, comparing in general with the Indianapolis and Louisville line, with the exception that over the right of way outside of Stockton the 1,200-volt current is collected from a third rail instead of an overhead wire. In this instance, as in the other, in order to avoid changing in the connections of the controlling lighting and heating circuits when changing from 600 to 1,200 volts, a motor-generator

set, or what is sometimes termed a "dynamotor," is carried on the car. This machine has two sets of windings on the same core and in the same slots; is provided with a commutator at each end of the shaft; and in present practice has a maximum capacity of 10 kilowatts. The current generated operates the motor-control circuit, lamps, air compressor, and heaters. The motor-generator contactor box contains a 600-volt and a 1,200-volt contactor controlling the admission of the current or the reverse condition according to the section of the line over which the car is operating and the voltage employed. Both contactors can not be closed at the same time, so that the car can pass readily and safely from one voltage to the other.

*Twelve-hundred-volt system.*—Up to the present time 1,200-volt motors have not been adapted to ordinary street-railway transportation, but they are considered desirable for interurban roads 25 miles or more in length. The important factor in the use of this higher voltage is, of course, in the elimination of the substation, which, aside from the first cost of installation, is expensive in operation, this expense, exclusive of interest and fixed charges, being placed at about $300 a month, which is virtually a fixed charge. It follows, therefore, that if one substation at 1,200 volts can be made to perform the same work ordinarily requiring two 550-volt or 600-volt stations, a saving of at least from 10 to 20 per cent in energy and other items is effected, while obviously over a shorter road the substation could be dispensed with altogether, and the energy generated at 1,200 volts direct current could be delivered directly to the line without any manipulation or transformation whatever. The results obtained in this direction have already made it possible for the voltage on direct-current trolley systems to be carried much higher, even to 2,400 volts, which of course would lead to a readjustment of conditions prevailing in the present census period.

*Use of single-phase alternating current.*—During the last three or four years an entirely new system of motive power has been developed for the operation of electric railroads, particularly those of the interurban class, although, as has already been pointed out, it has pushed its way into the steam-railroad field in this country, and in Europe has found a widespread application. This is the single-phase alternating-current system, applying a motor which can be operated entirely with alternating current at high voltage, but which can also, if desired, be employed part of the time, as within city limits, over direct-current sections as a direct-current motor. The use of such alternating-current methods carries with it the advantage of lower first cost and the elimination of the rotary-converter substation. Owing to the material reduction in first cost thus secured, many railroad problems, it is claimed, which have been economically impossible on account of the excessive initial expense of electrification, can now be considered from the electrical standpoint. It has previously been the practice to operate alternating-current apparatus at a high number of alternations of current in the circuit, but in the single-phase motors the frequency has been brought down as low as 25 or even 15 cycles. A great many of the interurban roads included in this report are of the single-phase type. Thus the Washington, Baltimore and Annapolis Railway, with 61.4 miles of track and 25 cars, employs 575 volts on its direct-current operation and 6,600 volts in operating single-phase with a frequency of 25 cycles. This road was not put into operation until shortly after the census year. The Indianapolis and Cincinnati Traction Company put into service in December, 1904, a system of this kind, with 116 miles of track and 25 cars, with motors operating at 550 volts direct current and 3,300 alternating single-phase, 25 cycles. The Spokane and Inland Empire Railroad Company, with 222.19 miles of track, had some 80 motor cars operated at 550 volts direct current and 6,600 volts alternating single-phase, 25 cycles. The Warren and Jamestown Street Railway (Pa.), put into operation in September, 1905, has 20.32 miles of track with 6 cars, operating at 3,300 volts single-phase alternating, 25 cycles. The Fort Wayne and Springfield Railway Company (Ind.), put into operation in January, 1907, has 20.55 miles of electric track with 4 cars, operating at 6,600 volts single-phase alternating and 25 cycles. The cars in almost all these instances of single-phase work are operated with 4 motors to the car, with a capacity ranging from 50 to 100 horsepower per motor, and are therefore examples of the heavy work comparable with that done on steam railroads. A number of other instances might be cited, but these will suffice to show how rapidly the new method has come into use, and the general manner in which it has been applied to one of the most difficult problems connected with interurban work, namely, the economical delivery of current over an extensive network to large motor cars operating at high speed.

*Higher voltage for wider distribution.*—It will be understood, however, that on the great majority of interurban roads, as well as on all the urban systems, the direct-current method is still in use, and is likely to continue the established system for various reasons, one of which is the cost of making a change. When the last report was compiled a number of the earlier interurban systems employed the direct current, not only at the motors on the line but for transmission purposes, but the use of alternating current for transmission was begun prior to 1902 and has developed enormously in connection with interurban work. One of the first roads of this character was the Toledo, Fremont and Norwalk Railroad in Ohio—now part of the Lake Shore Electric Railway system, with 16,500 volts alternating current delivered over 65 miles of road; this was followed in the Middle West by the Stark Electric Railroad (Ohio) and the Cleveland and Southwestern

Traction Company (now a part of the Cleveland, Southwestern and Columbus Railway Company) employing 22,000 and 24,000 volts, respectively; and the next step was taken by the Western Ohio Railway Company, which with an 80-mile line and a station of 3,300-kilowatt capacity went to the high potential of 33,000 volts. This utilization of alternating current with high pressures has enabled a single power plant to serve an extraordinarily large territory and trackage. Thus, for example, during 1906 the St. Mary's power plant of the Western Ohio, situated near the center of the system, with lines radiating in four directions, took care of 177 miles of road. At the end of 1906 the Medway power station of the Indiana, Columbus and Eastern Traction Company (lessor to Ohio Electric Railway Company) was supplying 165 miles, and since then has added considerably to the mileage served; the Cleveland and Southwestern, with 135 miles of road fed from a single station in 1906, has added 86 miles to its load; while the Lake Shore Electric in 1906–7 was supplying about 200 miles of track from its two power stations. This latter line has a single stretch of 120 miles, and the stations of approximately the same size, located at suitable distances from the ends of the line, distribute the load between themselves to the best advantage, the longest transmission being not more than 35 miles on the main line.

Some of the interurban roads, of which these cited are typical, generate the high voltage directly from the alternating-current machinery employed, while others develop the current at a low voltage and then use step-up transformers for delivery to the transmission line, the current being stepped down at the substation by transformers and delivered to the rotary converters in the usual manner. A pressure of 33,000 volts on the transmission system has now become quite common as a standard voltage, while others operate at 26,400 volts. During the last few years several of the interurban systems have taken their current from lines with even a greater voltage than these, as, for example, the power-transmission plant of the Grand Rapids-Muskegon Power Company, which is working at a pressure of 80,000 and 100,000 volts, furnishes current to several interurban railways.

With regard to substations, it may be noted that some little variation exists both as to the distance apart and the nature of substations or equipment. In Indiana the average distance apart of the substations on the interurban roads appears to be from 12 to 21 miles, giving perhaps an average of 15 miles; on the Indianapolis Northern division of the Indiana Union Traction Company the distance is, with one exception, 17 miles, while the substations of the Indianapolis and Northwestern Traction Company are 16 miles apart, irrespective of towns. Two methods have been common with regard to the location of substations, one of which has been that of placing the substations in villages along the route, where the attendant can perform the various duties of station operator, ticket agent, and freight agent. This has required the design of special buildings suitable for the purpose, with the substation in one part. Of late years, however, the tendency appears to be toward the isolation of the substation, so that the attendant can give his exclusive attention to the machinery, and also because in some towns and villages high-tension lines, passing through the streets to the substations, have been regarded as objectionable and dangerous. The Western Ohio Railway Company, for instance, has four isolated substations which are two-story brick residences, fitted up as homes for the attendants, who are on duty practically all the time. The Scioto Valley Traction Company (Ohio) has also isolated its substations and machinery. In a number of places its stations are in towns, and the ticket offices and the freight stations are in independent buildings and have separate attendants. Older methods are, however, often used in the later systems, as in the case of the Oregon Electric Railway system, organized in 1906, and not put into operation until 1908, and mentioned elsewhere in this report. This system has five substations of its own along the line, while the ends of the line are fed from substations belonging to the local power and light companies in Portland and Salem. The company's own substations, however, have not only electrical compartments for the reception and transformation of current, but have waiting rooms and ticket offices, and the attendants act as electricians, station agents, and telegraph operators.

The transformers and rotary converters in such stations are of a size dependent to a certain extent upon the work required and the amount of traffic over the road, but the step-down transformers range in size from 150 to 300 kilowatts, and are usually of the oil-cooled type. In like manner the rotary converter which receives the low-pressure alternating current and delivers it as direct current to the consumption line averages from 200 to 350 kilowatts.

An interesting practice that has developed during the census period is that of employing for various uses "floating" or portable substations, which are outfits mounted on cars. These stations are either old freight cars strong enough to carry the weight, or, more particularly in later practice, cars specially designed and built for the purpose, and are kept on convenient sidings to serve temporarily the purpose of substations. It often happens that at some seasons and points on a line there is a special congestion of traffic, due to ball games, county fairs, horse races, etc. At such times these portable substations are taken to the nearest convenient point along the line and are able to secure from the transmission circuits the additional current needed for handling the exceptional traffic. Or, in case of an accident to any of the permanent sub-

stations along an interurban line, one of these floating stations can immediately be called on to take its place. They constitute thus both a means of dealing with sudden or unusual congestion of traffic at any point and a reserve against accident.

*Bases of interurban exploitation.*—The work of developing interurban systems has been due largely to the operation of large syndicates, many of which are known in the electric-railway field under various corporate names and popular designations, and which often represent groups more or less closely related. Such operations were active during the census period and are likely to continue unchecked so long as the necessity for these roads exists or profit from their construction and management appears possible. Very close study, however, is now being made of all the conditions bearing upon the development of these roads, and with the control likely to be exercised by public-service commissions with large powers there is good reason to expect a cessation of the somewhat hazardous exploitation which marked the earlier stages.

In regard to interurban-railway work, it is safe to assume that traffic will increase with the population served; but it is exceedingly difficult to determine the number of people who are served by the roads or who may be regarded as living in the territory that would naturally supply it with traffic. One of the difficulties in this respect appears in connection with the terminal city of the interurban line. Most lines of this character have a city of at least fair size at one end of the line, and often at either end, and in such networks as have been referred to above several large cities are frequently included. These conditions obviously have a marked influence on the traffic, both passenger and freight, as the people in the country will be frequent visitors to the town, while those in the city will often ride into the country and may be tempted to live out some distance in the rural regions, actually occupying individual farms rather than living, as before, in merely suburban districts. It is obvious, however, that the entire population of the terminal city can not be included in any estimate of the interurban-railway business, or, if included and counted in the tributary population, can not be regarded in the same light as the residents of the smaller rural communities for whom the interurban line is the great if not the only means of transportation by rail. As to the interurban population itself, the facility with which people travel on the line is inversely proportional to the distance at which they live from the tracks, and in practice the usual method is to include all the population residing within 2½ miles on either side of the line. This district, however, has to be carefully canvassed, as the population is irregularly distributed, part of it being clustered in villages and hamlets and part widely scattered on farms which can not in any way come into the returns of urban or semiurban population. Hence a variety of methods are followed by engineers and financiers in making investigations as to the probable earning capacity of interurban systems. It appears that some of the financial or engineering authorities engaged in such work count in the entire population of the terminal city if below 50,000 people, while if above that figure they credit the terminal with 50,000 plus a gradually decreasing percentage of the additional inhabitants above that number. By others the population of the terminal city is thrown out altogether from the estimate, one of the reasons being that while the terminal city is on the route of the system the traffic, under ordinary circumstances, comes mostly from the rural population visiting the terminal city along the line rather than vice versa. This condition might be varied by the location of a park some distance out on the line of the road, as the park would be visited principally by city residents; but, if a special allowance be made for such travel, the ordinary traffic to be secured can be and often is figured exclusively from the rural population. Among the states which were prominent in the earliest days of interurban electric development are Ohio and Indiana, where such roads have been in operation longer than in other sections of the country, and have now become almost continuous. It was at one time assumed in many quarters that, owing to the favorable conditions, interurban roads in Ohio could earn from 20 to 25 per cent more per mile than roads in the adjacent states of Indiana or Pennsylvania. The reason given was that there was more manufacturing in Ohio than in the other states, which would tend to create a large amount of travel not to be found in rural or agricultural districts. The rapid development, however, of interurban railways in Indiana seems to contradict this theory and to prove that a prosperous agricultural population, not too far removed from urban centers, is quite as ready to use transportation facilities as one devoted to manufacturing, and equally able to contribute to its earnings.

The conditions connected with the introduction of the interurban-railway system include not only the consideration of tributary population for 2½ or 3 miles on either side of the track and the nature of the industries of the region—agricultural, manufacturing, etc.—but also the laws of the state or the rulings of the public-service commissions bearing upon the subject, particularly with regard to franchises and rights of way. The character of construction is also an important matter, dealing as it does with the kind of roadbed, grades, curves, rails, bridges, etc., and the power-plant equipment, while the estimate of cost must include right of way, roadbed, track, line construction, buildings and power plant, rolling stock, and a number of incidental expenses connected with the preliminary legal and engineering work. The question of probable earnings is perhaps the chief consideration, and increasing attention is given to it in a study of interurban-

railway problems. The gross earnings per annum are often approximated by comparison with other roads; by taking the assumed receipts per mile of track per annum; or by multiplying the number of persons tributary to the line by an assumed amount to be expended per person per annum for such transportation. Another general method is to estimate the probable passenger, freight, and express revenues separately, that from passenger receipts being derived by multiplying the number of car miles run by unit receipts per car mile, while the freight estimates are sometimes reached by multiplying the number of carloads of freight in and out of the territory by an average rate per car, and adding thereto a lump sum for express and light-package business. There will also be a possible income from special events, such as conventions, holiday travel, and summer amusements, and special estimates will also include rentals and the sale of power. The gross expenditures to be considered are operating and interest charges, taxes, and damages, while the net income is applied to depreciation account and dividends on the stock.

In discussing this general subject in 1907 Mr. Robert P. Wood, president of the Indiana Engineering Society, pointed out the complex nature of the conditions involved in interurban-railway work, and under the subject of franchises outlined in abstract a municipal franchise, considered fair to all parties, which would consist of 14 sections, as follows:

Sec. 1. Consent of authorities and designation of route. Sec. 2. Kind of rails with top conforming to surface of highway or street. Sec. 3. Right of company to repair and obligation to maintain existing pavement for width of 8 feet. Sec. 4. Obligation to repave the 8-foot width with new materials when balance of street is being paved, but the railway company is allowed privilege of doing its own work. Sec. 5. Right of company to maintain, construct, and operate the railway over and across all railroads and bridges. The bridge provision is omitted in county franchises. Cars are entitled to the tracks against all vehicles, except funeral processions and fire department when on duty. Sec. 6. Location, kind and manner of setting poles, and height of cross wires. Poles and wires not to interfere with existing telegraph, telephone, fire-alarm, or electric-light wire unnecessarily. Sec. 7. In a municipal franchise the city is relieved from any responsibility or damage done by or to traction company. Sec. 8. Nothing granted shall be construed to take away from the common council the exclusive power it now has over the streets and alleys. Sec. 9. Right to transport passengers, mail, express, and freight, and to regulate its own rates. Sec. 10. Company agrees to adjust tracks and fix grades during improvement work. Sec. 11. Company has right to run schedule it deems consistent. Sec. 12. Length of franchise, fifty years. Sec. 13. As a consideration for franchises the company shall construct, complete, and operate a line of electric railway in said city, town, or county, within two years from acceptance of grant, otherwise franchise is void. Sec. 14. Ordinance is in force from and after its passage and acceptance by grantee.

*Resort to private rights of way.*—With regard to securing such municipal franchises and also to utilizing a part of the highway, the practice of using a cross-country private right of way has distinctly grown in popularity. Many of the earlier interurban roads were built under county grant along the pikes and public highways. Thus, for example, the Lake Shore Electric Railway had in 1906 a location on the Perrysburg turnpike 10 feet wide for about one-third of its route. Several other roads in Ohio had considerable portions of their line along the national pike, a wide thoroughfare extending entirely across the state. In many places also they had the advantage of a ditch and poles between their tracks and the highway. The use of pikes has, however, been very generally abandoned, especially toward the close of the present census period, and many of the new roads in different parts of the country have bought private rights of way and shifted their tracks to these new locations. Among the objections to the use of pikes are the short life of the franchise, the inability to secure good drainage and grades, and the danger of operation due to collision, runaways, etc.

The next step in advance was the development of the system on a private right of way immediately adjoining the turnpike, it being often much easier to obtain from a man's farm a narrow strip adjoining the highway, where such a strip would be left almost invariably uncultivated, than one cutting across a farm and dividing it arbitrarily. The farmer was also willing and even anxious to have such a line pass immediately in front of his house or along the edge of his property. The more recent development in the direction of high-speed limited cars, intermingled frequently with long freight trains, has rendered the private right of way adjoining a pike almost as undesirable as the highway itself; and, in addition, a cross-country right of way enables the road to fence in on both sides, and to suit its own convenience in matters of grade, drainage, and speed.

*Paralleling of steam railroads.*—Another incidental method of development has been to parallel as closely as possible the right of way of a steam railroad; and the traveler on main lines of steam railroad in almost any part of the country can not fail to have noticed places where this practice has been put into effect, and has wondered, perhaps, why the competing electric road should thus put itself into such close relation with the steam railroad rather than get as far away as possible, in order to develop and control new traffic. There are, however, many incidental advantages in the close relation, and even though there may be some loss of traffic, it does not appear to cause the electric systems any anxiety. In some respects it enables the electric to serve better as a feeder to the main line, especially in the matter of freight.

*Desirability of avoiding main streets.*—It is still a question with interurban railroads whether it is better to seek a route along the main streets of villages or to be independent of them. The latter practice has lately been the general one, although such a system as that of the Berkshire Street Railway

Company, traversing a large portion of western Massachusetts, occupies the main thoroughfare in a large number of communities, except in places such as Lenox and Stockbridge, where the entrance of the trolley line has been forbidden by the inhabitants, who have restricted its tracks to the remote borders of the towns or hamlets. In Ohio many of the high-speed roads have carried their tracks away from the center of villages and towns wherever practicable, and find that they get as much business as ever, while avoiding the need of slowing down and the danger of accidents incidental to street operation. The Cincinnati, Georgetown and Portsmouth Railroad Company, which is a reconstructed steam railroad, owns every foot of ground traversed by the tracks, and the operation under such circumstances is most advantageous. Moreover, the private right of way across country, removed from turnpike and village streets, permits the roads to eliminate sharp curves, which are obviously objectionable from the standpoint of both high-speed operation and the running of trains of cars.

*Long-distance travel.*—So far as the development of its route and its track is concerned, the interurban electric railway is still in a period of transition and is trying to retain the advantages of the short haul while developing the long-distance travel and securing all the advantages of the long haul. Many of the interurban railroads of the newer type are strictly comparable with the main lines of steam railroad, but others must be included in the category of the ordinary street railway, making stops at practically every corner or farmhouse along the line, wherever passengers may wish to get on or off. With limited cars making only a definite number of stops between points widely apart, it is easy to maintain high speed and a highly organized train schedule, but where the stops are frequent and indeterminate, a low speed is demanded, and the total running time over a given route is so prolonged that the average rate of speed falls to a level not much higher than that of ordinary cars on a busy city thoroughfare.

The general attitude of street-railway and interurban managers on the subject is shown by the discussion which took place at the Central Electric Railway Convention at Indianapolis, in November, 1907, when the question was raised whether it paid interurban electrics to cater to long-distance travel. At the outset of the discussion it was urged that there should be agreement as to what mileage constituted long-distance travel, whether 60 miles or 160, since, a year or two before, a trip of 50 miles by interurban line had been considered long distance, but runs of 150 miles were now very frequent. It was held to be better for the long-distance car to make its entire trip only one-half or one-third filled with passengers than to start from a terminal with all the standing room taken and to discharge its passengers within 2 or 3 miles, as in suburban systems, continuing the remainder of the trip almost empty. Of the business on limited cars, 25 per cent was said to be made up of long hauls. One of the parties to the discussion said that with the existing facilities the interurban lines should not attempt to get business over distances of 400 or 500 miles, a remark which, passing without comment, shows how remarkably the ideas of interurban managers have changed in regard to the extent of operation they should undertake. The district passenger and freight agent of the Terre Haute, Indianapolis and Eastern Traction Company, and the Indiana Union Traction Company stated as an instance of what interurban roads can do in the matter of long-distance travel, that he had contracted to haul a party through from Indianapolis to Zanesville, Ohio, a distance of 250 miles. The party left Indianapolis at 8 a. m., made a one-hour stop at Dayton, Ohio, and a stop of one and a quarter hours at Columbus, arriving at Zanesville at 7 p. m. The passengers came back the same way and were delighted with the trip. It was urged by some of the debaters, on the other hand, that much energy might be dissipated in catering to long-distance travel to the neglect of local travel, which could always be added and was worth securing. A report of the board of directors of the steam railroad paralleling the Fort Wayne and Wabash Valley Traction Company was quoted, to the effect that all the local steam travel had been lost to the interurban road, owing to the attention given by the latter to this branch of the business.

*Cultivation of local business.*—The method of developing the business of interurban lines may be better understood from the consideration of specific cases, and some interesting data on the subject have been noted by Mr. C. M. Cheney, general freight and passenger agent of the Waterloo, Cedar Falls and Northern Railway, in a paper read before the Iowa Street and Interurban Railway Association. This system, chartered originally in 1895 under the name of the Waterloo and Cedar Falls Rapid Transit Company, adopted its present designation in 1904, having in the meantime built up an extensive interurban system in which one stretch of 33 miles was opened in 1903. More recently—in 1904—the company leased a branch of the Chicago Great Western Railroad, a steam line, the branch being 22 miles in length—an extension from Waverly to Sumner.

A few years ago this system had very inadequate freight terminals in the city of Waterloo, and had traffic connection with but one steam line, which it reached only through the city streets. Freight cars could be handled at night only, and abutting property owners protested. The management thereupon decided that good freight terminals were necessary in order to develop and handle a larger business of the

carload type, and built an outer belt-line extension around the northern and eastern sides of the city, connecting with the steam terminals, and having large freight depot facilities which were leased for a long term of years. At the terminal of the Denver division, 17 miles north, connection was made at the same time with the Chicago Great Western, which thus secured a much shorter route to points on its line north and west. A traffic contract was entered into by the two roads whereby freight directed to or coming from points north and west of Waterloo was turned over by the steam road to the interurban road for handling. This interesting arrangement opened up a great territory for the jobbers and merchants of Waterloo, and enabled the steam and electric lines to develop business jointly in the new territory as well as to win competitive business which the steam line had not previously secured on account of its inability to meet the time schedule made by other steam competitors.

During 1907–8 an additional belt line was constructed around the western side of Waterloo through a new factory district, and traffic connections were made with two of the steam lines entering Waterloo. The completion of this track in 1908 furnished freight transfer points with 4 steam railroads and an outer belt line around three-fourths of the city. Side tracks were built to various points in the new factory district and a station opened with an agent in charge. The effect on the system already developed was immediate, and the construction of the line has furnished from 2 to 4 carloads a day since the station was opened. An electric locomotive and switching crew were put on to handle the industrial and interchange switches, and Mr. Cheney states that this service is now interchanging from 5 to 25 cars per day with the railways. These figures give an idea in what way an interurban system can promote local industries; and, it is stated, several of the most important industries were brought to the locality by the organization of this new system and the consequent creation of facilities for securing raw material and dispatching manufactured goods. One of these industries in particular gave approximately 500 carloads of business in the first year and over 700 in the year following. The interurban system benefited naturally by the development of such traffic, but the enormous incidental gain to the whole community is apparent.

An illustration of a new way of promoting interurban business was mentioned by Mr. Cheney in his address. About five years ago he had occasion to visit one of the small country towns on the line, and in conversation with a bank cashier learned that the bank was in correspondence with four or five farmers in Illinois, with reference to securing farms at some point in Iowa. Following up this slight clue, Mr. Cheney himself went to Illinois to see the farmers, expecting, if successful, to get the haulage of 6 or 7 carloads of movables. The farmers, naturally impressed by such intelligent inquiry, were interested, with the result that they bought farms located at different points along the line. They were all progressive men, and one of the first things they did, on securing occupancy of their new farms, was to begin tiling them for drainage. This operation attracted the attention of the older farmers in the vicinity, with the direct result that from 75 to 125 cars of draintile have been shipped annually into the territory of the interurban road as compared with practically none in the years preceding. Interurban business is also developed by keeping in touch with building contractors and men handling materials for new construction, for by watching the award of contracts and following them up, it is possible to secure the routing over the interurban road of large quantities of brick, cement, plaster, hollow block, stone, sand, etc., purchased at points in the territory tributary to the electric line.

In developing less than carload shipments or "package freight" the shipments of milk and express parcels have been carefully looked after. Several years ago, when the system between Waterloo and Cedar Falls was put into operation and package freight first handled, it was necessary, in order to get the business, to meet the competition of a dray line, as the two towns were only 8 miles apart, and the slow dray service was well developed. A motor, freight, and express car was equipped, a schedule of two trips each way per day was laid out for the car, the arrangements were advertised, and by degrees the dray-line competition was eliminated, so that now nearly all the package freight between the two cities is handled by interurban motor express cars, with great economy of time, etc. This service has also handled, in connection with the Chicago Great Western road, shipments from Chicago into Cedar Falls aggregating several thousand pounds daily; in the factory district it handles factory shipments to and from the various factories; and from farms along the line, milk shipments for city dairies. This milk is picked up at country road crossings by the passenger cars, and is handled on a ticket arrangement, each milk can bearing a ticket of the required denomination. Such milk tickets are on regular sale and can be purchased at any of the company's stations. Six or seven cooperative creameries also deliver to the road at various country road crossings their butter shipments for Chicago and New York. The butter, amounting each week on an average to 1 carload in the winter and to 2 carloads during the summer, is picked up in refrigerating cars. As the Wells-Fargo Express Company operates over the entire line, the development of the express business is left largely to that concern, but the results are exceedingly satisfactory to the interurban-railway company.

The development of passenger traffic has followed similar lines. Joint ticket arrangements with some of the steam roads make it possible to sell through tickets to all points, an arrangement which has been the means of developing a large business. Cars on the interurban division are scheduled to make connection with the Chicago Great Western trains at Denver Junction, 17 miles north of Waterloo, and in cooperation with this railroad a large number of passengers are handled from strictly competitive towns. For several seasons the sale of combination Chautauqua tickets on the interurban line has been vigorously pushed, the ticket including round-trip transportation to the city each day during the season, and admission to all the Chautauqua entertainments scheduled. For several years past a large number of these tickets have been disposed of, bringing in considerable outside revenue to the Chautauqua Association, helping it to perfect a strong organization, and to secure a class of attractions steadily gaining in character and importance. The net revenue derived by the trolley system from the sale of these tickets is not in itself very great, but the business developed indirectly with other lines has made the effort well worth putting forth. The road has also given a good deal of its attention to building up local travel, so as to convert as much as possible of its interurban trackage into what might be called "suburban." The assistance given to new industries employing large working forces has added materially to the daily receipts, a fact which has been particularly noticeable during the past few years, on the older line between Waterloo and Cedar Falls. A large number of working people live in one city and have employment in the other, while yet others have built up suburban homes or are occupying small farms located between the two cities.

*Working up freight and express patronage.*—Many other instances might well be quoted to illustrate the manner in which interurban roads have built up their traffic. For example, the Mason City and Clear Lake Traction Company of Iowa, one of the earliest interurban systems, dating back to 1897, has depended very largely on its freight traffic. On the shore of a lake near one end of the line a large ice house has been built, which during the winter is filled with ice, and a salesman is put on during the summer to take orders for it. The freight revenue from this enterprise alone, when fully developed, is placed at $20,000 to $25,000 a year, in addition to which there would be a profit on the ice sold.

The Spokane and Inland Empire Railroad system, which was founded in 1906, and is itself a consolidation of other roads operating through a number of towns and cities in Washington, has tributary to it a very rich fruit district. Consequently one of its novel developments has been a "fruit special," which carries lecturers from town to town to interest and instruct the owners of orchards along the line in the most improved methods of fruit raising and handling. This experiment has been very successful. The lecturers are professors from the Washington State Agricultural College and the University of Idaho; and the railway company secures good audiences by sending out in advance a programme showing when the train will reach each station and what subjects will be discussed. A flat car forms part of the train and serves as an open-air stage on which demonstrations to accompany the lectures are given in plotting, spraying, and pruning fruit trees.

*System of train dispatching.*—One of the important elements in the operation of interurban roads is the system of train dispatching adopted. The high-speed interurban roads of the present time require the greatest number of safeguards, and have naturally developed a number of systems more or less complex, most of which are based on the general method worked out in the standard code of the American Railway Association applied to steam railroads, but modified to a considerable extent to meet the conditions peculiar to electric-railway operation. One of these variations is that which involves the use of the telephone for transmitting orders from the dispatcher to the train crew. Only a small proportion of the steam railroads have thus far adopted the telephone, but with few exceptions interurban lines all over the country use the telephone system for train dispatching. A great deal of interurban mileage is single track, and automatic block signals have not yet been adopted to any great extent for long stretches, although they have proved valuable at points of congestion or special danger. A few of the later double-track roads, which approximate closely in methods to the steam railroads, operate automatic block signals, using track circuits, but the cost up to the present time has been so great, it is said, as hardly to warrant the investment. Train-order signals, operated automatically from the dispatcher's office, and designed to stop a car or train in order to get into communication with the crew, have, however, been installed in large numbers, as valuable adjuncts to the ordinary dispatching system.

There are five standard codes of train-dispatching rules in existence, which include instructions for issuing, receiving, and carrying out written train orders; and the rule books of nearly all the interurban roads operating at high speed contain instructions copied verbatim from one of these five standard codes or modeled closely upon their phraseology and practice, the changes being made to meet local conditions or to cover special cases. These five standard codes[1] are

[1] The American Street and Interurban Railway Association (see Electric Railway Journal, October 6, 1909, p. 961) at its last convention adopted a code which differs from the American Railway Association code, but which it is said by authorities will undoubtedly be standard for electric roads; that is, there will undoubtedly be two codes, the A. R. A. code and the A. S. & I. R. A. code.

those of the American Railway Association (already noted), the American Street and Interurban Railway Association, the Central Electric Railway Association, the Indiana State Railroad Commission, and the Street Railway Association of the state of New York. From the standpoint of the interurban roads, as has been noted, the steam code of the American Railway Association did not meet all the conditions of street-railway operation as satisfactorily as the other modified codes, the principal objection being that it is too cumbersome to adapt itself readily to the quicker movement made necessary by the passage of more frequent single cars or short trains upon which the interurban system is essentially based. It assumes, also, the presence of an operator at each train-order station, who acts as an intermediary between the dispatcher and the train crews. Ordinarily, it is pointed out, the exigencies of traffic require means whereby every siding becomes a train-order station. This the telephone provides very adequately and, with train crews in direct communication by telephone, many of the clauses of the American Railway Association code are rendered useless. A number of interurban roads have adhered, however, to the provisions of this code, among which may be noted the Spokane and Inland Empire Railroad system (Wash.); the Interurban Railway, of Des Moines, Iowa; the Albany and Hudson Railroad system (N. Y.); the Northern Electric Railway Company, of Sacramento, Cal.; the Scioto Valley Traction Company (Ohio); the Toledo and Western Railroad (Ohio); the Waterloo, Cedar Falls and Northern Railway system, of Iowa; and the Toledo and Indiana Railway system (Ohio).

The code of the New York Street Railway Association was adopted in September, 1907, and follows closely the American Railway Association code with respect to the rules affecting train orders. A number of interurban systems in New York have adopted its rules, among them being the International Railway Company, of Buffalo; the Utica and Mohawk Valley Railway Company; the Rochester and Sodus Bay Railway; the Fonda, Johnstown and Gloversville Railroad; and the Rochester and Eastern Rapid Railway. The essential difference in the rules is the inclusion of a regulation in the New York code providing that on remote sidings train crews receive orders by telephone direct from the dispatcher. This rule is as follows: "When necessary for train crews to receive train orders by telephone the conductors must receive and make a written record of the order. The motorman must repeat it back from the record made by the conductor. The order must not be acted upon until 'complete' is given by the train dispatcher to motorman, and acknowledged by the conductor."

The rules of the Central Electric Railway Association are almost identical with those approved by the Indiana state railroad commission and adopted by a majority of the roads in the Middle West. The principal point which distinguishes the practice laid down by these rules is that in all cases one member of the train crew calls the dispatcher and writes the order as received over the telephone. The other member of the crew is then required to repeat the order, as written, to the dispatcher, and both must sign it before the "complete" is given and the order has force. The sole function of operators, at stations where they are on duty, is to set the train-order signal to stop and to receive the instructions of the dispatcher, the train crew, on arrival, calling the dispatcher and receiving the orders in the same way as at an outlying siding. Among the roads in the Central states which employ the methods outlined by these two codes are the Toledo Urban and Interurban Railway (Ohio); the Kokomo, Marion and Western Traction Company (Ind.); the Western Ohio Railway Company; the Fort Wayne and Wabash Valley Traction Company; the Terre Haute, Indianapolis and Eastern Traction Company; the Cleveland, Southwestern and Columbus Railway; the Pittsburg and Butler Street Railway (Pa.); and the Evansville and Southern Indiana Traction Company.

The rules of the American Street and Interurban Railroad Association have been developed more especially to meet the requirements of electric roads, which, in several important respects, they suit more fully than do the rules laid down for steam railroads under the older standard code. These rules assume the use of the telephone to transmit train orders, and provide a different proceeding for receiving train orders at stations where agents or operators are on duty from that in use at sidings where there are no operators. Among the interurban systems which have already adopted these rules may be noted the De Kalb-Sycamore and Interurban Traction Company (Ill.), the Northern Texas Traction Company, and the Utica and Mohawk Valley Railway (N. Y.), systems.

Universal as has become the use of the telephone on interurban lines at the time of this report, a few companies still adhered to the use of the telegraph, depending upon the telephone only in emergencies. The roads employing the telegraph follow more closely the proceedings of the American Railway Association in having an operator act as an agent for the transmittal of orders between the train dispatcher and the train crew. Such roads include roads in Iowa, California, and Washington, all of which use the telegraph in transmitting orders to stations where operators are on duty, but also have telephone lines which can be used by train crews at other points. Many of the more important interurban roads have installed an entirely separate telephone-dispatching system, which is connected to all stations, substations, and jack boxes or booths at sidings. An inquiry made by the Bureau of the Census (see Table

170) on the subject during 1908, as to the standard practice on 37 roads, showed that 27 of the systems employed a separate telephone line exclusively, for dispatching.

Three different forms of telephone instrument are in use—portable telephones carried on every car; telephones mounted permanently in the front vestibule of cars; and wall sets mounted permanently in stations or in lock booths at sidings. Various modifications of practice are found on different roads. The main idea, of course, is to keep the dispatcher in as close touch as possible with the cars or trains along the line. The frequency with which a train crew is required to report during a run between terminals depends, however, entirely upon local conditions and the strictness of the managerial control. The Berkshire Street Railway system, which covers a large part of western Massachusetts, requires all its interurban crews to report at each siding. On the Iowa and Illinois Railway, a high-speed interurban road between Davenport and Clinton, Iowa, a distance of 36 miles, where the run is made in one hour and eighteen minutes, and cars leave each end every hour during the day, the departure of the train from the terminals is reported promptly to the dispatcher by the station agent as it passes a substation which is a regular meeting point. These reports, together with his own record of the time of passing his office, about midway between terminals, enables the dispatcher to keep a close check on train movements, so that under the rules of this road the train crews are not required to obtain orders or to report at any particular siding or substation. A peculiar feature of the practice on this road is the method of holding back a train which has lost time, and which on becoming seven minutes or more late loses its right of way, and is held back, as an extra would be, in favor of regular trains. When necessary, another car is substituted at terminals on its return trip. This arrangement prevents heavy cars on the road from losing time waiting at the regular meeting points for a single delayed car, and thus enhances the general quickness and regularity of movement over the whole system.

An interesting table is included in this chapter summarizing the data with regard to several of these features on interurban roads in New England, the Middle West, and other parts of the country, the data being furnished in reply to special inquiries addressed to the managers of the various systems.

TABLE 170.—TRAFFIC OF SELECTED

[Prepared from replies to a

| | STATE. | Name of company. | Method of train dispatching. | Miles of track operated. | Average speed of cars in miles per hour. | Frequency of passenger cars on main lines. | Estimated average distance traveled by each passenger, in miles. | Estimated average fare per mile (cents). |
|---|---|---|---|---|---|---|---|---|
| 1 | Massachusetts | Connecticut Valley Street Ry. Co | Telephone | 47.30 | 10 to 16 | 30 minutes and 1 hour | 10 | 1.25 |
| 2 | Massachusetts | Boston and Worcester Street Ry. Co | Telephone | 79.58 | 11 to 21 | 15 and 30 minutes | 16 | 1.43 |
| 3 | Massachusetts | Fitchburg and Leominster Street Ry. Co | Telephone | 40.70 | 8 to 14 | 15 minutes, city; 30 minutes and 1 hour, suburban and interurban. | 5 | |
| 4 | Connecticut | New London and East Lyme Street Ry. Co | Verbal orders | 11.14 | 11 | 30 minutes, summer; 1 hour, winter. | | 1.67 |
| 5 | Connecticut | Groton and Stonington Street Ry. Co | Regular passing points. | 20.66 | 14 | 30 minutes | | 1.43 |
| 6 | New York | Rochester, Syracuse and Eastern R. R. Co | Telephone | 71.73 | 23 | 20 and 50 minutes | | |
| 7 | New York | Oneonta and Mohawk Valley R. R | Telephone | 66.33 | 18 and 19 | 1 hour | (3) | 1.25 |
| 8 | New Jersey | Camden and Trenton Ry. Co | Telephone | 44.55 | 12 | 30 minutes | 24 | 1.25 |
| 9 | Pennsylvania | Lackawanna and Wyoming Valley R. R. Co. | Telephone | 49.60 | 25 to 38 | 20 minutes and 1 hour | | 1.50 |
| 10 | Pennsylvania | Meadville and Cambridge Springs Street Ry. Co. | Cars meet at sidings | 17.10 | 16 | 1 hour | 10 | 2.00 |
| 11 | Pennsylvania | Conestoga Traction Co | Telephone | 143.78 | 15 | 30 minutes and 1 hour | | |
| 12 | Ohio | Eastern Ohio Traction Co | Telephone | 82.78 | 12 to 19 | 1 hour | 8 | 2.00 |
| 13 | Ohio | Cleveland, Painesville and Eastern R. R. Co. | Steam-road dispatching methods. | 45.09 | 20 | 30 minutes | | 1.00 to 2.00 |
| 14 | Ohio | Dayton and Xenia Transit Co | Private telephones | 53.01 | 14 and 18 | 1 and 2½ hours | 9 | 1.39 |
| 15 | Ohio | Toledo, Port Clinton and Lakeside Ry. Co | Telephone | 57.03 | 22 | 1 hour | | 2.00 |
| 16 | Ohio | Toledo Urban and Interurban Ry. Co | Telephone | 58.56 | 35 | 15 minutes, city; 1 hour, interurban. | 25 | 2.50 |
| 17 | Ohio | Stark Electric R. R. Co | Telephone | 34.42 | 20 | 1 hour | | 2.00 |
| 18 | Ohio | Steubenville and Wheeling Traction Co | Dispatcher | 12.40 | 12 | 30 minutes | | 1.25 |
| 19 | Indiana | Evansville Suburban and Newburgh Ry. Co. | Written train orders | 27.80 | 19 and 22 | 1 hour | | 2.00 |
| 20 | Indiana | Louisville and Northern Railway and Lighting Co. | Semaphore signals, telephone, written orders. | 31.39 | 12 to 21 | 30 minutes, 1 and 2 hours | 5 | 2.00 |
| 21 | Illinois | Chicago, Harvard and Geneva Lake Ry. Co. | Telephone | 11.62 | 20 | 1¼ to 3¾ hours | | 2.00 |
| 22 | Illinois | Chicago and Milwaukee Electric R. R. Co | Telephone | 132.86 | 30 and 35 | 15 minutes | 6 | 1.50 |
| 23 | Illinois | Chicago and Joliet Electric Ry. Co | Automatic block | 82.95 | 9 to 20 | 10 to 20 minutes, city; 30 minutes and 1 hour, interurban. | 7 | 1.35 |
| 24 | Illinois | Illinois Traction system | Telephone | 418.82 | 25 and 28 | 1 hour | 10 | 2.00 |
| 25 | Michigan | Grand Rapids, Holland and Chicago Ry | Telephone | 76.60 | 20 to 29 | 30 minutes, 4 months; 1 hour, 8 months. | 10 | [4] 3.33 |
| 26 | Michigan | Detroit, Flint and Saginaw Ry. Co | Telephone | 13.75 | 14 | 1 hour | | 1.67 |
| 27 | Michigan | Detroit and Port Huron Shore Line Ry | Telephone | 127.72 | 22 | 30 minutes and 1 hour | | |
| 28 | Michigan | Detroit, Jackson and Chicago Ry | Telephone | 104.86 | 16 to 22 | 30 minutes | | |
| 29 | Michigan | Detroit, Monroe and Toledo Short Line Ry. Co. | Telephone | 74.46 | 21 | 1 hour | | |
| 30 | Iowa | Iowa and Illinois Ry. Co | Telephone | 40.38 | 28 | 1 and 1½ hours | | 2.00 to 2.50 |
| 31 | Iowa | Interurban Ry. Co | Telephone | 70.65 | 23 and 24 | 1½ hours | | 1.75 |
| 32 | Iowa | Cedar Rapids and Iowa City Railway and Light Co. | Telephone | 30.50 | 18 | 1 hour | 8 | 2.50 |
| 33 | Missouri | Southwest Missouri R. R. Co | Telephone | 64.57 | 14 to 18 | 30 minutes | | 1.50 |
| 34 | Kentucky | Louisville and Eastern R. R. Co | Telephone | 23.82 | 25 and 34 | 30 minutes and 1 hour | 10 | 1.75 |
| 35 | Colorado | Colorado Springs and Cripple Creek District Ry. Co. (electric division). | Telegraph, same as steam. | 18.42 | 12 and 14 | 30 minutes and 1 hour | 5 | 1.67 and 2.00 |
| 36 | Washington | Spokane and Inland Empire R. R. Co | Telegraph and telephone. | 222.19 | 33 | 45 minutes to 5 hours | (5) | 1.90 and 2.50 |
| 37 | California | Pacific Electric Ry. Co | Telephone | 454.20 | 16 to 30 | 5 to 20 minutes | | 1.50 |

[1] Less than one-tenth of 1 per cent. [2] Nearly all. [3] Total, 8; interurban, 19.

INTERURBAN RAILWAYS: 1907.

special schedule of inquiries.]

| Estimated proportion of passengers who are carried— Wholly within towns (per cent). | Between towns (per cent). | Proportion of total steam and electric passenger traffic carried by electric lines. | Effect on local business of steam railways. | Proportion of earnings from freight and express to total railway earnings (per cent). | Character of freight and express carried. | Remarks regarding freight and express. | |
|---|---|---|---|---|---|---|---|
| 10.0 | 90.0 | 2 lines get practically all. | Reduced fares; decreased local business. | 2.6 | National Express Co. business and small parcels. | Think prospects good—propose going in on larger scale. | 1 |
| 10.0 | 90.0 | ..... | No means of comparing. | (1) | None..... | Believe freight and express service to be a great convenience and to help build up passenger service. | 2 |
| ..... | 33.0 | ..... | None in recent years.. | ..... | None..... | ..... | 3 |
| 50.0 | 25.0 | ..... | Run cars oftener..... | 4.0 | Freight..... | Prospects for future development good. | 4 |
| ..... | (2) | ..... | Reduced fares..... | 0.6 | Meat, grain, groceries, green stuff, dressed lumber, iron castings, furniture, fish. | Less profitable than passenger, but are well pleased with growth. | 5 |
| ..... | ..... | ..... | ..... | ..... | None..... | None handled..... | 6 |
| ..... | 80.0 | Larger..... | Does not injure steam roads. | 24.2 | Milk, farm produce..... | Expect steady increase..... | 7 |
| ..... | ..... | ..... | Do not know..... | ..... | None..... | No franchise for carrying freight..... | 8 |
| ..... | 100.0 | ..... | ..... | 9.1 | General freight..... | Usual interchange arrangements on through billing. | 9 |
| ..... | 100.0 | Practically all..... | Take all local traffic... | 6.7 | Groceries, ice cream, fruit, meat, beer 50 per cent. | Agents at terminals handle freight; prospects very good. | 10 |
| 35.0 | 40.0 | Local traffic almost exclusively. | Practically all taken away. | 5.0 | Milk, farm produce, groceries, tobacco, etc. | Should show rapid increase..... | 11 |
| 20.0 | 80.0 | No competition..... | ..... | 27.3 | Merchandise, all kinds..... | Depends on growth of country..... | 12 |
| ..... | ..... | ..... | Reduced on short hauls. | 6.3 | Handled by Electric Package Agency. | ..... | 13 |
| 33.3 | 66.7 | ..... | ..... | 7.7 | Merchandise, all kinds..... | Records show regular increase..... | 14 |
| ..... | 100.0 | ..... | Can not say..... | 12.9 | Crushed stone..... | Can not say..... | 15 |
| 5.0 | 95.0 | Five to one..... | Slight..... | 10.8 | Merchandise..... | Interchange of local business with steam roads would increase traffic 75 per cent. | 16 |
| 5.0 | 95.0 | ..... | ..... | 4.9 | General merchandise; package freight. | Could be greatly increased..... | 17 |
| ..... | (2) | ..... | ..... | 4.9 | ..... | Freight so light, was discontinued..... | 18 |
| ..... | ..... | ..... | Has been reduced about 90 per cent. | 23.5 | Merchandise..... | Good field for development..... | 19 |
| ..... | 100.0 | ..... | Can not say..... | 1.2 | All kinds of freight except live stock. | Limited future development..... | 20 |
| 1.0 | 99.0 | No steam road connecting. | ..... | 52.9 | General freight and express..... | Increasing yearly..... | 21 |
| 2.0 | 98.0 | ..... | ..... | 13.7 | Stone, coal, gravel, milk, water.... | ..... | 22 |
| 2.9 | 97.1 | Carry twice as many as 3 combined steam roads. | Eliminated stops..... | 0.6 | 95 per cent freight, limestone; 80 per cent express, meat, beer. | Charter compels carrying of freight; business not profitable. | 23 |
| ..... | 98.0 | Earnings per mile more between common terminals. | Not affected, as a rule. | 12.1 | All commodities..... | Will equal passenger receipts if developed; district soliciting agents. | 24 |
| 25.0 to 30.0 | 70.0 to 75.0 | 20 to 30 times as great. | Reduced fares. Travel has been reduced from 80 to 95 per cent. | 20.8 | General merchandise, 80 per cent; grain, 5 per cent; fruit, 10 per cent; other farm produce, 5 per cent. | Would increase greatly with through railroad connections. | 25 |
| ..... | 100.0 | ..... | ..... | 6.2 | Cheese, groceries, fresh meat, milk, etc. | Carried in baggage apartments. Can be largely increased. | 26 |
| ..... | ..... | ..... | ..... | 13.4 | Groceries, provisions, dry goods, hardware, milk, butter, eggs, fruits, vegetables. | Still in its infancy..... | 27 |
| ..... | ..... | ..... | ..... | 16.2 | Groceries, provisions, dry goods, hardware, milk, butter, eggs, fruits, vegetables. | Still in its infancy..... | 28 |
| ..... | ..... | ..... | ..... | 12.5 | Groceries, provisions, dry goods, hardware, milk, butter, eggs, fruits, vegetables. | Still in its infancy..... | 29 |
| ..... | 90.0 | Quadruple local business. | Withdrawn local trains. | 14.1 | All kinds..... | Can be greatly increased..... | 30 |
| ..... | 100.0 | ..... | ..... | 25.8 | Coal and brick..... | More profitable than passenger..... | 31 |
| 4.0 | 96.0 | Practically no competition. | ..... | 15.1 | Merchandise, 40 per cent; stock, 35 per cent. | Less profitable than passenger..... | 32 |
| 25.0 | 75.0 | ..... | Impossible to determine. | 1.2 | Fruits and vegetables..... | ..... | 33 |
| ..... | 100.0 | Very much in excess.. | ..... | 18.2 | General merchandise..... | Should be large and very profitable... | 34 |
| ..... | 100.0 | 95 per cent..... | Electric line built to relieve steam line. | ..... | Steam trains handle..... | Steam trains will always handle..... | 35 |
| 75.0 | 25.0 | ..... | Reduced fares..... | 24.4 | Agricultural products, 20 per cent; mining products, 3 per cent; lumber, 54 per cent; manufactured articles, 14 per cent. | Great possibilities for future development. | 36 |
| 44.0 | 56.0 | ..... | Material extent..... | 6.7 | Crushed stone, leading commodities, fruits, vegetables. | Increasing steadily..... | 37 |

[1] Over 3 miles.

[2] City, 1; interurban, 22.

*Speed of interurban travel.*—The average speed of cars for an entire trip is governed to some extent by the length of the run, but high rates of speed are maintained over large networks, as, for example, that of the Illinois Traction system, with 418.82 miles, which shows an average rate of 25 and 28 miles; the Spokane and Inland Empire reports an average of 33 miles an hour; the Toledo Urban and Interurban, one of 35 miles an hour; and the Chicago and Milwaukee Electric Railroad Company (Ill.), with 132.86 miles of track, has speeds of 30 and 35 miles per hour. In some instances, however, the speed falls as low as 12 miles an hour, or even less. The determining condition in this respect is the development of limited service. At the beginning of 1907, out of 26 of the leading interurban lines in Michigan, Indiana, and Ohio, 17 were giving limited service. One of the first of these roads to offer such service was the Cleveland, Painesville and Eastern Railroad (Ohio), operating a fast car which ran from Painesville into Cleveland in the morning and back in the evening. The Indiana Union Traction Company was also a pioneer in giving limited service—the idea being to accommodate the people of the larger towns and cities. Such cars or trains do not stop at the smaller towns or hamlets, but only at stated points, and thus compete very closely and on nearly equal terms with the steam railroads making similar stops. This class of service, especially where connecting lines have adjusted their limited trains to each other, has brought to the interurban lines a variety and an amount of business that could not otherwise have been secured. The bulk of the business on limited trains does not, however, come from long hauls, but the long haul is a high class of business and has been extensively catered to, although to some extent there has been a reaction in regard to the nature of accommodations offered. Some of the earliest limited trains furnished all the comforts and luxuries of Pullman parlor cars, with the accompaniment of reading tables and literature, and in some instances, buffet service for light luncheon, etc. For such features an excess fare was generally charged, but in Ohio, at least, the excess fare has been entirely eliminated and the present standard excludes no one really needing the fast-time service, but unable to pay for the high-class accommodations.

*Use of limited cars.*—The practice has been taken up on some of the systems of making every other car a limited one, this being a practice in Indiana and to some extent in Ohio, but the method more generally followed in Ohio has been to operate from 2 to 5 limited trains a day in addition to the regular local service. In Indiana, with the object principally of keeping off the local traffic between adjoining towns, which necessarily lowers the speed possible with a limited service worthy of the name, a graduated excess fare from 5 to 25 or 30 cents, according to distance, has been the rule. In Table 170 a column summarizes the frequency of passenger cars on the main interurban lines of 37 roads tabulated, which in several instances reported a frequency of every hour, associating this with a schedule of from 20 to 35 miles per hour for the entire trip. It will also be noticed from the table that on several of the roads the average distance traveled by each passenger was above 10 miles, which implies a liberal use of the limited methods of operation. Many of the roads have printed schedules and time-tables, like those of the steam railroads. The table also shows a very large proportion of passengers carried between towns, but this does not bear upon the limited service unless it is definitely connected with towns that are wide apart. The experience of interurban systems appears to have been that the residents in the rural districts are as a rule short-distance riders.

*Rates of fare.*—A very significant column in the table is that showing the estimated average fare per mile. While in some instances the average rate was 2 cents, in several others it fell even as low as 1¼ cents. While it is possible that 2-cent fare laws may have had some effect in this direction, it is more likely that competition with steam railroads has been the determining factor. The Cleveland, Painesville and Eastern reported the fare as from 1 to 2 cents. The minimum fare for one ride, however short, may be taken as 5 cents, from which unit the scale falls in proportion to the length of the trip. It is obvious, therefore, that those riding short distances pay in proportion a higher rate of fare, but it is to be borne in mind that the actual cost of stopping and starting a heavy interurban car is considerable, and that frequent stops involve an appreciable consumption of electrical energy as well as wear and tear not observable in continuous operation for a long run.

*Number of stopping points.*—Outside of limited service, which frequently has its stations at least 10 miles apart, practice differs widely as to distance between stopping points and appears to be independent of the length of road. Some roads will make one stop to the mile, while others will have as many as five stopping places in the same distance. Thus, for example, the franchise of the Detroit, Ypsilanti, Ann Arbor and Jackson system (now part of the Detroit, Jackson and Chicago Railway) requires it to stop trains at any point along the line where a prospective passenger may give the signal, under which conditions it is obviously difficult to maintain a rate of speed much, if any, higher than that obtaining within city limits. The tendency on most of the systems has been to avoid private stations and to stop only in towns and at important road crossings. When it is considered that 400 miles in a day has become possible on regular heavy roads of the latest type, it will be seen that the limited system is an absolute necessity and that the interurban roads themselves have had to come to a sharp differ-

entiation between the limited cars and those which may be compared with the local or way trains on steam railroads. Some other differences of systems, affording a compromise between way and limited service, have been developed, as, for example, a chartered car on the Eastern Ohio Traction line, known as the "Blue Blood Special," operated for the benefit of wealthy residents in the suburbs, who club together for its operation. It stops at no points in the city, and in the country only where members of the club who desire to board the car hold up yellow membership cards, indicating their right to travel thereby.

With regard to the baggage for passengers on limited trains, various practices prevail. Some of the lines carry baggage free, either on the same train or on the regular train immediately preceding or following. This depends to some extent on the provisions made on the limited cars for handling baggage.

*Freight and express service.*—The statistics on financial operations show that the street and electric railways of the whole country earned $5,231,215 from freight service and $1,560,802 from their express business, which income, it will be understood, was largely due to the work of the interurban roads. Table 170 throws some light on the conditions applying to interurban lines, and it will be seen that in several instances the proportion of the earnings from freight and express is very large. One system—the Chicago, Harvard and Geneva Lake Railway—reports as high a proportion as 52.9 per cent; six other roads, proportions ranging from 20.8 per cent to 27.3 per cent; and several of the systems report below 5 per cent and two even less than 1 per cent. In furnishing information on this point one of the roads reports that it carries freight because it is required to do so by its charter, but evidently regarded it less as a privilege than as a nuisance and as an interference with an efficient passenger service.

The variety of freight and express carried is remarkable, and includes all kinds of commodities and merchandise. Two of the systems report that a large percentage of their business, in one instance 50 per cent of the total, is derived from the transportation of beer. In many instances milk, vegetables, and other farm produce in season constitute a large percentage of the traffic, but these are supplemented by building materials, brick and stone, lumber, gravel, iron castings, water, groceries, fish, and tobacco. As to this kind of traffic the remarks indicate a general appreciation of the opportunity afforded to serve the community and to secure an increase of income. It would appear that in some cases a high state of development has already been reached, while in others increase is expected; although here and there it is intimated that for various causes the development will be limited, and that steam trains rather than the trolley systems will always handle the freight. To a certain extent, of course, growth will depend upon the increase of population in the region traversed, but evidently much depends upon the energy with which the managers seek to cultivate this department. Various forms of activity in this direction have already been discussed in other parts of the text in connection with the development of the business of interurban lines, but, in addition, other methods employed are worth enumerating.

The Electric Package Agency of Cleveland is an association representing five of the traction properties in that city, each of which furnishes its own equipment, crew, and maintenance, while the package agency furnishes a messenger on each car. At the beginning of 1907 this agency was operating apparently over about 550 miles of road, with 40 wagons in various towns and cities, 14 messengers, and 53 agents, who either devoted their time entirely to the package service or divided their work between the local railroads and the package agency. This organization was managed at that time by an executive committee of three; the earnings of each road are kept separate, and after the operating expenses of the package agency, amounting to about 50 per cent of the receipts, are deducted, the roads receive the remainder, from which the train-operating expenses and cost of maintenance are deducted. The package agency also handles the baggage transported over the different roads and is credited with 10 cents per trunk. On some of the roads, such as the Cleveland and Southwestern (now part of the Cleveland, Southwestern and Columbus Railway Company), the bulk business handled in package cars is unloaded at the outskirts of the city, and the entire earnings go to the road itself, and not to the package agency. The rates made by the agency were somewhat higher than those of electric roads elsewhere; one rate covered fruit, groceries, eggs, vegetables, etc., and was usually 10 cents lower than the regular rate on commodities; the higher rate, however, tended to limit the amount of farm produce handled. The lowest rate was 30 cents per hundred for the special class within 35 miles, and the highest rate, 75 cents to Toledo, 120 miles. Carload stuff was handled, when required, at the rate of 50 cents a car mile for the whole, including the return of the empty car, and business was interchanged with other express companies and with the lake-boat lines. Where roads entering Cleveland, such as the Eastern Ohio Traction Company, have not been in the electric package arrangement, goods have been handled on express cars run to the package agency's station, a portion of which has been leased for such service.

*Handling of milk.*—The handling of milk may be taken as an example of the development of these various items of the freight business. The Eastern Ohio Traction Company, traversing a rich farming district, reported that it billed 5,000 to 6,000 gallons daily in 1906, and that its receipts from milk transportation alone had reached as much as $25,480 in a

single year. The company has made a flat rate of 2 cents per gallon for any distance, placing all the farmers along the line on an equal footing, and thus increasing the gross quantity handled; has encouraged the farmers to build platforms at which cans can be picked up; and will stop for any number above three. Tickets, which may be attached to the can, are sold for this traffic, and the cans are returned free to the farmers. The Cleveland and Southwestern system reports handling an average of 800 cans a day, with receipts in one year approximating $20,000. As the bulk of this milk is delivered to distributing wagons at the city limits, the company gets all the receipts up to that point. Rates for dairy produce vary according to the distance. A higher rate is charged for cream than milk.

In Michigan the quantity of milk handled by the Detroit United Railway system was so great as to require special trains, one of which is operated on each of the interurban divisions of this system, and milk is also carried in the early morning baggage cars. The milk train on the Flint division is made up of a motor car and a trailer fitted with racks for carrying cans on each side of a central passage way. The charge, based on the length of the haul, varies from 6 to 10 cents per 10-gallon can. In order to make a proper accounting of the system a two-part tag is used; one part is taken from the can by the conductor, while the remaining part is left on and serves for the return of the empty can. Creamery companies which pick up milk through the country districts are purchasers of a large quantity of tickets. Any number of the tickets are sold at one time to private shippers, but the purchases are usually made in lots of from $2 to $5 worth. About 220 cans of milk were being handled daily over the Detroit, Ypsilanti, Ann Arbor and Jackson Railway (now part of the Detroit, Jackson and Chicago Railway), the cans being carried in freight or express cars with a two-part ticket and at a charge of 10 cents per can regardless of distance.

In Indiana the Indiana Union Traction Company and the Indianapolis and Northwestern Traction Company handled milk on a three-part ticket, one part of which is torn off by the conductor, one serves as a receipt for the customer, and the third answers for the return of the empty can. During the earlier part of the census period the cans were carried in the baggage department of the regular passenger cars, but more recently special milk trains have been put on. On the Indianapolis and Cincinnati Traction system a charge of 1½ cents per gallon has been made regardless of distance hauled, with three-part tags in different colors for cans of 3, 4, 5, and 8 gallon capacity. Loading platforms have been built wherever the shipments justify the expense, and many private loading stations are erected by the shippers. All this milk is carried in express cars. About 2,000 gallons of milk per day have been handled by the Indianapolis, Columbus and Southern Traction system. For hauls of less than 10 miles the charge is 1 cent per gallon; above that distance 1½ cents, the rates including the return of the empty can. Shippers are required to buy 100 tickets at a time and to erect their own loading platforms.

On the lines of the Terre Haute Traction and Light Company no tags have been employed, but the milk is billed in the same way as freight. Farmers are supplied with blank billheads which they fill out for each shipment, and settlement at the rate of 1 cent per gallon is made at the office of the company every Saturday. Over the system of the Fort Wayne and Wabash Valley Traction Company, 500 gallons of milk are handled daily, for which the shippers make out a bill of lading, leaving it on the shipping platform with the cans, and the train crew that picks up the cans makes out the waybill. The shippers make monthly settlement at the rate of 10 cents per full can and 2½ cents for the return of the empty cans, this charge being regardless of distance.

With regard to the freight and express business in general, the following interesting statement may be quoted from the report of the Chicago and Joliet Electric Railway Company in reply to the special inquiry on the subject:

> Our ticket agents at the several stations along the line handle express traffic. No special facilities for handling freight, which is almost exclusively stone; and our service consists in switching the cars from the quarry tracks to the steam railroads.
>
> The freight cars do not make regular trips, but are sent to the quarries as required for switching purposes. Up until 1906 all express matter was handled on the regular passenger cars. Since that date a combination car makes one round trip between Joliet and Lemont daily. We have no statistics upon which to base the tons carried, as the switching is charged for by the hour irrespective of the load, and express matter is handled at so much per package.
>
> We do not believe that there is much future for the freight business along this line, as we are merely used when the steam roads can not perform the service. Furthermore, we are not particularly anxious to develop it, as at the season of the year when the stone business is at its height, namely, in the summer time, our passenger traffic is so heavy that the handling of the freight interferes with it, and as the passenger business is much more remunerative than the freight business, we are indifferent as to the growth of the latter.
>
> It is our opinion that the freight business is unprofitable when it is handled in competition with the steam roads and where the freight handled is of the coarser, heavier kind. Where, however, it partakes more of the nature of an express business—that is to say, light and perishable matter upon which the shipper is willing to pay a higher rate in consideration of quick and frequent service—we believe that it is fairly remunerative.

*Use of special cars.*—The plan of handling express and freight matter on combination cars is declining, except in the case of a few roads which distinguish between freight and express traffic and do considerable fast-express business in the combination cars. Many roads now have special cars for such service, but the designs for such cars are as varied as for those for passenger service. On the Western Ohio Railway and on lines in the vicinity of Dayton and Detroit old Man-

hattan Elevated cars have been transformed into trailers for this purpose; the various branches of the Indiana, Columbus and Eastern Traction system have several 60-foot express cars with large carrying capacity, and the express motor cars built for the Scioto Valley Traction Company are 45 feet long and equipped with 125-horsepower motors and a train-brake system for handling one or more trailers. The Dayton, Covington and Piqua Traction Company has a 56-foot express car of unusually substantial construction and large capacity, fitted with an adjustable platform with roof, so that it may be used as a line-construction car. On the Cleveland and Southwestern the express car is 54 feet long, built with heavy floor frame and bumpers and designed to carry at least 20 tons; two double doors on each side as well as doors at each end render it very convenient for handling theatrical scenery or other long or bulky articles.

*Mail data.*—There is little that is new to add to the former report of 1902 on the subject of the handling of United States mail by the interurban roads of the country. As in most respects typical, may be cited the general practice in Ohio, where nearly all the interurban roads handle mail matter in sacks and derive an income on the basis of a fixed amount per mile per sack. In 1906–7 three roads—the Eastern Ohio Traction Company, the Toledo and Western Railroad, and the Cincinnati, Georgetown and Portsmouth—covering districts not traversed by steam roads, had provided for regular mail-car service a special compartment fitted up for the distribution of mail en route, and for this service they receive 3 cents per mile per sack for pouched mail, and 7½ cents per car mile. On the Cincinnati, Georgetown and Portsmouth the mail compartment is partitioned at one end of a 56-foot express car. The Toledo and Western road and Eastern Ohio road, like many others, carry the mail on passenger cars. The interurban systems are constantly endeavoring to secure more of this business, notwithstanding the fact that the rate is not regarded as attractive nor the traffic remunerative.

*Opinions from steam railroads.*—The opinions of steam railroads have been solicited as to the effect upon their business of the competition of electric interurban railroads, and some very interesting statements have been furnished, a few of which may be cited.

TABLE 171.—REPLIES OF STEAM RAILROADS REGARDING

| | Effect of electric lines in decreasing passenger traffic between competing points. | Effect on long-distance passenger traffic. | Effect on practice of steam lines. Passenger. Fares. | Effect on practice of steam lines. Passenger. Number of trains. |
|---|---|---|---|---|
| 1 | Largely | None | Not reduced | No changes in service |
| 2 | 50 per cent some places | Not appreciable | Not reduced | Improved service |
| 3 | Material decrease | No data | Not reduced | No change |
| 4 | 90 per cent 10 miles or less | Increasing, trolley being feeder to steam road. | Not reduced | Decreased local trains to minimum |
| 5 | All short-haul business | Not appreciable | Not reduced | Two branches discontinued |
| 6 | Probable decrease; no data | Assume some increase | Reduced 25 per cent | No change |
| 7 | 90 per cent short-haul business | None | Reduced in some cases | No change |
| 8 | No competition; better service mutually | Increase; can not say to what extent | Not reduced | Discontinued some stops |
| 9 | Varies | Not appreciable | Reduced on one branch | Increased |
| 10 | More or less affected between all competitive points. | Not appreciable | Reduced in four instances | Decreased; abandoned 1 station |
| 11 | Traction gets all passengers | No reply | Not reduced | No change |
| 12 | 78 per cent first year | Little, if any | Not reduced | No change |
| 13 | No statistics | Considerable increase one or two points | Reduced | No change |
| 14 | 50 per cent on one line | None at all | Commuter rates introduced | Decreased |
| 15 | 40 per cent some places; others not perceptible. | None | Not reduced | Abandoned stations and trains decreased. |
| 16 | Very materially reduced | None | Reduced | Abandoned stations |
| 17 | 40 per cent | None | Not reduced | Decreased; abandoned stations |
| 18 | No data; think inconsiderable | None | Not reduced | No change |
| 19 | Decrease; can not say to what extent | Increase; can not say to what extent | Reduced fares | Decreased; abandoned stations |
| 20 | Estimate 50 per cent | None at all | Not reduced | No change |
| 21 | 50 per cent, one line | None | Not reduced | No change |
| 22 | Loss $34,000 first year | None | Not reduced | No change |
| 23 | Large decrease | None | No reduction | No change |
| 24 | Greatly reduced local earnings | Very little | Reduced fares | Decreased; abandoned several stations. |
| 25 | No figures; local conditions govern | No figures | Reduced slightly | No change |
| 26 | Take considerable short-haul business | Contribute to long-haul business; doubtful whether through business received offsets loss of local travel. | Have made no effort to compete | |
| 27 | Governed by local conditions | Not apparent | In twelve instances reduced | Decreased; abandoned 14 stations |
| 28 | More or less seriously between important points. | Scarcely noticeable | Reduced | Decreased; abandoned 3 stations |
| 29 | No accurate figures; varying conditions at different places. | Not appreciable | Reduced in a half dozen instances | Decreased |
| 30 | Between all important points | Not to any apparent extent | Reduced in four instances | Abandoned 4 stations |
| 31 | Loss from 20 to 30 per cent where there is competition. | Very little | No reduction | No change |
| 32 | From 33⅓ to 90 per cent | No increase | No reduction | No change |
| 33 | No data | No data | No reduction | Decreased |
| 34 | 50 per cent | Not at all | Not reduced | No change |

[1] Numbers 1 to 10 are replies from roads on the Atlantic seaboard; numbers 11 to 32 from the North and Middle Central states; numbers 33 and 34 from the Southwest and Pacific coast.

THE EFFECT OF ELECTRIC-RAILWAY COMPETITION: 1907.[1]

| EFFECT ON PRACTICE OF STEAM LINES—continued. | ULTIMATE AND GENERAL EFFECT ON STEAM LINES. | | |
|---|---|---|---|
| Freight. | Passenger. | Freight. | |
| None | Further injury to local travel | | 1 |
| Not serious | Serious competition | Problematical | 2 |
| Not appreciable | Continuation of present effect | | 3 |
| Slight | Injury on short hauls | Not much development expected | 4 |
| None | Will ultimately build up long-haul traffic | | 5 |
| No reply | Further loss | No reply | 6 |
| Decrease | | Continue to feel competition | 7 |
| No injury | Electric and steam lines will work together to advantage of both. | Will not be affected | 8 |
| Not material | Will do two-thirds of business 8 miles or more | Can not say | 9 |
| Not material | Losses on 15-mile distances | Would not venture to state | 10 |
| None | Further injury on short hauls | Injury on short hauls | 11 |
| Active competition—fruit and vegetables—short hauls. | Injury will result from competition at more points | Continuation of present conditions | 12 |
| Slight increase in volume of building material hauled | Injury | Conjectural | 13 |
| | Injury | May lose freight and express short hauls | 14 |
| None | No opinion | No opinion | 15 |
| Not extensive | Further injury | No beneficial effects | 16 |
| Loss of hauling milk | Continuation present detriment | Increasing competition | 17 |
| Have lost only business that steam roads will not accept | No injury as long as present fares are maintained | Ultimate gain | 18 |
| Considerably reduced | Injury | Probably further loss of business | 19 |
| No reply | Serious competition that will further reduce revenue | Revenue will be decreased | 20 |
| Have lost considerable package and other less-than-car-load local freight. | Serious injury, but not more than in the past | Greater decrease | 21 |
| Have lost considerable package and other less-than-car-load local freight. | Serious injury, but not more than in the past | Greater decrease | 22 |
| No reply | Formidable competition on short hauls. Look for further reduction in revenue. | Decreasing revenue | 23 |
| Slight | Great injury | Can not say | 24 |
| None to any extent | Depends on local conditions | Depends on local conditions | 25 |
| Not serious | Unable to say | Will lose greater part of short-haul traffic | 26 |
| Not noticeable | Injury to hauls of 15 to 20 miles or less | Impossible to state | 27 |
| Not material | Further losses between short-distance points | No opinion | 28 |
| None to any extent | Losses on 10 to 20 mile distances | No opinion | 29 |
| None to any extent | Extensions planned which will cause serious competition for local traffic. | Impossible to state | 30 |
| Comparatively slight | Probably no further injury | No injury anticipated | 31 |
| None | An injury | More competition | 32 |
| Impossible to state | Serious competition for local traffic | Impossible to state | 33 |
| None | Further damage | None anticipated | 34 |

In one or two instances the information given is confidential, the companies asking that they be not identified with the data furnished. Thus one of the large railroads of the country reports that it comes into competition with interurban railway systems at 7 large cities and a large number of intervening towns, and that altogether it is in competition with no fewer than 63 electric railways. This company has no specific records as to the amount of traffic lost, but the trolley is declared to be a constant menace to the revenues of steam railroads for short-haul or suburban business, the competition being on unequal terms, owing to the smaller amount of capital invested in the trolley systems for track and terminals, and the cheaper operating expenses, cheaper labor, and lighter equipment. Fares on this road have been reduced and stations have been abandoned, but the service of the road is improving constantly, although not so much on account of trolley competition as a part of a sustained policy. In other words, the policy of the road is to ignore electrics rather than to make a constant effort to meet their competition.

Another large system, the Delaware and Hudson Company, which is interested in electric railways, reports no competition with any electrical lines, but connection with 6 of them, serving in common 17 towns and cities. This company says that the efforts of the steam railroad and the traction companies have been to better the service rendered, so arranging their schedules that a through service convenient for the public has been brought about. The electric lines doing the local business are usually in more satisfactory shape to handle it than the steam lines, while the latter do the through business more satisfactorily than the electrics. There has been a tendency to eliminate unimportant stops on the steam lines so as to better the through service, and a corresponding tendency to increase the number of stops on the electric lines. The general effect of the electric roads has been to develop travel, as they take the travelers short distances in a satisfactory manner and discharge them at convenient locations; steam railroads do not render this service so well. The two systems working together, however, afford the public a better service than can be given by either alone and thus the revenues of both are increased. There has been no reduction in passenger rates other than that brought about by state laws. With regard to freight, it is noted that the electric lines which give a satisfactory passenger service with frequent stops can not do so in connection with a freight service. They can, however, operate express service successfully, but this suffers delays when the attempt is made to handle large or heavy packages, and interferes with the passenger schedule. It is believed that the tendency will be toward the curtailment of freight service and an increase in small-package delivery and mail service, but the steam railroads will not be affected to any great extent. "Usually where electric lines have attempted a commutation or a through high-speed passenger business such service has been rendered at a loss, and the tendency will be toward the perfection of the local service working in connection with the steam railway."

The Central Railroad of New Jersey finds itself in competition with 10 electric-railway companies in 33 towns and cities in Pennsylvania and New Jersey, and reports that these lines have taken practically all the short-haul business, but that the long-haul traffic is not appreciably affected. The only change resulting from competition has been the abandonment of passenger service on the Cumberland and Maurice River and the Nanticoke branches. It is anticipated that the interurban lines will ultimately build up territory served by steam, and will thus tend to increase the long-haul travel of steam-railroad companies. At the eastern terminal of the system serious competition was anticipated between New York and Newark, owing to the opening of the Hudson River tunnel. The Lehigh Valley Railroad Company reports contact with 29 electric-railway systems touching it at 31 places, 14 of the systems being in competition with it. There has been a considerable loss on distances of 10 miles or less, with the result that trains for local service have decreased to a minimum. There has, however, been very little change in freight. It is believed that the trolley serves as a feeder to the steam railroad and results in an increase of long-haul business.

The Atlantic Coast Line Railroad Company, operating in North Carolina, Virginia, and Florida, reports that the local traffic is largely affected, but least in the winter months, when, owing to tourist travel, the proportion of the railroad increases, as the railroad gets nearly all the travel for through passengers, especially those with baggage.

The New York, Chicago and St. Louis Railroad Company has reduced fares in certain zones, but notes no other change. There has been a considerable increase in long-distance travel fed by the electric roads, but these roads are expected to affect the movements of people between local stations and to increase slightly freight for building materials, etc., required for the development of the suburbs.

The Chicago, Cincinnati and Louisville Railroad is a somewhat novel example, and possibly unique, in being a steam road built after the electric-traction line existed. It parallels this traction line for 5 miles and reports that the interurban system between those points has practically all the passengers; it believes that traction competition will surely injure steam railroads on short-haul business. There has been no freight competition, but it is expected that the interurban railways will work up a large merchandise business, "especially in the huckster line."

The Chicago, Indianapolis and Louisville Railway Company has found itself since the last census in competition in Indiana with one interurban system. The reduced passenger traffic between the points paralleled amounted to 78 per cent in the first year; and there was also a reduction in freight of 50 per cent for fruit and vegetables for short hauls. Practically no change has been made to meet competition. The Cincinnati, Hamilton and Dayton Railroad Company reports competing with 11 electric companies at 24 places, with the result that fares have been reduced, traffic has been materially cut down on short distances, and some stations have been closed. No benefits have been felt, and further ill effects are anticipated. The Cincinnati, Lebanon and Northern Railway Company has competition in 4 towns, with a loss of 40 per cent on local passenger traffic. The cheaper construction, cheaper labor, and the penetration of towns that steam railroads only touch at the outskirts make the electrics a menace to the steam systems wherever they come directly into competition. The express and freight business has been affected only in the handling of milk, as most of the electric freight consists of farm produce carried formerly in wagons. The change of electric roads to standard gauge, with the demand for interchange of business on equal terms with the steam roads, is anticipated. The Toledo and Ohio Central Railway Company competes with 3 electric lines in 7 leading towns. It is not known to what extent the competition has been felt, but the local passenger traffic is reported to have decreased, although long-distance traffic has increased. In a general way, the road reports reduced fares, decreased train service, and abandoned stations, and it anticipates a further loss of freight business.

The Baltimore and Ohio Railroad Company reports as to Pennsylvania, Maryland, West Virginia, Ohio, Indiana, and Illinois a loss in local traffic—at some points of 50 per cent. Freight competition is not serious, but passenger competition may become so.

In respect to the Western states, the Chicago, Milwaukee and St. Paul Railway Company reports competition with 5 companies touching 13 cities and towns in Wisconsin, Illinois, and Minnesota. The loss of traffic at some points is 40 per cent, but at others it is not appreciable; no long-distance electric travel has been developed. Trains have been decreased and stations abandoned between St. Paul and Minneapolis; otherwise no changes have been made.

*Effect on local trade.*—Another line of inquiry similar to that made in 1902 deals with the effect of interurban systems upon the business done by small or general merchants in the rural districts and by country stores, as well as the effect upon merchants in the larger towns to which the interurban roads bring rural customers.

TABLE 172.—EFFECT OF ELECTRIC INTERURBAN RAILWAYS

[Replies of local merchants to

| | STATE. | Name of city or town reporting. | Large cities with which connected by electric railways. | Merchants' class of business. | Effect of electric railways on sales to people in town. |
|---|---|---|---|---|---|
| 1 | Massachusetts | Braintree | Brockton, Quincy, Boston | Groceries | Some decrease |
| 2 | New York | Syracuse | Auburn, Oneida | Department store | Benefit |
| 3 | New York | Troy | Albany, Schenectady | Dry goods | No injury |
| 4 | Pennsylvania | Erie | Conneaut (Ohio) | Department store | No decline |
| 5 | Pennsylvania | Cambridge Springs | Meadville, Erie | Mercantile | No injury |
| 6 | Pennsylvania | Quakertown | Allentown, Philadelphia | Dry goods, notions, groceries | Opened another store to meet conditions. |
| 7 | Ohio | Alliance | Canton, Salem | Retail dry goods | No decrease |
| 8 | Ohio | Chagrin Falls | Cleveland | Dry goods, carpets, etc | No particular decrease |
| 9 | Ohio | Elyria | Cleveland | Dry goods | No decline |
| 10 | Ohio | Kent | Cleveland, Akron | General merchandise | No injury |
| 11 | Ohio | Massillon | Cleveland, Akron, Canton | Dry goods, carpets, wall paper, etc | Business fallen off, but owing to other conditions. |
| 12 | Ohio | Oberlin | Cleveland, Elyria, Lorain, Norwalk, Wellington. | Clothing, tailoring | No decrease |
| 13 | Ohio | Hubbard | Youngstown; Sharon, Newcastle (Pa.). | General store | Business increased in proportion to increase of population. |
| 14 | Ohio | Youngstown | Warren | General dry goods | No decline |
| 15 | Ohio | Perrysburg | Toledo | Dry goods, clothing, hats, shoes | No decrease |
| 16 | Ohio | Bowling Green | Toledo, Findlay | Dry goods, carpets, etc | No decrease |
| 17 | Ohio | Crestline | Mansfield, Bucyrus | Dry goods, carpets | Little loss |
| 18 | Ohio | Lima | Dayton, Toledo; Fort Wayne (Ind.) | Dry goods | No decrease |
| 19 | Ohio | Elmwood (2 miles from electric line). | Columbus | General store | No decline |
| 20 | Ohio | Greenville | Dayton | Department store | No decline |
| 21 | Ohio | Miamisburg | Dayton | Dry goods | Some decline |
| 22 | Ohio | Xenia | Dayton | General merchandise | Perceptible loss |
| 23 | Ohio | Harrison | Cincinnati | Clothing, furnishings | Slight decline |
| 24 | Ohio | Franklin | Cincinnati, Dayton, Hamilton, Middletown. | Dry goods, carpets, clothing | No decrease |
| 25 | Indiana | Columbus | Indianapolis; Louisville (Ky.) | Millinery, china, toys, etc | No injury |
| 26 | Indiana | Greenfield | Indianapolis, Richmond; Dayton (Ohio). | Department store | Loss on one line more than made up on others. |
| 27 | Indiana | Peru | Indianapolis, Fort Wayne | General merchandise | Loss to large cities offset by gain from smaller ones. |
| 28 | Illinois | Evanston | Chicago | General dry goods | Can not say; business has grown |
| 29 | Illinois | Elgin | Chicago, Rockford, Aurora | Dry goods, carpets, millinery, shoes, etc. | Loss to Chicago; gain from smaller places. |
| 30 | Illinois | Joliet | Chicago, Aurora | Steel manufacturing | Some decrease |
| 31 | Illinois | Belleville | East St. Louis, Collinsville; St. Louis (Mo.) | Dry goods | No injury |
| 32 | Michigan | Adrian | Toledo (Ohio) | Dry goods, carpets | Gone other places to some extent |
| 33 | Michigan | Holland | Grand Rapids | Furniture, carpets | Some decrease |
| 34 | Michigan | Jackson | Detroit | General dry goods | No injury |
| 35 | Michigan | Ypsilanti | Detroit | Dry goods, cloaks, carpets | Holds its own would show increase but for Detroit. |
| 36 | Michigan | Mount Clemens | Detroit, Port Huron | Dry goods | Not much decrease since 1902 |
| 37 | Missouri | Carthage | Joplin, Webb City; Galena (Kans.) | Dry goods | No injury |
| 38 | Texas | Dallas | Fort Worth | Department store | Benefit |
| 39 | California | Santa Monica | Los Angeles | Dry goods | Some decrease in rate of growth |

UPON RETAIL BUSINESS IN CITIES AND SMALL TOWNS: 1907.

a special schedule of inquiries.]

| Effect on sales to farmers and people from smaller villages. | General opinion of merchants as to effect of electric railways. | Remarks. | |
|---|---|---|---|
| No increase | Generally an advantage. Trolley express cars would be a great help. | | 1 |
| Some increase | Favorable | Will bring rural and urban population into closer relationship | 2 |
| Some increase | All consider it an advantage | Increase business in cities; decrease in villages | 3 |
| Some increase | Advantageous | Increase trade from small towns | 4 |
| Farmers come in bad weather and from a greater distance. | Generally glad to see more coming | Kills the corner grocery in the country, but helps the village and city | 5 |
| Increased rural trade | Objection died out. Younger business class knows no other conditions. | Additional roads would benefit | 6 |
| Some increase | Advantage to our town | Business increased | 7 |
| No change | Make local merchants work harder to hold trade | Tends to build the cities in nearly every instance | 8 |
| Some increase | Indifferent | Very good effects | 9 |
| Some increase | Generally favorable | | 10 |
| Farmers take advantage of electric roads. | Generally agree they are beneficial | New line now under way will greatly help Massillon | 11 |
| Increase from towns not formerly connected. | Very good | Will abolish country stores; farmers coming to towns this size | 12 |
| Some increase | Build up the town; increasing business | Will cause more farming to be done on small farms and relieve congestion in cities. | 13 |
| Some increase | A decided advantage | Further increase | 14 |
| No change | Feeling prevails that they are a benefit | Will increase population, increasing business. Improved shipping conditions. | 15 |
| Some increase | Divided | The more the better | 16 |
| No increase | Grocers lose some, furniture stores lose more | | 17 |
| Some increase | Want all we can get | Bound to do good | 18 |
| Too far from line | Favor electric lines | | 19 |
| People get to town often who formerly did not come at all. | Advantage to business of town | Will bring new business | 20 |
| Takes more out than it brings in. | Disadvantage | Large towns eat up small ones | 21 |
| Decrease | Take business to large cities | | 22 |
| Small increase | No change to town | Increase in business would follow if road gained entrance into Cincinnati, making this a suburb. | 23 |
| Think it on the whole an advantage. | A great help to town | Will improve towns if merchants progress as they should | 24 |
| Increased patronage | Advantage | Will improve business | 25 |
| Great increase | They wonderfully aid prosperity | Increased development means everything to increased business facilities | 26 |
| Increased patronage | Generally favorable | Cheaper freight; more consideration for rights of shippers | 27 |
| No farming trade | Big town benefits at expense of smaller | | 28 |
| No change | Bring rural trade to large centers | Both good and evil | 29 |
| Increased patronage | Incentive to trade | More railways under construction which will improve trade | 30 |
| Some increase | None would wish to be without them | Better for our city. Aid in delivering goods | 31 |
| No change | Favor roads from smaller towns | Prospects good | 32 |
| Some increase | Ideas differ according to effect on business | Will cut out the small dealer | 33 |
| Some increase | Want all we can get | Benefits all trading centers; large towns from smaller; small towns from farmers. | 34 |
| Farmers go to Detroit | Detriment. Force merchants to carry larger stock to keep trade. | Gradual but sure concentration of retail business in large cities | 35 |
| No increase | Hurts small business houses. Concentrates business in cities. | Anticipate continued concentration | 36 |
| Some increase | | Anticipate betterment | 37 |
| Some increase | Potent factors in material development | | 38 |
| Some increase | Feel competition with Los Angeles stores | Build up towns but turn trade to cities | 39 |

The evidence is quite conflicting and the situation complicated to some extent by the development of the mail-order business, utilizing the express and freight systems for the delivery of goods ordered from distant points outside the specific area of interurban contact. A merchant at Miamisburg, Ohio, 10 miles from Dayton, where the fare is 25 cents the round trip, remarks as follows: Loss of trade; no gain of any kind; disadvantage to merchants; large towns eat up the small ones. On the other hand, a firm at South Bend, Ind., says: "We are not competent witnesses, having but recently embarked in a wholesale notion, hosiery, and underwear business. We want all the electric lines we can get, and are sure they are a great benefit to the business interests of any town." A firm at Holland, Mich., remarks that they lose trade to Grand Rapids; no benefit except some traders from a small village called Saugatuck; think electrics will cut out the small dealers. A merchant at Oberlin, Ohio, connected with Elyria, Lorain, Cleveland, Norwalk, and Wellington gives his experience as follows: No loss of business; increased 20 per cent in four years. Gain of country trade; merchants want the roads; anticipate the doing away with country stores; the farmers trading in towns this size. A merchant in a town in Ohio, 10 miles from Toledo, says that there is no change in trade, but benefit from better means of transportation. The feeling prevails that roads are a benefit, as they tend to increase population, and each new family brings a certain amount of trade to merchants. A general firm at Youngstown, Ohio, reports that the business has increased from smaller towns and doubled since 1905, but holds that this may be due partly to the enlargement of the store. A firm at Erie, Pa., states that business has almost doubled since 1902, but that the increase is by no means all due to the interurban railways. They have benefited from smaller towns. A merchant in one of the towns in Michigan says that business holds its own, and would show increase but for the trade that goes to Detroit. A merchant in a Pennsylvania town remarks that the farmers come in bad weather when they formerly stayed at home, and they come from a greater distance; but that the interurban road kills the four-corner grocery in the country and helps the village and the city. An interesting comment is made by a merchant at Hubbard, Ohio, to the effect that the interurban roads will cause more farming to be done by small farmers—more truck farming—and will relieve congestion in the cities, as farming was being neglected for lack of easy access to town. A merchant at Glens Falls, N. Y., wrote: "Our system of electric roads which connects with the outlying villages has been a wonderful factor in building up the mercantile interests of this city. It connects with prosperous villages, and so far as I can learn it has been a source of development in all these villages. Of course, it has directly helped to augment all kinds of business in Glens Falls, and yet I can not learn that it has in any manner injured these smaller places with which it connects." Among other opinions offered are these: "Builds up the towns but turns trade to the cities." "Cheaper freight and more consideration of rights of shippers." "Benefits all trading centers, large towns from smaller, and small towns from farmers." "Will bring rural and urban population into closer relation, to the advantage of both." "The more, the better." "Gradual but sure concentration of retail business in large cities."

# CHAPTER V.

## FRANCHISES, PUBLIC REGULATION, AND PUBLIC OWNERSHIP.

The report of 1902 contained an exhaustive discussion of franchises, public regulation, and municipal ownership of street railways. It dealt comprehensively with all the relations between the companies, the municipalities, and the public, and may still be referred to for general data as to the principles and methods adopted in regard to franchises, regulations of fares, car licenses, percentages exacted of income, publicity of accounts, and other conditions. It is not intended, therefore, that the present report shall cover the same ground, for while, during a period notable in American politico-social development for its drastic remodeling of all the terms under which corporations exist and do business, changes have taken place along all these lines, the main body of legislation remains practically the same, except possibly in New York and Wisconsin.

For the census of 1902 the general schedule of inquiry for street-railway companies contained a number of special inquiries as to their franchise rights and obligations. The information obtained in this manner was supplemented by that secured from similar special inquiries addressed to the mayors of cities, and upon this data was based Chapter IX of the report, supplemented by a digest of state laws and typical local ordinances of states where street railways had enjoyed notable development.

*Municipal-taxation methods.*—It is not the intention to repeat this elaborate treatment in the present report. The questions as to franchises were omitted from the schedules for 1907 addressed to street-railway companies, and the series of questions submitted to mayors of municipalities related more particularly to changes in the power of officers or boards to grant franchises, and the terms of franchises granted, during the intervening census period. The aim of the present report will therefore be rather to indicate the tendency of the times in granting franchises, by setting forth the differences between present local practice and that in vogue at the time of the former census. The special schedule for 1907 repeated, however, some general inquiries as to method and rates of taxation, and as to reservation by municipalities of any rights to purchase upon expiration of the term of any franchise.

At the census of 1907 explicit questions with regard to taxation were introduced in the special schedule addressed to mayors, as follows:

3. What municipal taxes are assessed on the property of street-railway companies and on what basis?
   *a.* Real estate and buildings?
   *b.* Track and physical property in the streets?
   *c.* Rolling stock?
   *d.* Franchises?
   What, if any, payments to the city are required other than those noted above?
4. Amount of payment, if any, by all street railways to the city for the last fiscal year, not including ordinary taxes, such as paid by other classes of property?

The replies received in answer to inquiries 3 and 4 gave interesting information; but it was impossible to reduce them to concise order. Some schedules report the *method* of making assessments and the *rate* of taxation under the headings *a*, *b*, *c*, *d*, while others report the *amounts* paid into the city treasury, without stating the actual value of real or personal property on which such amounts were levied. Inquiry 4, when answered, in some cases duplicated the amount previously reported after *d*, under inquiry 3. Even where inquiries have been similarly interpreted by persons furnishing information, the answers disclose the widest possible difference in municipal practice in the assessment of street-railway property and franchises.

The city of Bridgeport, Conn., reports that all taxes are paid to the state, but that the city receives from the state $750 for every drawbridge crossed by the street railway—an increase of $250 over the amount reported in 1902. The city of Hartford, in the same state, receives from the company 2 per cent of the gross amount of fares collected within city limits. Los Angeles, Cal., reports street-railway property assessed as is other property. The franchise is assessed by deducting the assessed value of all tangible property from 50 per cent of the market value of the outstanding securities of the company, as a result of which assessed valuation of the tangible and intangible property is equal to 50 per cent of the market value of the outstanding stock and bonds. An assessment of 2 per cent of the gross income after five years is also made. The city of Riverside, in the same state, assesses street-railway property at 40 per cent of its actual value, making no assessment on the franchise, and receives 2 per cent of gross earnings after five years. Denver, Colo., assesses a municipal tax of 14.3 mills on a valuation of $3,200,000. Pensacola, Fla., assesses 13 mills on real estate, track and physical equipment, and rolling stock.

Quincy, Ill., reports personal property assessed on the basis of one-fifth of the full value, and gives the amounts paid on real estate and buildings, track and physical property, and capital stock. There is also a car license of $20 per car in daily use. Evansville, Ind., reports a graduated franchise tax as follows: First twelve and one-half years, 2 per cent gross earnings; second twelve and one-half years, 2½ per cent gross earnings; third twelve and one-half years, 3 per cent gross earnings; fourth twelve and one-half years, 4 per cent gross earnings. Des Moines, Iowa, reports a tax levied on assessment in bulk, 82 mills on one-fourth value. Dubuque reports a total tax assessment, also a proportion of the city electrician's salary. Marshalltown, in the same state, reports the entire property listed at $150,000; taxable value $37,500, at 22½ mills yearly, or about $850, adjusted after appeal to court.

Leavenworth, Kans., reports "regular tax" on real estate, track, and rolling stock. There is no franchise tax or other requirement, except a certain amount of street paving. Covington, Ky., reports amounts paid on 75 per cent value for *a*, *b*, *c*. The franchise is assessed on the net earnings capitalized at 6 per cent, with $8,000 added per year in lieu of street repairing. Frankfort, Ky., reports $10,000 on tracks and $14,000 on all property; while Lexington in the same state simply answers "Yes" to all inquiries, adding, under franchises, "by state board."

The cities of Massachusetts report an excise tax paid the state, and by it apportioned to the local governments, but the practice aside from this appears to differ locally. The city of Adrian, Mich., reports state, county, city, and school taxes assessed on real estate and buildings, track and physical property in the streets, and rolling stock, but no franchise assessment, other than a special tax levy for paving streets, sewers, etc., while Grand Rapids has assessed taxes on real estate, buildings, and franchise, and also $5 per car license; pro rata for snow removal; and $2,244.72 for "police at crossings."

Missouri taxes are assessed by a state board. St. Joseph reports also $15 per car license. St. Louis reports a special tax of 1 mill per passenger other than the usual taxes. The ordinance levying this special tax has been held valid in the United States Supreme Court. A motion for rehearing is now pending.

The property and franchise in St. Paul, Minn., are reported to be assessed under state law. Keene, N. H., reports no taxes whatever. Newark, N. J., reports street-railway property assessed as is other property, with a state tax on franchises, an additional payment to the city of 5 per cent of the gross receipts, and a license fee of $10 per car per year. At Binghamton, N. Y., real estate, buildings, and franchise were assessed, but not personal property, owing to the indebtedness exceeding value. In Buffalo the amount paid as 3 per cent of gross receipts was deducted by order of the court from the state franchise tax. Gloversville reported assessments "same as other property" on real estate and buildings, track, rolling stock, and franchises, with no other payments. In Rochester taxes were assessed on real estate, track, and physical property in streets, with $5 per car on rolling stock, applied on general taxes, besides a payment of 1 per cent of gross receipts. All this appears to be additional to the state franchise tax. The mayor of Mansfield, Ohio, wrote: "The fact of the matter is that our city council has been too free in granting franchises for the occupancy of its streets by street railways. There are 3 street-car lines now operating in our city, and not one cent has been paid, or asked of them, for a franchise, which to my notion is not what it should be."

Allentown, Pa., reports no taxes assessed on real estate or buildings, track, physical property, or franchises, but a license of $25 per car on rolling stock, $1 per pole, and $5 per mile of wire. A franchise privilege for certain new streets was given for the payment of $15,000 toward the building of a bridge. Easton, Pa., exacts a license of $25 per car and a pole and wire tax. In Erie the local company is taxed 10 cents per pole and $25 per car. Pittsburg receives an annual license of $100 on each car. Reading receives a real-estate tax of 10 mills and a license of $10 per car per year. York makes no assessment of real estate or buildings, but receives 3 per cent of the gross earnings.

Columbia, S. C., reports that street-railway property is taxed as other property, and that in addition a license tax is required, but does not give amounts. Memphis, Tenn., in addition to its tax rate of $1.91 per $100, receives a privilege tax of $20 per annum on each car. Nashville, in addition to assessment on real estate and buildings, track and physical property, and rolling stock, receives 3 per cent of the gross receipts. Houston, Tex., assesses on 60 per cent of the value of real estate, track and physical property in the streets, and rolling stock and franchises, and receives 1 per cent of gross earnings, while in Paris, in the same state, only a straight "ad valorem" tax is reported. In Virginia taxes appear to be fixed by the state corporation commission at $1.40 on $100 valuation. In addition to this, Danville receives a franchise tax of one-half of 1 per cent on the first $40,000 gross receipts, and 1 per cent on all over $40,000 gross. In Norfolk the Bay Shore Terminal Company, under an ordinance of July, 1901, agrees to pay the city, in addition to ordinary taxes and license, $30,000 in annual installments of $1,000 each. The license tax to the city of Norfolk is 6 per cent of the gross receipts. In addition thereto, an ordinance effective May 1, 1908, requires an additional $1,500 license for running trolley cars on the streets of the city and beyond city limits within the state of Virginia. In Richmond the franchise tax is arranged on a sliding scale.

Spokane, Wash., has assessed 13 mills on a basis of 60 per cent of real estate, track and physical property in the streets, and rolling stock and franchises; also 2 mills per car mile made. Parkersburg, W. Va., reports assessment made by state board of public works, and a tax rate of 35 cents per $100.

Janesville, Wis., reports that it receives 2½ per cent of the gross receipts, and Oshkosh 2 per cent of the gross receipts and $1,000 per year on franchise for thirty-five years.

*Street sprinkling.*—In the special schedule of 1907, addressed to mayors, an inquiry was made as to the extent to which street-sprinkling obligations were imposed upon the traction companies. No such inquiry was made at the census of 1902, so that no basis of comparison is afforded; but the replies received at the present time indicate a growing practice of exacting this class of service from street-railway companies as part compensation for franchise privileges. Out of 85 replies to this question, 54, applying more particularly to franchises granted some years ago, reported no such requirement. The tendency in this direction is shown by reports from such cities as Buffalo, N. Y., where sprinkling on certain streets is required under the franchises granted recently, and Utica, N. Y., where such a provision was then being contemplated. Fourteen cities reported sprinkling to be a regular franchise requirement, and in Baltimore a penalty is imposed for neglect to live up to this obligation. The company at Oakland, Cal., does the street sprinkling voluntarily and at its own expense. Hoboken, N. J., Harrisburg, Pa., and Houston, Tex., also report some sprinkling done by local street-railway companies without franchise requirement. At Springfield, Mass., the street-railway company pays toward the expense of street sprinkling $100 per mile of trackage, and under this requirement the amount received in 1907 was slightly in excess of $2,208. Grand Rapids, Mich., on the other hand, furnishes water and pays the company for sprinkling. Covington, Ky., and Richmond and Norfolk, Va., furnish the water, while the street railways do the sprinkling.

*Right to purchase.*—Inquiry 6 of the special schedule for 1907 was: "Does the city reserve the right to purchase the property, or has it the right of succession on expiration of franchise?" No fewer than 64 cities answered this in the negative. A number of cities, including Denver and Des Moines, reported franchises in litigation at the time. At Houston, Tex., the new charter adopted in 1905 provides that in all franchises granted under it the city expressly reserves the right to purchase. The reservation of such rights is also reported by 9 other cities. Seattle, Wash., provides for purchase by the city at any time, with no value assigned to the franchise. Richmond, Va., reserves the right not only to purchase the old franchise, but to grant a new franchise upon the expiration of the present one.

*Voting on franchises.*—Inquiry 7 of the special schedule for 1907 was to this effect: "Has there been any change in the power of officers or boards to grant franchises; in the proportion of the vote of the city council required; or in the matter of ratification by popular vote, and if so, what changes?" In reply to this the cities reported in 58 cases that no changes had been made. A great variety of practice is revealed in the responses. Denver states that by the charter of 1904 the franchise is to be submitted to a vote of the qualified tax-paying electors. Houston, Tex., states that the charter of 1905 puts a restraint on granting franchises, requiring their publication three times in three successive weeks and for thirty days after passage before going into effect; it also provides that 500 voters may cause the matter to be submitted to popular vote. It contains also clauses as to adequate compensation, and the power of the city to purchase at expiration, forfeiture to secure efficiency of service, and the right to inspect the books of the company. At Los Angeles the referendum clause in the charter of 1903 extends the existing franchise grant by competitive bid, the franchise being limited to twenty-one years. As to the initiative the charter provides that any proposed ordinance may be submitted to the council by a petition signed by registered electors of the city equal in number to a given percentage. With regard to the referendum it provides that no grant of any franchise shall be construed to be an urgency measure and that all franchises shall be subject to the referendum vote for which it provides. Petitions against the passing of an ordinance shall be valid if signed by electors equal in number to at least 7 per cent of the vote cast for all mayoralty candidates at the last general election. The city charter of 1905 of Memphis, Tenn., contains a referendum clause to the effect that, provided a petition by 500 freeholders demands a vote upon a franchise ordinance, it must be submitted to the citizens and approved by a majority of those voting. The charter of Grand Rapids, Mich., provides that, on petition of 12 per cent of the voters, the franchise must be submitted to a referendum. A renewal provision requires application to be made one year before the granting thereof.

The charter of Des Moines, Iowa, to which reference is often made in discussions of the subject, provides that all franchises for use of the streets or other city property must be submitted to a vote of the people; also, that if the people desire to vote upon any such measure not originating in the council, they may force submission of the question to a vote of the people by filing with the clerk a petition of 25 per cent of the voters, upon which he must then call the election.

At Newark, N. J., franchises have been granted in perpetuity, but future franchises are to be limited to

from twenty to forty years. Franchises for over twenty years can be granted only after an election on the subject, and no franchises whatever are to be granted for periods of over forty years. The right is reserved to amend the franchises with regard to particular subjects. New Orleans, La., reports that the city has the right to purchase and that extensions are granted on competitive bid, based on the highest percentage of gross earnings. No franchise is granted for more than fifty years, and an amendment of any grant is subject to mutual agreement. At Paterson, N. J., where it appears that no franchises have been granted since 1902, it is stated that a majority vote of the Board of Public Works carries the power to make a grant, subject to the approval of the mayor.

At Frankfort, Ky., the issue of a franchise requires a ratification by a two-thirds vote of the council. At Riverside, Cal., a majority of the board is required for granting a franchise, the board having been increased from 5 to 7 members. Since 1902 the old company has surrendered part of its system and has been granted new franchises, the principle upon which they were granted being that of competitive bids and the highest bidder. The new franchises have been limited to fifty years. Danville, Va., reports that the state requires, under the last constitution, that franchises shall be put up at public auction and sold to the highest bidder. Richmond, Va., reports to the same effect, and also that franchises are granted for ten years, and it reserves the right to grant new franchises to any person or corporation on expiration of the present one, the physical plant to be paid for by the successors.

Youngstown, Ohio, states that the legislature had provided for a referendum vote on the granting of franchises. Mobile, Ala., reports that all franchises have to be awarded to the highest bidder. Seattle, Wash., states that the charter amendment passed March 8, 1908, provides for a referendum vote when petitioned for by 8 per cent of the voters who voted for mayor at the last previous election.

*Competitive bids.*—Inquiry 9 of the special schedule for 1907 inquired as to whether franchises were granted on competitive bid, and if so, by what method. Some of the data under the previous heading applies to this inquiry. A specific answer of "No" is given by 46 cities. As already noted, several of the state constitutions, as in Virginia, required that franchises shall be advertised at public sale, and the same is true of Louisiana and New York. At Seattle, Wash., the bids are considered by the city council on the basis of the general terms proposed and a percentage of gross receipts to be paid to the city.

*Duration of franchise.*—Inquiry 10 of the special schedule for 1907 was: "Is the duration of new or renewed franchises limited? If so, how long? And what, if any, provision is made for renewal?" In reply to this, 13 cities answered "No," or "None," and 31 failed to answer. Pittsburg, Pa., reported that there had been a great public demand for limitation of term of franchises, but that as yet nothing had been done. Two franchises were reported as perpetual; 2 for ninety-nine years; 7 for fifty years with no provision for renewal; 1 for fifty years from the time of the original franchise; and 1 for fifty years, which may be renewed. One of the franchises was for forty years; 1 for thirty-five years, with no provision for renewal; 1 for thirty-two years; and 8 for thirty years, with no provision for renewal; 6 of the franchises were for twenty-five years without provision for renewal; and 1 at Baltimore, for twenty-five years, to be renewed on revaluation. In the case of 1 franchise, for twenty-five years, the company was to apply one year before the expiration of the present grant. In the case of 1 franchise for twenty-one years, provision is made for the arbitration of the rental value of some of the railway lines. In the case of 1 franchise for twenty years, application for renewal is to be made one year before the expiration of the present franchise. One of the franchises is for as brief a term as ten years. At Scranton, Pa., the renewed franchise is limited to a term of fifty years, and 2 franchises appear to be operative, but there is no provision for renewal. In the case of Seattle, Wash., all franchises are to expire December 31, 1934, with no renewals beyond that date. At Toledo, Ohio, it is reported that extensions have been limited to the time of life of the original franchise of the lines thus extended.

*Rates of fare.*—Inquiry 11 in the special schedule for 1907 was: "What, if any, restriction was placed on rates of fare?" To this 19 municipalities failed to make any reply, while 18 reported that no restriction has been made; 25 reported a 5-cent limit, and 8, a 5-cent limit with transfer requirements.

Houston, Tex., requires general transfers, and one-half fare for school children. Three municipalities report 6 tickets for 25 cents; and 2 have 5-cent fares, with 3 cents for school children. York, Pa., reports 5 cents for a single fare, 6 tickets for 25 cents, and 25 tickets for $1. Youngstown, Ohio, reports 6 tickets for 25 cents, and 25 tickets for $1, with universal transfers. Saginaw, Mich., reports 6 common tickets or 8 labor and school tickets for 25 cents. One city reports that an ordinance of 1903 requires one-half fare for school children during school hours. At Seattle Wash., the rate is 5 cents, with transfer privileges 25 tickets for $1, without transfer privileges, and one-half rate for school children. At Detroit, Mich., industrial or labor tickets are issued between certain hours morning and evening, 8 tickets being sold for 25 cents, with universal transfers. If tickets are sold after 8 p. m., the rate is 6 for 25 cents. The general subject of fares is treated in another chapter.

*Street paving.*—In inquiry 12 of the special schedule for 1907 information was asked, as follows: "What are

the requirements in regard to the paving of streets traversed by street-railway tracks?" In reply, 24 municipalities reported that the companies within their jurisdiction are required to pave between the rails and 1 foot on each side; 17, between the rails and 1½ feet on each side; 16, between rails and 2 feet on each side; 4, between rails and 3 feet on each side. One company is required to pave between the outside rails of track or tracks. One municipality reports that it requires paving between rails and 8 inches on each side, and another between rails and 9 inches on each side.

At Binghamton, N. Y., the company is required to pay for one-fifth of the paving between rails, while at Gloversville, N. Y., the railway pays for paving a strip 9 feet in width. At Adrian, Mich., the company pays for the labor and the city furnishes the material for paving between rails. At Pittsburg, Pa., all the companies are required to pave and keep clean and in repair the space between tracks and 1 foot on each side, while in one or two instances the company has been required to keep the streets clean and in repair from curb to curb. At Covington, Ky., the city keeps the streets in repair, and the company pays $8,000 per year toward the expenses in lieu of other contributions of the kind. Two cities require 7 feet of paving for single track and 14 feet for double track.

*Amending franchises.*—Inquiry 13 of the special schedule for 1907 was as follows: "Does the city reserve the right to amend the franchise grant during its term, either generally or as regards particular subjects?" In reply to this 52 answered "No;" 2, in Massachusetts, added "under state law." Fourteen municipalities either did not answer, or reported no new franchises granted. At Houston, Tex., this reservation is stated not to be in the franchise, but the new charter places restrictions and imposes conditions. Baltimore has no right to amend, but can regulate and superintend. Youngstown, Ohio, has no rights reserved, except as to service and schedules. Quincy, Ill., states that under its franchise it may regulate the manner and place of laying track and may by ordinance prohibit the laying of track where it may be deemed injurious to the public. Toledo, Ohio, reserves no right to amend franchises, but can regulate operation and standard of service. St. Louis, Mo., in like manner exacts an agreement to conform to all present and future ordinances. Adrian, Mich., has reserved the right to amend, and can by special ordinance, if necessary, make rules to protect the public. Chattanooga, Tenn., has reserved the right to amend the franchise, except as to rights that are vested in some franchise ordinances; in other ordinances no rights are reserved. At Fort Wayne, Ind., the company is required to observe all ordinances in effect or subsequently to be granted, while Fitchburg, Mass., reserves the right to amend or to revoke if conditions are violated. The company is required to file a letter accepting conditions before the franchise becomes operative.

*Special experiments in franchises.*—Philadelphia is one of the important cities that has attempted to deal with the problem of franchises in its own way, and the ordinance approved by the mayor on July 1, 1907, and accepted by the Philadelphia Rapid Transit Company is an interesting example of joint operation and division of profits between the municipality and the corporation. The contract, or agreement, sets forth the fact that as the company has come into control and operation of one general system embracing practically all the street-railway companies in the city, such companies numbering upward of fifty since the year 1857, with all kinds of franchise conditions and restrictions, it proved desirable that a readjustment of relations should be reached. There was dispute and uncertainty in regard to terms under the various franchises and ordinances, and it was believed to be in the interest of the public as well as of the parties concerned to supersede all former contracts, and to define, with a view to better regulation, the future relations between the city and the company. The ordinance approaches the problem from three points of view. It states first that it is desirable that the city should have a voice in the management of the company and a supervision of its accounts and expenditures. The second point is that as the company required a large sum of money for the extension and perfection of its system the better to serve the public, it was essential that its position should be clearly defined so as to strengthen the value of its securities and properties and to render it easy for the company to enjoy proper credit in financing increased transit facilities. The third point is that it had been found desirable so to remodel the system of exacting revenues from the company as to secure the direct payment into the city treasury of a fixed sum in lieu of a license fee per car, and of a further sum to represent care and maintenance of streets and pavements containing street-railway tracks. In this respect it was desirable that provision should be made whereby the city would share in the company's earnings from the future growth of population, without making the city liable for any of the company's obligations, and with a view to the ultimate acquisition by the city of the company's real estate and property.

The ordinance, therefore, provides conditions under which the company can increase its stocks and bonds at any time upon receiving the approval of the city. All such increases in capitalization are to be paid for at par value in cash. In case the city council should determine that extensions are necessary and the company should fail to accept such plans, the city is at liberty to take up the work with other parties. The company is entitled to pay its stockholders a return

of 6 per cent upon the actual capital paid into the treasury, and in the case of any profit in excess of that, the city shares equally with the stockholders in all net earnings properly distributed as dividends. It is provided that the mayor ex officio and two citizens shall be chosen from time to time by the councils of the city to serve for four years or longer as members of the board of directors of the company, exercising full power as if they were directors for the stockholders, but without incurring any liability.

The ordinance provides for a sinking fund to be in the custody and control of a commission composed of the mayor of the city, the president of the company, and the president of the board of directors of the city trusts. The payments to this fund from July, 1912, are to be at the rate of $10,000 monthly for a period of ten years, with an increase of $5,000 at the end of each ten-year period until 1952, when the final increase will bring the rate up to $30,000, which is to continue to the end of the fifty-year contract—1957. The city reserves the right to purchase the property outright at that time upon paying it an amount equal to the par value of its capital stock then outstanding, namely, the $30,000,000 authorized at the start plus any additional stock issued in the meantime. The sinking fund is to be available in making the purchase, the commission on investment and reinvestment being confined in its operations to securities named by statute as proper investments for trusts, except that the stock of the company may be purchased at any time at a price not above its par value, while the bonds and underlying securities may be purchased on a 4 per cent income basis. The city reserves the right at any time after the sinking fund has reached the amount of $5,000,000 to require by an ordinance of council that the same shall be turned over to the city treasury and become its absolute property.

In addition to this sinking fund the ordinance provides that in periods of ten years the company shall pay into the city treasury yearly sums ranging from $500,000 to $700,000, these payments to be in lieu of all obligation and liability for paving, etc., and license fees. In case, however, of any additional streets occupied by the company after 1907, provision is made that it shall add to the yearly sum to be paid an amount for certain street paving at the following rates: 7 cents per square yard for macadam pavement, 8 cents for asphalt, and 6 cents for pavement of other character; while should any streets be abandoned by the company the payment will be reduced in like manner, providing that the company is in no wise released from the obligation to replace or repair pavement removed or damaged by work which it may undertake in regard to its tracks or its conduits. Provision is made for the publicity of accounts, and for a full statement of receipts and expenses to the city comptroller. The ordinance provides also for the development of the elevated system within three years from June, 1907.

It will be seen that in Philadelphia, as in the case of Chicago, to be noted hereafter, the contract or ordinance embodies obligations of partnership between the railway and the city; and it was expected that such partnership not only would serve as a protection to the city in its dealings with the corporation, but also would eliminate labor troubles. This expectation has not been borne out wholly by the facts, although it may perhaps be considered that labor troubles are less than would have been the case had the conditions existing previous to the passage of the ordinance continued.

Chicago is another city which has tried the "joint-ownership" plan, which in this case dates from the ordinance of 1907. At that time street railway affairs had drifted into a state of dire confusion, in which the companies had been seriously discredited and the properties had depreciated in value. Previous to the ratification of the ordinance proposed for submission to the voters of Chicago, a valuation board had estimated the value of the physical property of the Chicago City Railway Company and the Chicago Union Traction Company at $52,000,000 with pavement and $47,000,000 without pavement. The total value of the two properties was finally assumed to be $50,000,000, and on this basis the ordinance provisions were founded. In accepting the ordinance of 1907 the two railway companies agreed to rehabilitate their properties thoroughly, raising the money for such purposes themselves. The work has already cost about $30,000,000, and the total amount to be expended is estimated at $40,000,000. According to the ordinance the city may, on six months' notice, purchase the property at the original valuation, plus the rehabilitation costs, certified by the board of supervising engineers; a renewal and depreciation fund of 8 per cent of the gross receipts of each month must, however, be set aside to guarantee the upkeep of the property to 85 per cent condition. From the gross receipts are deducted, besides the renewal and depreciation fund, the operating expenses and 5 per cent interest on the capital invested at the time of the signing of the ordinance. The balance that remains is divided, 55 per cent going to the city and 45 per cent to the companies as interest.

With the object of controlling the rehabilitation work and the books of the companies, so that a proper division of net earnings could be made, a board of supervising engineers, having its staff of auditors and its staff of engineers and inspectors, was created, and this board has laid down a system of accounting as well as a general system of control. It was stated that at the beginning of 1909 the board, which is responsible to the city, had had charge of the work distributed over 651 miles of city tracks, 213 miles of

which were being rehabilitated. A large amount of new work was also in hand.

The partnership ordinances resulted in payments to the city in 1907 and 1908 of a sum of about $3,000,000, which was approximately 8 per cent of the gross receipts. Reference has been made above to the advantages expected to accrue from such joint ownership and operation, especially with regard to an improvement of the conditions between capital and labor. The disputes between the companies and their employees over hours and wages have, however, been renewed, and the companies have declared their inability to meet the demands made upon them. Under such circumstances the argument has been advanced by members of the city council that the city should and could meet the demands by paying the increase out of its proportion of the profit accruing from joint operation. It is argued on the other hand that the adoption of such a policy would have vicious results in many ways, besides sacrificing some of the material benefit derived by the city under the new ordinance.

Under the new policy in Chicago the principle of indeterminate franchise applies to a marked degree. The initial term of the franchise is twenty years, but the city holds the right to purchase at any time either during this period or after its expiration. At the end of twenty years the city may grant the franchise to another company, but should it do so, the new company is under obligation to purchase the property of the old one. Should the city exercise its right of purchase before the expiration of the franchise term for any other purpose than direct municipal ownership, it is required to pay a bonus of 20 per cent on the agreed price. It may transfer this right to a company, but such company must pay the 20 per cent bonus. If, however, a company is organized to operate the railway at a profit that shall not exceed 5 per cent, such a company may purchase the property of its predecessor without paying the 20 per cent bonus. At the end of the initial term of twenty years no bonus need be paid either by the city or by any new company.

The curious plan of operation adopted in the city of Cleveland, Ohio, has not been justified by results. A long period of controversy and difficulties in Cleveland led to the transfer of the street-railway properties in that city to the Municipal Traction Company. The property of the Cleveland Railway Company thus transferred or controlled was valued at the time of the lease at nearly $24,000,000, while the holding corporation, the Municipal Traction Company, was incorporated with $10,000 of authorized stock, said stock to be held by the directors for the benefit of the city of Cleveland. Under this plan, devised by Mr. Tom L. Johnson, mayor of the city and treasurer of the Municipal Traction Company, the Cleveland Electric Railway Company leased all of its property rights, privileges, and franchises to the Municipal Traction Company for a period of fifty years, the lease to be renewable for like periods. The traction company was required to pay the railway company 6 per cent rental on about $15,000,000 capital stock and 6 per cent on any additional stock that might be issued for financial betterments or extensions or for other proper objects.

It has generally been supposed that the city had specific control over the Municipal Traction Company, but this does not appear to be the fact, except so far as the directors of the Municipal Traction Company were officials of the city. As soon as the change of control was made, early in 1908, the new company put in operation a system which was supposed to be based upon a 3-cent-fare rate. As a matter of fact it established a 3-cent fare within certain limits, with a charge of 1 cent for a transfer; but as routes were changed and lines were abandoned, the charge per ride appears to have increased in a great many instances, and some extreme fares, as high as 12 and 13 cents, were reported. The changes appear to have worked to the disadvantage particularly of the long-distance passenger, and, as a matter of fact, the object of the low fare was to make riding attractive to the short-haul passenger. The long-distance passenger is said to have suffered, however, in various respects. For example, in regard to Euclid Beach, a summer resort on Lake Erie, outside the city limits of Cleveland, the old company charged one fare or sold 11 tickets for 50 cents. The new company did not operate any line directly to the beach from the downtown sections of the city, so that passengers had to pay up to 9 cents or more for a ride, depending upon the number of lines they were obliged to take or their unfamiliarity with the ticket scheme in force. If they did not ask for the proper transfer, another fare was exacted. The grant to the Cleveland Electric Railway Company required that in East Cleveland, a residence suburb, practically the same service should be given as was provided on Euclid avenue within the city, with the same rate of fare and the same transfer privileges. When the Municipal Traction Company took over the system this village was treated like all the other suburbs as to the fare charged. A rate of 3 cents was made to the city limits, and those who wished to ride to points within the village were required to secure a suburban-fare check, for which they paid 2 cents additional, thus equaling a straight 5-cent fare. A fare of 5 cents also was charged in the other direction, and for rides within the village. The changes caused troubles which resulted in an injunction suit decided in favor of the village, but after its settlement the company, while reducing its fare to 3 cents, put in operation a schedule provided for in an old ordinance requiring a car each way every ten minutes. The result was that the morning and evening traffic was seriously congested with heavy loads, small closed cars carrying at times from 100 to 140 persons.

Various conditions like this led to disputes with the public, followed by further labor troubles due to the treatment of employees, with the result that the Municipal Traction Company, after a short but eventful career, being unable to meet its obligations and falling deeper and deeper into debt with every month of operation, went into bankruptcy and passed into the hands of receivers. The citizens, at a later election, declared themselves against the plan put in force by Mayor Johnson, thus leaving the way open to further attempts at a settlement of the controversy.

New York City has adopted the principle of joint ownership or operation in its later relations with traction companies. The entire subway system now operated by the Interborough Rapid Transit Company was built by the city and is leased to the company for fifty years, with a privilege of renewal for twenty-five years. A later franchise, that of the Hudson and Manhattan Railroad Company for its tunnels under Sixth avenue and Eighth street, secures to the city the right to purchase the property at any time after twenty-five years, and also contains a provision for the readjustment of compensation or rental to the city at the end of each twenty-five-year rental period. The franchise, while of indeterminate character, does not provide for the transfer of the city rights to another company. In addition to the above, a number of individual street-railway companies in the city hold franchises which maintain the right of the city to amend or appeal them.

During the last few years the legislatures of various states, in dealing with public utilities, have taken steps to create public-service commissions which should have supervision of such utilities and of the general adjustment of relations between them and the public. The railroad commissions in various states exercise to varying extents supervision over other utilities, but in 3 states—New York, Wisconsin, and Vermont—the supervision and control exercised by the new public-service commissions appear to be most general and complete. The application of the public-service commission principle, however, is not yet by any means as thorough as is supposed even in these states. For example, in New York state the commission has not been given supervision of telegraph and telephone companies. In Massachusetts the extent of the supervision is the same as that in Wisconsin, but the jurisdiction exercised by one commission in New York and in Wisconsin is divided among three separate commissions in Massachusetts. The railroad commission in Pennsylvania has jurisdiction over navigation companies, pipe lines, railways, and telephone companies. The Kansas commission has supervision over electric railways. The Georgia commission is not known as a public-service commission, but seems to be such a body in reality, as it includes street railways, gas works, and electric-light and power plants in its scope of action.

One of the most important functions of such public-service commissions is found in their relation to the franchise, and to the adoption of the indeterminate form. Thus, for example, the public-utilities law of Wisconsin not only provided that all future franchises must be revocable at any time, but allowed any company that received originally a limited franchise to exchange it prior to July 1, 1908, for an indeterminate one. A number of utility companies in the state have availed themselves of this permission. The new constitution of Michigan, approved during 1908, adopted the same principle in another way, prohibiting local authorities from granting franchises, unless such grants were revocable, without ratification by popular vote. In Massachusetts the public-utility franchise is essentially of the indeterminate character. As defined by Commissioner Maltbie, of the public-service commission for the first district of New York:

> The indeterminate franchise, or tenure during good behavior, as it is sometimes called, briefly defined, is a franchise which may be terminated by the proper authorities at any time upon the payment of a fair compensation for the value of property thus taken, exclusive of franchise. There are many other provisions of importance which are necessary to the practical operation of the plan; but any fundamental principle is the right of acquisition at any time at a reasonable cost. *This is the only way whereby a community can always and continuously control its own destinies and direct its own growth.* Governmental supervision of corporations is an effective weapon, but there are times when the desired results can be obtained only by the complete elimination of a given corporation or group of men, and then the right of purchase, to be followed by governmental operation or lease to another private corporation is the only adequate remedy.

The principle of granting indeterminate franchises has been adopted in Porto Rico and the Hawaiian Islands, and has been made applicable in the District of Columbia, where the street railways of Washington hold their franchises subject to alteration, amendment, or appeal at any time. In speaking of this subject the Chicago Street Railway Commission of 1900 makes the following remarks on the experience obtained at the national capital:

> In Washington, franchise grants are conferred by act of Congress, and all grants are subject to alteration, amendment, or appeal at any time, at the will of Congress. Under the power thus reserved Congress orders such improvements in service as it may deem desirable, and whenever it deems them desirable, and the orders are at once executed without parley or litigation. The overhead trolley was never permitted in Washington. When the underground trolley was shown to be feasible, Congress passed an act reading in part as follows: "That the said Metropolitan Railroad Company be, and the same is hereby, authorized, empowered, and required to equip and operate the lines of its cars * * * with an underground electric system for the propulsion of such cars." Under this order Washington was the first city in the country to secure the underground trolley. Under the reserved power to alter, amend, or appeal grants at will Congress has required different companies to make arrangements for issuing transfers from the line of one company to those of another, and it has also required different companies to use certain tracks in common where the public interests would be served by such an arrangement.

As regards the work of public-service commissions it is stated by Commissioner Maltbie, in the report to which reference has already been made, that continuous control and supervision by state or city authorities should be provided for either by franchise or by general statute. This control should include the approval of plans of construction and equipment and of subsequent changes, power to adopt and enforce general or special rules and regulations as to construction, operation, and service, the regulation of contracts, rates, and transfers, and the control of capitalization, accounting methods, consolidation, etc., and in every way endeavoring to secure the best service to the public at the lowest rates consistent with a fair profit on the investment. This, Mr. Maltbie states, presupposes the existence or creation of such an authority as a public-service commission, with an organization adequate for the exercise of its power. As to the partnership plan, or sharing of profits, he says that while there may be instances where it seems desirable to make such provision by ordinance, it is better to lower rates than to tax the user of a service to defray the expenses of the government. Discussing the results obtained with the Wisconsin Public Utility Commission, Dr. B. H. Meyer, president of that body, in an address before the American Civic Association and the National Municipal League, states that the Wisconsin legislation has taken the utilities out of politics; that the public-utilities law tended to eliminate feuds between citizens and the management of the public and private plants; that it raised the standard of morality through the eradication of the evil of discrimination and the protection of a reasonable rate; that the law is working a revolution in business methods by enforcing the adoption of uniform accounting and systematic, scientific rates; and that all the effects of the law taken collectively show its tendency to place investments in public-utility enterprises on a more favorable foundation by removing them largely, if not entirely, from the field of speculation, and putting them in the class of conservative, certain, and stable investments.

# CHAPTER VI.

## FOREIGN TRAMWAYS AND ELECTRIC RAILWAYS.

Herewith are presented some general data with regard to the development of street railways and electric-railway systems in foreign countries during the five-year census period. In the report for 1902 the exact figures were obtainable for the United Kingdom, Germany, and France, though for various reasons they did not all coincide as to date. The figures given in the present report are fullest for the United Kingdom, Germany, and France. In regard to the last-named country, the statistics are the latest obtainable, being those for 1905, issued by the ministry of public works while this report was in preparation. Those for Germany are for the year 1907, while those for the United Kingdom include some covering 1908 in part, but not enough to vitiate any comparison that may be sought. Outside these three countries the data in any fullness are obtainable with difficulty, as few governmental authorities in Europe appear to collect them carefully; and there is no authority in this country that can furnish them. In the report of 1902 no data were given beyond those of the United Kingdom and the Continent of Europe; but the present report includes information in regard to other parts of the world, particularly the Dominion of Canada and the Republic of Mexico. The census period has witnessed considerable development in South America, Asia, and Africa, of which notice is taken, and in regard to which it may be remarked that American enterprise and capital have been enlisted in many of the undertakings.

The statistics presented in this chapter were expressed in units of measure in use in the country to which the statistics related. For the purpose of comparison with the statistics relating to the United States, the several units have been reduced to the standard units of the United States.

Nowhere else can a growth of interurban railways be found at all comparable with the remarkable development in the United States during the period 1902 to 1907. The chief reason for this is that the place filled by the trolley system in this country is taken, in the leading European countries, by their "light railways," fostered for a long period by special laws and regulations. Broadly speaking, none of these railways are included in the street or electric railway statistics issued as such by the authorities of the United Kingdom, France, or Germany, and are not included here in bulk, although referred to as they were in the report of 1902. Hence care should be exercised in making any comparisons based on the statistics of street railways proper in Europe and on those in this country, which, on account of the interurban lines, embrace so large a mileage and so extensive a business. These European light railways are usually operated under steam conditions highly unfavorable to good financial results, and a change to electric motive power might naturally be expected; but no foreign experts look for an early revolution of that kind. In a paper read by Mr. O. Petri before the International Congress of Street Railways and Light Railways at Munich in 1908, the extent of the development of light-railway traction in Belgium, France, and Germany was given in the following statement, which shows that Belgium has gone farthest per unit of area as well as per capita in the erection of street railways, while the financial results in that country are least satisfactory:

| | Network in miles. | Miles of light railways and street railways. | | Mean dividend. |
|---|---|---|---|---|
| | | Per acre. | Per 10,000 inhabitants. | |
| Belgium | 1,822 | 2.5 | 2.5 | 1.50 |
| France | 3,799 | 0.3 | 1.0 | 3.16 |
| Germany | 5,115 | 0.4 | 0.8 | 2.48 |

In Germany only 4 cities with more than 35,000 inhabitants have no street railway, but the general financial results are unsatisfactory, the mean dividend of street railways being below 2.5 per cent. The electric street railways and light railways might be divided into two groups, those that have their own generating stations and those that buy energy from central stations. The cost of energy in proportion to the cost of operation and per kilowatt hour were given in the following statement, the figures of course representing mean values:

| | Energy cost in per cent of cost of operation. | Cost per kilowatt hour (cents). |
|---|---|---|
| Light railways with their own electrical stations | 19.6 | 1.66 |
| Light railways which buy energy from central stations | 27.7 | 2.85 |

The average cost of energy for electric street railways was 2.49 cents per kilowatt hour. The ratio of the energy cost to the first cost is comparatively high,

3.34 per cent. This ratio is important for estimating the economy of operation.

It is not to be understood, however, that Europe has been without electric-railway development outside the cities. On the contrary, considerable work has been done since 1902 in changing or equipping lines of considerable length. Note is made of several such roads under the respective heads in this chapter. At first work was carried out with direct current. A brief period followed, more experimental than practical, of work with 3-phase alternating current. Six roads using this type of current were built, including the famous Zossen road in Germany, 14 miles in length, on which speeds in excess of 100 miles an hour were attained with a trolley line carrying 11,000 volts. Another and a permanent example is the Valtellina road in Italy, 67 miles in length, on which speeds of over 40 miles an hour have been attained. These roads employ three live contact conductors to supply current to their motor cars or locomotives. It was not until the single-phase current with only one working conductor was seriously taken up that any great progress was made, but since its general acceptance in Europe for long-distance work, the utilization of electricity in heavy long-distance traction work has been most significant. Subjoined is a table, compiled early in 1908, showing the growth effected in about three years.

TABLE 173.—SINGLE-PHASE RAILWAYS IN EUROPE: 1908.

| NAME OF LINE. | Length in miles. | Frequency. | Line voltage. | Number of motor cars, with horsepower on each. | Number of locomotives, with horsepower on each. | Date of opening. |
|---|---|---|---|---|---|---|
| Bergamo-Valle Brembana | 19.0 | 25 | 6,000 | ..... | 5-300 | December, 1907. |
| Blankenese-Ohlsdorf | 41.5 | 25 | 6,000 | 6-250 | ..... | January, 1907. |
| Blankenese-Ohlsdorf | ..... | 25 | 6,000 | 51-345 | ..... | January, 1907. |
| Borrinage | 13.0 | 40 | 600 | 20-80 | ..... | April, 1905. |
| Compagnie Generale Parisienne de Tramways | 1.0 | ..... | 500 | 2-50 | ..... | Experimental. |
| Murnau-Oberammergau | 15.0 | 16 | 5,000 | 4-160 | ..... | January, 1905. |
| Spindlersfeld | 26.0 | 25 | 6,000 | 2-200 | ..... | August, 1903. |
| Prussian State Railway | 1.5 | 25 | 6,600 | ..... | ..... | Experimental. |
| Rome-Civita-Castellana | 34.0 | 25 | 6,000 | 15-80 | ..... | March, 1907. |
| Stubaital | 11.75 | 42 | 2,500 | 4-160 | ..... | August, 1904. |
| Stubaital | ..... | ..... | 6,000 | ..... | 2-200 | |
| Stubaital | ..... | ..... | 5,000 | ..... | ..... | |
| Swedish State Railways | 12.0 | 25 | 20,000 | ..... | 1-330 | Experimental. |
| Swedish State Railways | ..... | ..... | 6,000 | ..... | ..... | |
| Swedish State Railways | ..... | ..... | 20,000 | ..... | 1-330 | |
| Vienna-Baden | 17.0 | 15 | (A. C.) 10,000 | 13-100 | ..... | January, 1907. |
| Vienna-Baden | ..... | ..... | (D. C.) 500 | ..... | ..... | |
| Locarno-Bignasco | 17.0 | 20 | 5,500 | 4-160 | ..... | September, 1907. |
| Seebach-Wettingen | 12.0 | 15 | 15,000 | ..... | 2-400<br>1-225 | December, 1907. |
| Midland Railway | 16.6 | 25 | 6,600 | 3-350 | ..... | April, 1908. |
| Brighton Line | 17.2 | 25 | 6,000 | ..... | ..... | ..... |
| Parma Provincial | 26.5 | 25 | 4,000 | 17-120 | ..... | |
| Parma Provincial | ..... | ..... | ..... | 1-60 | ..... | Not yet open for traffic. |
| Rotterdam-Hague | 45.0 | 25 | 10,000 | 20-350 | ..... | |
| St. Polten-Mariazell | 66.5 | 25 | 6,000 | ..... | 23-350 | |
| Tergnier-Anizy | 20.0 | 25 | 3,300 | ..... | ..... | |

Europe had 19 single-phase lines, aggregating 415.5 miles, while in the United States at the same time there were 28 such lines, aggregating 956.3 miles. Further reference will be found below to this work, which seems destined to have an important influence on European railroad conditions.

Without anticipating the specific separate data as to the individual countries dealt with, it is fitting to cite here, as illustrative of the best European conditions, a table presented in 1908 by President Mordey, before the Institution of Electrical Engineers of England, in a paper on electrical development. This table summarizes the detail data, quoted in two tables given later, as to results with electric tramways in England and Germany. In regard to these figures, Mr. Mordey remarks: "The most striking difference between the countries is in the car miles per inhabitant—the German figures being nearly double the British for both groups. This difference is, of course, due to the use of small cars in Germany." He explains that the average capacity in Germany is 33 passengers, including standing space, while in England it is about 50. The cost per passenger is much higher in Germany, but the total cost per car mile is lower, due in part, it is said, to lower wages. The table follows:

TABLE 174.—COMPARISON OF ELECTRIC-TRAMWAY STATISTICS FOR ENGLAND AND GERMANY: 1908.

| TOWNS. | PER INHABITANT. | | | | | PER PASSENGER. | | PER CAR MILE. | |
|---|---|---|---|---|---|---|---|---|---|
| | Capital. | Journeys. | Revenue. | Yards of track. | Car miles. | Revenue (cents). | Cost (cents). | Revenue (cents). | Cost (cents). |
| Six large British | $11.68 | 160 | $3.55 | 0.29 | 16.5 | 2.21 | 1.38 | 21.49 | 13.38 |
| Six large German | 13.77 | 157 | 3.67 | 0.36 | 27.8 | 2.33 | 1.50 | 12.77 | 8.51 |
| Six medium British | 9.98 | 92 | 1.99 | 0.31 | 8.9 | 2.15 | 1.40 | 22.30 | 14.39 |
| Six medium German | 8.71 | 78 | 1.84 | 0.30 | 15.2 | 2.33 | 1.60 | 11.96 | 8.31 |

In a general way it may be said that the sociological and economic aspects of street-railway operation in Europe are widely different from those in America, though conditions are very much alike from the engineering standpoint. In England largely, and to some extent on the Continent, the street railways are owned and operated by the various municipalities, while in the United States such a condition is almost unknown. In Europe a zone fare prevails, here the flat rate of 5 cents. In Europe the transfer is not in use, while here its use is practically universal. In Europe the tramways are all subject to a central national authority; here the effective control hardly extends beyond the community in which the line operates, except in states where railway or public-service commissions have been created. Other notable points of difference could be mentioned. But in respect to engineering practice, the methods in vogue are surprisingly similar, and a constant interchange of principles and apparatus goes on, as to car building, motor equipment, controllers, brakes, line material, track construction, and current-generating apparatus.

*Trackless trolleys.*—No trackless trolleys are in operation in the United States, but several have been tried here as well as in Europe, and while the present report has been in preparation a special committee of the town council of Leeds, England, has made a study of and a report on the subject. Such systems can hardly be regarded as railways, but partake more of the nature of stagecoach lines, although the overhead wires may be regarded as in the nature of conducting track.

Three trackless-trolley routes are now in operation in Austria, 6 or 7 in Italy, and 1 or 2 in Germany; these being representative of three systems. The vehicles correspond in general appearance to the single-deck motor omnibus, plus the means of collecting current. A double-trolley method is necessary in order to complete the circuit from the wire through the motors and back to the generating plant. On one of the lines in Vienna two pairs of cables are used, so that passing cars do not have to stop and exchange connections as on other lines and as was done by some of the earlier electric-railway trolley systems in the United States. The Austrian vehicles, which, empty, weigh 2½ tons apiece, each carry 12 passengers seated, with standing room for 12 more. The electric motors, each of 20 horsepower, form the hubs of the rear wheels, and current is led to them by a flexible cable attached to a pair of wheels which run on top of the wire, a similar pair making the return circuit; a weighted pendulum slung from a frame presses the wheels down upon the wires. The cost of the coach chassis is $2,750, and the cost of overhead construction is $8,500 per mile.

In the Italian system each coach, which carries 30 passengers, has a direct-current motor of 10 to 12 horsepower. To maintain the circuit a framework supports two pairs of wheels, but in this case the wheels are pressed by a pole against the underside of the wires, as in regular trolley work. The route examined by the committee is 4½ miles long, and the fare charged is 8 cents. The cost of overhead construction, wooden poles being employed, is placed at $3,756 per mile.

The system seen in operation in Germany had current gathered by sliding shoes pressed against the wire by short poles. The empty vehicle weighs 6,280 pounds and carries 15 passengers seated. Only the front wheels have rubber tires, so that there is considerable vibration and noise, and as the single motor drives on the front axles the steering is rather cumbrous. It is stated that all the systems examined operate smoothly, with few hitches, and that owing to the comparative lightness of the vehicles the surface of the road suffers less than in the case of cars carrying gasoline or other engines. The committee reports itself as much impressed with the practicability of all the systems for transportation feeder purposes in sparsely settled districts, and as a means of avoiding the heavy expense required for the installation of ordinary street railways.

### CANADA.

Statistics with respect to electric railways were not collected by the Department of Railways and Canals until 1901, so that the history of events up to that time is not of record. Subjoined are data from Mr. J. L. Payne, Comptroller of Railway Statistics of the Dominion:[1]

| YEAR. | Miles. | YEAR. | Miles. |
|---|---|---|---|
| 1901 | 512 | 1905 | 793 |
| 1902 | 558 | 1906 | 813 |
| 1903 | 759 | 1907 | 815 |
| 1904 | 767 | | |

Whether or not the relatively slow growth in mileage of the past three years indicates that Canada is approaching the saturation point can only be a matter of conjecture. The older provinces are well served at present. Ontario has 29 lines, with 402 miles of track; Quebec has 8, representing 198 miles; the Maritime Provinces account for 7, with 71 miles; and in the west there are 3 systems aggregating 104 miles.

Up to June 30 last the investment of capital stood as follows:

| YEAR. | Amount. | YEAR. | Amount. |
|---|---|---|---|
| 1901 | $39,076,018 | 1905 | $61,033,321 |
| 1902 | 41,593,064 | 1906 | 63,587,970 |
| 1903 | 47,096,453 | 1907 | 75,195,476 |
| 1904 | 50,399,188 | | |

These figures represent a capitalization of $76,320 per mile in 1901 and of $92,264 in 1907. The explanation of this increase is probably to be found in the

[1] Street Railway Journal, February 1, 1908.

larger earnings and larger capacity of power production. The railways required betterments and got them by increasing liabilities. Of the $75,195,476 outstanding on June 30 last, $39,251,746 was in common stock, $4,200,000 in preference stock, $28,459,537 in bonds, and "other sources" made up the remaining $708,437. A floating debt of $7,567,025 also was returned. In a few instances state aid was given to electric railways, the Dominion government having contributed $118,400, provincial governments $306,945, and municipalities $173,000. In one instance British Columbia gave a grant of land.

The financial results are fairly satisfactory, as the following statement shows:

| YEAR. | Gross earnings. | Operating expenses. | Expenses to earnings (per cent). |
|---|---|---|---|
| 1901 | $5,768,283 | $3,435,163 | 59.55 |
| 1902 | 6,486,438 | 3,802,855 | 58.63 |
| 1903 | 7,233,677 | 4,472,858 | 61.83 |
| 1904 | 8,453,609 | 5,326,517 | 63.01 |
| 1905 | 9,357,126 | 5,918,194 | 63.25 |
| 1906 | 10,966,872 | 6,675,038 | 60.87 |
| 1907 | 12,635,905 | 7,757,252 | 61.23 |

That the earnings should have increased 119 per cent while the mileage was growing 59 per cent, may be taken as proof of the response which came from the public when more adequate transportation facilities were provided. The increase in capitalization within the same period was 92 per cent. The proportion or relationship of earnings to working expenses shows the flourishing condition of electric-railway interests in Canada. The gross earnings for the year were made up as follows: Passenger traffic, $12,101,922; freight traffic, $344,368; mails and express, $41,952; other sources, $238,664. The division of operating expenses was: Maintenance of line, buildings, etc., $765,685; cost of power, $1,412,359; working and repairs, $1,060,783; general operating charges, $4,498,425.

The history of traffic, mileage, and equipment reveals the same relative measure of growth. The following summary gives the essential facts:

| YEAR. | Passengers carried. | Tons of freight. | Car mileage. | Number of cars. |
|---|---|---|---|---|
| 1901 | 120,934,656 | 287,926 | 31,750,754 | 2,194 |
| 1902 | 137,681,482 | 266,182 | 35,833,841 | 2,374 |
| 1903 | 155,662,812 | 371,286 | 38,028,529 | 2,533 |
| 1904 | 181,689,998 | 400,161 | 42,066,124 | 2,601 |
| 1905 | 203,467,317 | 510,350 | 45,959,101 | 2,789 |
| 1906 | 237,655,074 | 506,024 | 50,018,836 | 2,950 |
| 1907 | 273,999,404 | 479,739 | 53,361,227 | 3,157 |

While the number of cars in service was increased by 44 per cent, the number of passengers grew to the extent of 127 per cent. Details are not given as to the well-known increase in the size and carrying capacity of the cars. The effect of this larger traffic was to raise the number of passengers carried per car from 55,121 in 1901 to 86,791 in 1907—a betterment in that respect of 57 per cent. At the same time the car mileage was increased 68 per cent. The effect of all this was to increase the cost of power 181 per cent, but the account as a whole must be viewed with satisfaction from the standpoint of the companies. In 1907 the average cost of running an electric car 1 mile was 14.5 cents, and the gross earnings, reckoned on the same basis, were 23.7 cents.

During the year 1907 special inquiries were made with respect to equipment. The number of cars in service was found to be 3,157, of which 75.5 per cent was of domestic manufacture. During the year 207 had been added, of which 45, or 21.7 per cent, came from the United States. This would seem to indicate that in earlier years the importations made up a larger proportion of total equipment, which was no doubt the case. At one time nearly all the cars for use in Canada were brought in from the United States, and to this day the importation of parts goes on to a considerable extent; but with the steady growth of the electric-railway business it was only natural that shops for meeting home needs should be erected in Canada.

With respect to employees, it was shown that the total number reached 9,131, and was divided as follows: Staff officers, 190; clerks, 483; conductors, 2,394; motormen, 2,352; and others, 3,712. Conductors and motormen were paid all the way from a minimum of $30 per month to a maximum of 27½ cents per hour. The difference was governed by geographical and other conditions, the lowest rate prevailing in the extreme east and the highest in the west. The average remuneration in Ontario was about $55 per month. The total wage bill was officially reported as being $5,291,585, and revealed a significant difference as between the operations of electric and steam railways. In Canada last year the cost of labor of all classes contributed 56.59 per cent to the working expenses of steam railways and 68 per cent to those of electric railways. The figures for the year as to accidents show that in all 71 persons were killed and 1,736 injured, which exceeded by 1 the fatalities recorded by steam railways. Of the persons killed, 27 were passengers, 7 were employees, and 37 were classed as "others." The fatal accidents to passengers were in the proportion of 1 to every 10,148,126 persons carried as compared with 40,311,552 in 1901. That 1 employee in every 664 was killed, as against 1 in every 125 on steam railways, shows the relative measure of hazard, but with regard to injuries the danger in each case appears to be about the same. The chief increase in casualties applies to those who are neither passengers nor employees, and clearly demonstrates that the risk to this class is in almost definite ratio to the number of cars run and the population directly served thereby.

The harnessing of Niagara has brought into definite shape, on a somewhat extensive scale, a number of new electric-railway projects in Ontario, and in other directions there are signs of considerable expansion. The

established systems are certain to grow, in view of the centralization of population and the extensive immigration. This latter influence must produce large results in the west.

Various propositions have been made to electrify main lines of railroad, chiefly in the western section of the Dominion, where water power is abundant and the availability of Niagara for the Grand Trunk and the Canadian Pacific has been discussed and analyzed. During the preparation of the present report the electrification of the Grand Trunk Pacific or National Transcontinental Railway has been under serious consideration by the Dominion government, the New Brunswick parliament, and the railway authorities. The distance between the St. Lawrence River and Moncton is about 460 miles, and for a considerable part of this distance the road passes through country yielding a heavy traffic in lumber and farm products, while at Grand Falls on the St. Johns River, 170 miles from the St. Lawrence and 160 miles from Moncton, is water power sufficient to furnish energy for the operation of the whole road. At this point the river has a natural fall of about 130 feet, and electrical experts estimate that by inexpensive storage and conservation at least 100,000 horsepower can be obtained continuously, whereas the requirements of the road are placed at no more than 40,000 horsepower.

### MEXICO.

The development of street railways in the Republic of Mexico has been slow but has already attained considerable magnitude. Some statistics from 73 different roads or systems are available for 1907 for capital invested, capitalization, dividends, the number of passengers carried, etc., but they are not in any way complete. The large majority of the roads reporting were operated by horse or mule power, though these roads did not rank first as to cost or equipment, but at the time of the report several of them were undergoing transformation to electricity or had made contracts for that purpose. It would appear that 63 roads employed animal power wholly or in part, with 572 miles of track and 1,248 cars of all kinds. Steam was in use on 7 roads with 177 miles of track and 127 cars. Electricity had been adopted and put in use by 5 roads with 225 miles of track and 593 cars. These give totals of 974 miles of track and 1,968 cars, but there is probably a small amount of duplication, owing to the fact that two or three systems may in some cases use the same track and cars in common. The tendency in 1907 toward the adoption of electricity was marked, although there was no expansion of the steam system. Mexico is rich in water power, and wherever available it has been utilized both for electric traction and for lighting purposes.

The street-railway system of the City of Mexico, under American control and management, is comparable in extent with roads in the United States, but embodies many features peculiar to Mexico. The lines reach out from the city into the federal district and to the foothills of the surrounding mountains. The system embraces about 133 miles of track operated by electricity and 31 miles by animal traction; but the latter portion is in process of being electrified. Slightly over 500 cars of all kinds were in use in 1907. There is an absence of any appreciable evening traffic because the people do not go out much at night, but on the other hand a considerable traffic is due to the midday siesta when business is virtually stopped and people go home. Another striking feature is the admixture of funeral and freight cars with the regular passenger cars. Owing to the fare system the running of cars in trains is the general practice. The absence of bell ringing is noticeable; fares are not "rung up" on registers, and as, by the aid of mirrors, the motorman can see the rear platform, he can start up without a bell signal from the conductor. The freight service is fairly extensive, and involves a complicated tariff for goods and baggage. The strict regulation of speed necessitates the use of controller handles for high and low speeds, and their change at various fixed stations.

Among the notable features of the system is the use of first and second class cars and two rates of fare. All of the lines in the City of Mexico have a uniform first-class fare of 6 cents (Mexican coin) for the shortest ride. A zone system is in use, by which the fare is proportioned to the distance, and the passenger must state his destination when paying his fare. The maximum ride in the city is about 5 miles. On the interurban lines the first-class fare averages 3 cents (Mexican) per mile, and the second-class fare usually 40 per cent less. Commutation tickets are issued permitting three or four round trips per day. On one line where the one-way first-class fare is 10 cents (Mexican) such a ticket costs $5.75 for the month, whereas the full fare for four round trips per day for one month would be $24. As already noted, fare registers are not in use, but trip tickets are issued which are viséed by inspectors, who tear them up or cancel them. All commutation tickets are punched.

All the rank and file of the tramway force in the City of Mexico are native Mexicans, who are given free uniforms and badges, and who also receive free baths and free barber service. Motormen receive from 17 to 24 cents (Mexican) in silver, per hour, the higher rate being paid to instructors. Conductors of all grades receive 15 cents an hour (Mexican). Men from the cars who have good records for a year or more are eligible for promotion to the positions of inspector, dispatcher, and chief inspector.

Perhaps the most striking feature of the system in the City of Mexico, to a visitor, is its funeral-car service, which furnishes nearly 4 per cent of the total revenue. Owing to the remoteness of the cemeter-

ies, the company handles all city funerals, providing the trolley hearse and cars for mourners, as a result of a special arrangement with the undertakers. In general, the lines of least traffic are used and there is little interference with ordinary travel. The cost of a funeral train ranges from $3.75 to $140, and a wide range of styles is provided. The bodies of paupers are carried free.

The service in the city is freely used by the people not only for personal transportation but for the conveyance of freight, household effects, and even domestic animals, charges for which are based on classification and distance. The population served, including that in the suburbs, is about 800,000. It is stated that the population of 650,000 using the system of St. Louis, Mo., pays annually for passenger traffic about four times as much as is received by the Mexico Tramway Company for every kind of traffic. The freight and package express business over city and suburban lines is large. Freight is shipped in open gondola cars having a capacity of from 5 to 22 tons. The company is not allowed to haul more than two freight trailers behind a motor car through the city streets. Closed motor express cars are used for handling packages, milk in cans, and similar commodities. In second-class motor cars a compartment is provided in which small packages, bags and crates of produce, and even pigs or goats, are carried; but all these must be accompanied by a passenger, who is responsible for loading and unloading them. A large number of chartered cars are maintained; also a special car for the exclusive use of the presidential family, and a spur track runs into the grounds of Chapultepec Castle. Most of the motor cars and trail cars are equipped with air brakes and geared hand brakes, and "long-nose" fenders of an English type are used. It is interesting to note that in sharp contrast with American practice, smoking is permitted on all cars, inside and out.

Illustrative of modern power development in Mexico, the company at the capital supplements its steam-power-plant energy with current from distant water power. Coal is generally expensive in the republic, and hence the rapid development of hydro-electric generating systems. Current is carried into the city from Necaxa, 100 miles away, at a potential of 60,000 volts, by means of an overhead-transmission line carried to the main substation on lofty steel towers.

### CUBA.

Cuba has several street or electric railway systems. That of the Havana Electric Railway Company operating in and around the city has $7,500,000 of common stock issued and $5,000,000 of 6 per cent cumulative preferred, as well as $7,823,181 of consolidated mortgage 5 per cent bonds. The system is controlled in the United States. Most of the officers and directors are American citizens. The road has 50.4 miles of electric track, 240 passenger cars, 72 freight cars, 11 cars of other kinds, and 7 electric locomotives; and it operates 167 stagecoaches. The total income in 1907 was $1,889,665, and the operating expenses were $964,733. The net income was $366,075. No dividends were paid on the common stock, but in 1908 it received 2 per cent. During 1907 the road ran 7,527,469 car miles, and in 1908 it ran 7,948,973 car miles. The latest reports of passengers carried were those of 1905, when the total of revenue passengers and transfers was 33,658,952.

The Habana Central Railroad Company, having offices in New York and Havana, bought certain rights from the Insular Railway Company to build 120 miles of road connecting Havana, Regla, Guanajay, Güines, and Guanabacoa. It has 36 miles of electric line completed, with 38 passenger and baggage cars, 10 electric locomotives, 5 steam locomotives, and 300 freight cars. It has $8,162,500 of stock issued, and $8,500,000 of first-mortgage 5 per cent gold bonds. The road obtains current from 5,000 horsepower of steam turbine generators.

The Camagüey Company of Puerto Principe is a corporation of Canadian origin. It has 4 miles of electric trolley, with 8 passenger and freight cars, and 1,425 horsepower of generator plant. It has $700,000 of capital stock issued and $600,000 of first-mortgage 5 per cent bonds.

The Santiago Electric Lighting and Traction Company of Santiago de Cuba has 11 miles of electric-trolley line, 18 cars, and 1,500 kilowatt capacity of power plant. Its capital stock issued is $1,500,000 and $1,000,000 of first-mortgage bonds are outstanding.

### REPUBLIC OF HAITI.

The street-railway development of the Republic of Haiti is of no importance. The Port au Prince tramways, with 40 miles of track and 93 cars of all kinds, are operated by 11 steam locomotives. The Compagnie Haitienne of Port-de-Paix has 12 miles of cable line, but this is apparently employed for carrying freight only.

### BRITISH WEST INDIES.

The street-railway enterprises of the British West Indies are not numerous and owe their existence chiefly to Canadian capital. The mountainous conditions of most of the islands, and the manner in which the population is scattered over the rural regions, militate against the creation of extensive systems. The West India Electric Company, Limited, operates the Kingston and St. Andrew electric-car system of Jamaica, originally a horse-car line. It has 26 miles of track and 36 cars, and in 1907 carried 4,711,708 passengers. The railway earnings that year were $173,831. The company generates current for light, power, and traction at a water-power plant some distance out of the city of Kingston.

The Trinidad Electric Company, Limited, of Port of Spain, Trinidad, has 14 miles of electric trolley line, with 24 cars and 2,200 horsepower of generating plant. The Bridgetown Tramway Company, Limited, of Barbados, operates with mules, of which it has 112. These haul 20 cars over 9 miles of track.

In this West Indian group may be included the system of the Demerara Electric Company of Georgetown, British Guiana, which maintains a lighting and traction system. The traction system includes 10½ miles of single track with overhead-trolley wires. The rolling stock consists of 16 open-type cars, each seating 45 passengers. The car mileage made per annum is given as 420,000 and the number of passengers carried was 1,830,000—year of report not specified, but probably 1907.

### SOUTH AMERICA.

A number of electric street-railway systems are now in operation in the various countries of South America, but in few instances is definite or authentic information regarding them obtainable through official channels. The most extensive systems are those in Brazil, Chile, Peru, the Argentine Republic, and Uruguay, although a few roads are to be found in some of the smaller republics.

*Bolivia.*—La Paz, the capital and chief commercial center of Bolivia, with an area of 10½ square miles and a population of 60,000, has recently been furnished with street-railway service through the instrumentality of a New York firm. This electric railway connects on the outskirts of the city with the Guaqui-La Paz Railway, which is electrified for 5½ miles, and which, like the urban system, operates cars of American construction. The interurban road terminates at Guaqui on Lake Titicaca, and is 56 miles in length, being in reality over a large part of its length a regular steam railroad. The street-railway system consists of a stem with two branches coming together and forming a loop. From the Guaqui-La Paz Railway station the main stem of the line continues to the principal plaza of La Paz and thence two lines run to the lower part of the city, the distance by either route being about 2½ miles. The city system has been furnished with 8 cars of similar dimensions, but of three distinct classes—first, and second, and combination. Considerable difficulty was experienced in transporting the material for this road from the United States to La Paz, which is the highest capital in the world, its altitude above sea level being 12,470 feet. The streets are narrow, irregular, and generally steep, and the grade of the electric railway ranges in several places from 8 to 12 per cent. Before the material for the line could be delivered at the point of use it had to be built, then disassembled and packed in small sections, and handled five times before it could be delivered to the Guaqui Railroad terminal.

*Venezuela.*—The city of Caracas now has a complete electric-railway system. Prior to the year 1905 two small horse-railway companies were in operation there, one being the Bolivar and the other the Caracas tramway. In that year the two companies were consolidated, and during 1907 the system was electrified, capital being furnished from England, and part of the apparatus from the United States. The line has a total length of 10 miles of track, with routes converging upon the Plaza Bolivar, the political and social center of the city. The maximum grade of the line is 4 per cent. Overhead side-bracket construction has been employed, with aerial feeder cables. The power system of the company is interesting from the fact that part of the electrical energy used is supplied from 2 hydro-electric generating plants about 10 miles from the capital. In the evenings, however, when part of the current is needed for lighting, electrical energy is produced in the power house itself by means of oil engines of 240 horsepower each, belted to 3 motor generators, oil being used on account of the high price of coal. The current thus obtained is manipulated so as to be available for the direct-current motors on the cars.

*Uruguay.*—It is reported from Uruguay that 3 street railway systems are operated in the city of Montevideo. Two of these, the Sociedad Comercial and the Sociedad Transatlantica, are electric. The other system, the Tranvia y Ferro-Carril del Norte is operated by horse in the city limits and by steam beyond. This line appears to be owned partly by the government and partly by private persons.

*Peru.*—The only electric railways in Peru are those in and around Lima. The Ferro-Carril Electrico de Lima y Callao connects Lima with the port of Callao. The Tranvia Electrico de Lima y Chorrillos is an interurban line running from Lima through Miraflores and Barranco to Chorrillos, a distance of about 8 miles. The Ferro-Carril Urbano de Lima operates in the city, with about 25 miles of track. All these three companies are parts of the system of the Empresas Electricas Asociadas, and all their machinery, cars, etc., are of American manufacture. Another electric road which was started in opposition to the one above mentioned runs from Lima through Miraflores and Barranco to Chorrillos, and is called the Tranvia Nacional de Chorrillos. The apparatus installed for it is partly German and partly American. The Lima-Callao line is 6 miles in length; the other lines from Lima to Chorrillos and from Lima to Magdalena are respectively 9 and 4 miles long. The fare all over these combined lines which serve the city of Lima is 5 centavos, which is equivalent to 2½ cents in money of the United States. On the Lima-Callao line the rate of fare is equivalent to 10 cents for first-class passengers and 5 cents for second-class passengers. The Peruvian system is modern in design and construction, and a number of American-made cars

of the latest type have been acquired since 1905, including recently some semiconvertibles, such as are in widespread use in the United States. The cars in use on the road have first and second class compartments, each seating 20 passengers. The Empresas Electricas Asociadas not only operates 3 electric railways, but furnishes light and power, having 2 hydroelectric plants equipped with American machinery, which deliver electrical energy to 3 substations.

*Argentina.*—According to the report of the directors of the Buenos Aires traffic office, submitted to the Inspector-General, mechanical traction is gradually displacing traction by animals, not only in the car service but with all other vehicles of transportation. With a population of 1,000,000, Buenos Aires has 25,842 vehicles of various kinds in circulation in the streets, but the development of street-railway systems appears likely to have some effect on these, owing to the extent of the system and its cheapness. Seven electric-railway companies operate in Buenos Aires, having a total of 378 miles of track and 1,658 cars in use. These companies reported carrying 255,071,846 passengers during 1908, with receipts amounting to $25,229,266, national currency. The cars made 4,672,545 trips, but the mileage is not given. The largest system is the Anglo-Argentino, with a total trackage of 189 miles. Other companies operating are the Compañía de Tranvías La Capital, Compañía de Tranvías Metropolitano, Compañía de Tranvías Gran Nacional, Compañía de Tranvías Lacroze, Compañía de Tranvías Electrícos del Sur, and Compañía de Tranvías Ciudad de Buenos Aires. The street-railway developments in Buenos Aires have been and still are the subject of a great deal of financial manipulation and consequent rapid change in management, although the general result has been a very marked gain in economy and efficiency of operation and in excellence of service. The city is laid out in squares, and nearly every thoroughfare of importance is traversed by a trolley line, which avoids congestion in the commercial section of the city. Most lines are single track, and use certain streets for going in one direction and others for returning. The first section of the electric lines was laid in 1897, when the congestion of traffic became so great that the municipality found it necessary to construct a network of diagonal avenues, and to widen the streets. A subway system is under consideration and will doubtless soon be undertaken.

One of the most interesting and extensive of the tramway systems is that of the Buenos Aires Lacroze Tramway Company, the only native Argentine tramway in the city, and the only line running a high-speed suburban service on the American plan. It was founded in 1884 by one of the pioneers of tramway traction in Buenos Aires, Mr. Frederico Lacroze. The first line which he built was sold afterwards to the Anglo-Argentine group, and it forms the nucleus of the very large system now operated by that company. Mr. Lacroze continued his service out into the country with a private right of way, and cars equipped on the American plan for a maximum speed of 50 miles an hour. One of the interesting points in connection with the original franchise was that it was granted to the concessionaire with the provision that horse traction must be used exclusively. The reason for this was that the government wished to encourage horse breeding as one of the great national industries of the country. The original tramway was continued by degrees under this old concession for a distance of upward of one hundred miles into the country, and it is believed to have been the longest tramway system run by horse traction in the world. Moreover, the "rural tramway," as it was called, could boast of having been the only horse tramway to run a sleeping car over its lines. This car was designed and built in the United States. After a time, when the industries of the country became more diversified, the authorities recognized that if an efficient and speedy service were to be given, horses must be abandoned, and they therefore granted permission to use steam locomotives. The development of the Tramway Rural at the hands of Frederico Lacroze was carried on on a larger scale by his sons, who in 1905 made a contract with a well-known firm of American engineers for the reconstruction and electrification of the old city lines, under the name of the Buenos Aires Lacroze Tramways. The lines were laid in the upper part of the city where the streets were wide enough for double tracks, and the construction was durable and attractive, center steel poles being used between the tracks for carrying the overhead wires. Semiconvertible cars are largely in use, being well adapted to the climate, which is temperate and equable, with an average temperature during the winter months of 50° and 73° F. during the summer, while the average daily range during the year is about 11°. According to the statement of one of the authorities on the subject, each inhabitant of Buenos Aires used the street-car systems on an average of 168 times during 1905, while the inhabitants of Berlin, Paris, and London during the same period used their street railways 153, 122, and 53 times, respectively. The number of city and suburban passengers in Buenos Aires for 1907 is given at 200,000,000, which compared with the figures previously quoted for 1908, indicates a gain of about 55,000,000 during the latter year.

*Chile.*—Four electric street-railway systems are reported for the Republic of Chile, namely, those in Valparaiso, Santiago, Concepción, and the interurban road from Santiago to San Bernardo. This last road uses American machinery, as does the Concepción Electric Company, while both the Santiago and the Valparaiso tramways are operated by German companies, and their material is all of German manufacture.

*Colombia.*—During 1907 arrangements were made for the equipment with American material of the first electric street-car railway in the Republic of Colombia. This road has been constructed at Bogota, the capital, and replaces earlier mule-car lines. Colombia is situated in the interior of the country and at a considerable altitude, so that the equipment is transported from the point of landing 15 miles by steam railroad, then 400 miles by water route, and 100 miles on muleback, followed by a second water trip and another muleback journey. Owing to these conditions the apparatus has to be shipped in small packages. The road is about 6 miles in length and some 8 or 9 cars have been placed in service, with the intention of enlarging the system at a later date. Each car is equipped with two 25-horsepower motors, and current is generated at a power plant belonging to the city.

*Brazil.*—The Republic of Brazil has enjoyed electric street-railway service for some time past, and some of the systems, such as that at Rio de Janeiro, are of an extensive character. The entire street-railway figures for the country are not obtainable, but all indicate considerable activity and prosperity. During 1906–7 the tramway lines in Bahia, Brazil, were electrified, all the apparatus being purchased in the United States. This included an American boiler and condenser, and a steam turbo-electric generator of the latest design, as well as direct-current generators driven by standard motor-generator sets, etc. The equipment contract included 40 miles of trolley-line material, track, bonds, etc., and motor equipment for 36 cars, each of which carries a 2-motor 40-horsepower equipment. The San Paulo Tramway Light and Power Company is also a large system, inclusive of tramways and lighting. The latest report available for this company—that for the year 1905—shows that the gross earnings during the period increased $489,067, or 34 per cent, with a net increase of 31 per cent over the preceding year. The company paid 8 per cent during the year on its stock, and had a surplus of $363,032 after the application to the contingent fund of $50,000. The operating expenses were reported as 35.1 per cent of the gross earnings.

The city of Para, with a population of about 125,000, has an extensive and complete electric-railway system, reaching all parts of the city and extending into the suburbs, with 35 miles of track and 100 cars. The tramways were formerly operated by mules, but in 1905 a concession was obtained for a period of ninety-nine years for electrifying the tramways, and the old systems were absorbed by the Para Electric Railway and Light Company (Limited), of London. The old city of Para (or Belem, as it is called officially) was founded in 1615, and therefore is one of the oldest cities in the Western Hemisphere, and the ancient part of the city, now the business section, has very narrow streets, while the new part, or residential district, has many wide and beautiful thoroughfares, most of which are lined with trees. The patronage of the street-railway system is liberal, and requires a high class of equipment. The road had, in 1908, 67 cars of four different types, 24 of which were first-class, and 20 second-class vestibule cars, while 14 were first-class "double-service" cars, and 9 combined baggage and second-class vestibule open cars. In addition to these, 2 parlor cars, lavishly upholstered and equipped, were maintained and reserved for the use of the governor of the state and the mayor of the city. A large part of the equipment was purchased in the United States. The electrical energy for the system is supplied from a modern steam plant driving direct-current generators. Overhead construction, chiefly of the span type, is used on the line, with tubular steel poles. The rolling stock has been increased, according to figures given by the International Bureau of American Republics.

The largest and most complete electric-railway system in Brazil is that of the Rio de Janeiro Tramway Light and Power Company, Limited, a corporation which was formed under the laws of Canada and financed with international capital, and the president of which is a prominent engineer of New York City. The unification concession for the tramway system of the company was granted in 1907, but the work was not carried through until the following year. At the end of 1907 the company had, as reported in its annual statement for 1908, 34.70 miles of electric lines, 89.04 miles of mule lines, 68 electric cars, 358 mule cars, and 5,082 mules. The intention is ultimately to electrify the entire system, and work in that direction is rapidly progressing. The total number of passengers carried in 1907 was 90,305,439, and the gross income from tramway operation $3,504,743, which was an increase of more than $120,000 over that for the preceding year. The net income from tramways was $1,353,273, the proportion of net to gross being 38.61 per cent. The total number of miles run in 1907 was 8,558,030 over mule lines and 4,348,234 over electric lines. In connection with this system it is interesting to note that Rio de Janeiro is the first of the world's great capital cities, except the City of Mexico, to be adequately supplied with transmitted water power, and a large proportion of this long-distance electrical energy is utilized for the tramway system. The company owns a very considerable hydro-electric development at Rio das Lages, and the voltage of transmission is high, being 88,000 volts, while the distance is 51 miles. The lines are carried in duplicate, each line consisting of steel towers varying in height from 45 to 60 feet. The current on arrival at the city limits is stepped down and manipulated for its various uses, and the company has a private right of way over almost the entire line. This hydro-electric service supplements the extensive steam-power systems upon which

the company has hitherto depended for its supply of electrical energy.

Deputy Consul-General Joseph J. Slechta, of Rio de Janeiro, sends the following information of the plans for furnishing rapid suburban transit in the Brazilian capital:

The greater part of the suburban districts of the city of Rio de Janeiro is reached by the trains of the Central Railway, the government line. Special suburban trains are run over the tracks of the main trunk line which connects this city with Sao Paulo. The increase in this suburban traffic has been so great as to call for some solution of the problems of providing adequate facilities for the large population which depends for transportation upon these trains. The number of passengers carried in the suburban trains increased from 12,600,000 in 1901 to 19,250,000 in 1906, an increase of about 52 per cent. It has been proposed that the suburban lines be electrified, and plans are now being made to that end. It is probable that this service will be entirely separated from the main line of the Central Railway, a loop being run through the outlying suburbs so that the service will be that of a circular system. The mileage will probably be about 20 miles, some seventy minutes being required for the circuit. The present estimate places the cost of the work at about $3,500,000, but it is probable that it can not be done for less than $5,000,000. Three years is to be the time limit for the completion of the work. The plan specifies that trains are to run on a schedule providing a three-minute service, or 20 trains per hour, accommodating 40,000,000 passengers per year.

## UNITED KINGDOM.

Very complete information as to the street-railway system of Great Britain and Ireland for 1907 is obtainable from the statistical publication, Garcke's Manual of Electrical Undertakings, as well as from the publications of the Board of Trade and from other public and private authorities. The first four tables presented herewith are based on data from the Manual. Table 175 gives a general idea of the total investment in such enterprises, but would seem to include some roads that are not embraced in the French or German statistics, as being more properly placed in the separate class of light railways. It is hardly possible, however, to separate such roads, and the table may be taken as accurate, subject to that reservation.

TABLE 175.—*Street railways of the United Kingdom: 1907–8.*

| | Total expenditure on capital account. | LENGTH OPEN FOR TRAVEL (MILES).[1] | | | Number of undertakings. |
|---|---|---|---|---|---|
| | | Total. | Double. | Single. | |
| Total, United Kingdom | $331,894,901 | 2,464 | 1,522 | 941 | 305 |
| Tramways and light railways belonging to local authorities | 218,604,723 | 1,619 | 1,113 | 505 | 177 |
| Tramways and light railways belonging to other than local authorities | [2] 113,290,178 | 844 | 408 | 435 | 128 |

[1] The items of trackage do not add to the totals indicated. Information not available to harmonize the figures.
[2] These figures include cost of buildings and equipment in respect of certain local authorities' lines worked in conjunction with other lines.

Table 176 is interesting as giving a general view of results at three distinct periods through which the transportation systems have passed, namely, those of horse traction, steam power, and electricity. The steam period includes also cable roads, while the electric period includes roads where other kinds of power as well as steam are in use to drive the generators.

TABLE 176.—*Miscellaneous statistics of street railways of the United Kingdom: 1879 to 1908.*

| | Electric period, 1907–8. | Steam period, 1898. | Horse period, 1879. |
|---|---|---|---|
| Length of route mileage open | 2,464.22 | 1,064.19 | 321.27 |
| Total number of passengers carried | 2,625,532,895 | 858,485,542 | 150,881,515 |
| Capital expenditure per mile of single track open: | | | |
| Lines and works | $63,007 | $37,813 | $38,153 |
| All items | $83,246 | $50,947 | $48,066 |
| Percentage of net receipts to total capital outlay | 6.81 | 6.38 | 3.97 |
| Percentage of net receipts to net capital outlay (eliminating amounts expended on construction or purchase of old lines and works now superseded) | 7.41 | (1) | (1) |
| Percentage of working expenditure to gross receipts | 62.64 | 76.93 | 83.81 |
| Passengers carried per mile of route open | 1,065,462 | 806,703 | 469,641 |
| Passengers carried per car mile | 9.29 | 9.48 | 7.77 |
| Average fare per passenger, cents | 2.21 | 2.49 | 3.73 |
| Amount paid in relief of rates out of profits of undertakings worked by local authorities | $1,555,703 | (1) | (1) |

[1] Not available.

Table 176 shows that as between the steam and electric periods the percentage of operating expenses to gross receipts has fallen from 76.93 to 62.64. On the other hand the passengers per car mile have declined from 9.48 to 9.29, indicative of a larger service; and the average fare per passenger has fallen from 2.49 cents to 2.21 cents, due probably to the zone-fare system, with low fares for the shorter distances.

Table 177 shows the combined results from the operations of all the roads, whether under the control of municipalities or owned by companies. It will be seen that the tramways of the United Kingdom represented a capital expenditure of $331,894,901, with a gross revenue of $60,537,435. The number of passengers carried was 2,625,532,895, and the car miles run were 282,588,392. The rolling stock included 64 locomotives and 12,049 cars of all kinds, of which 10,908 were reported as electric-motor cars. There were 5,288 horses employed.

There is ceaseless controversy as to the alleged success or failure of the municipal street railways of the United Kingdom, but no question can exist as to the extent of such undertakings. Although slightly inferior in number, compared with roads owned by private capital, they predominate in every other respect. They represented in 1907–8 (the periods of comparison between the two groups do not exactly coincide) no less than $218,604,723 of the total capital expenditure of $331,894,901, and of the revenue of $60,537,435 from all sources they received about $44,000,000. Of the 2,625,532,895 passengers, they carried 1,989,573,290; of the energy used, they employed about three-fourths; and of the 12,049 cars, they had 8,300. It is also noteworthy that of the total of 282,588,392 car miles run, their cars ran 200,622,219 miles.

TABLE 177.—*Miscellaneous statistics of street railways of the United Kingdom: 1907–8.*

[Municipalities and companies, combined table.]

| | |
|---|---|
| Capital expenditure | $331,894,901 |
| Revenue from passenger traffic | $58,124,050 |
| Revenue from all sources | $60,537,435 |
| Total working expenses | $37,022,994 |
| Permanent way | $2,322,440 |
| Electrical equipment | $714,809 |
| Engines or horses | $113,774 |
| Rolling stock | $3,745,249 |
| Buildings, tools, etc | $432,919 |
| Power | $9,165,006 |
| Traffic expenses | $15,712,357 |
| Rent | $407,117 |
| Rates and taxes | $2,021,169 |
| Insurance | $1,089,030 |
| Miscellaneous | $2,199,064 |
| Net receipts | $22,614,441 |
| Interest or dividend | $9,198,026 |
| Repayment of debt or sinking fund | $4,534,235 |
| Other charges | $1,835,352 |
| Reserve or depreciation | $4,454,901 |
| Relief of rates | $1,555,703 |
| Balance, etc | $1,067,910 |
| Passengers carried | 2,625,532,895 |
| Car miles run | 282,588,392 |
| Total average revenue per route mile | $224,566 |
| Energy used, kilowatt hours | 431,969,119 |
| Cars, electric, number | 10,908 |
| Cars, nonelectric, number | 1,141 |
| Locomotive engines, number | 64 |
| Horses, number | 5,288 |

It is to be observed that, with about half the population of the United States, the United Kingdom reported figures equal to about one-fourth of the companies or systems, one-seventh of the earnings, one-fourth of the passengers carried, one-seventh of the cars, one-tenth of the energy used, and one-tenth of the capital account. The figures compare thus:

*Comparison of street and electric railway statistics of the United States and the United Kingdom.*

| | United States, 1907. | United Kingdom, 1907–8. |
|---|---|---|
| Number of companies or systems | 1,236 | 305 |
| Capital account | $3,774,772,096 | $331,894,901 |
| Earnings or income | $429,744,254 | $60,537,435 |
| Passengers carried | 9,533,080,760 | 2,625,532,895 |
| Cars | 83,041 | 12,049 |
| Miles of line (route mileage) | 25,547 | 2,464 |
| Car miles run | 1,017,731,300 | 282,588,392 |
| Kilowatt-hours used | 4,759,130,100 | 431,969,119 |

It appears that in the period 1898 to 1908 about 1,400 miles of electric track were constructed in the United Kingdom, while during the same period 23,000 miles were added to the electric trackage of the United States. In the report of the National Civic Federation of its inquiry into municipal ownership it is stated that in 1905–6, 46 British cities of 25,000 to 100,000 population, and two cities of 100,000 or more, were without street railways; also that 295 localities of from 8,000 to 25,000 population were in the same condition. The United States Census report of 1902 on street railways showed only 21 municipalities of 25,000 and under to be without such facilities, and none in the higher groups. Various reasons are urged in explanation of the contrast, including national characteristics and the restraint of municipal ownership. In an address before the Tramway and Light Railways Association of Great Britain, on his study of the tramways of the world, made in 1907, Sir Clifton Robinson, managing director of the London United Tramways, said that among the things handicapping British street railways were these: The cars are not permitted to travel fast enough, the average speed being less than 10 miles per hour. The double-deck tramway car in general use causes much delay, particularly at stopping points. The adoption of this type of car is consequent upon the regulation enforced by the authorities that no car shall be licensed to carry any passenger for whom a seat is not provided. Traffic could be handled more successfully on special occasions were the present licensing restrictions regarding passengers removed or amended. He added that British lines suffered also under many other minor disabilities. For instance, the licensing powers outside the metropolitan area (London) are vested in every little local authority through whose district the lines are laid. At present, municipal bodies working tramways under perpetual tenure have an enviably open field before them, and they are working it zealously, but without the initiative, concentration, and originality that characterize private enterprise. The civic phase of street-railway construction and administration has been singularly barren of contributions to invention or to the understanding and conquest of scientific or traffic problems.

During recent years the relation between coinage and street-railway fares has attracted some attention in Great Britain, owing to the proposal to adopt a new British coin having the value of 1.2 pennies, or 2.43 cents. At the present time there is no coin in England between 1 penny (2.03 cents) and 3 pence (6.08 cents), so that in order to conform to this the street-railway systems are divided broadly into penny zones, although there are special subdivisions of a half-penny (1.01 cents), 1½ pence (3.04 cents), and 2½ pence (5.07 cents) representing the respective zones.

Street-railway enterprises as a general thing have not flourished very well in Great Britain, and it is thought that they would be materially assisted if the average fare could be increased by 20 per cent by adding 0.02 pence to each penny fare. The penny in England is divided, however, into quarters, called farthings, and it is suggested that a new coin embodying farthing values would be more in harmony with those now in use, and that fares of a penny plus a farthing would increase the rate 25 per cent instead of 20 per cent under the zone system, and would not complicate a decimal coinage with that already in existence.

The idea of a new coin is perhaps more favored by the private than by the municipal street railways, although it is considered that the latter would benefit by the addition. Some of the street-railway systems have devised other means of increasing their revenues, of which perhaps the most striking is that of the Edinburgh Tramway, which has levied a charge for parcels and personal baggage carried by passengers, and also makes a charge for dogs. The amount to be paid is based upon the conductor's estimate of the weight

and bulk of the parcel, and the tariff is exacted whether the package is left on the platform or taken inside. A golfer has been charged for carrying his bag of clubs, and another passenger for the transportation of a traveling rug, but these instances are said to be due to misunderstanding on the part of the conductors. The company, however, charges postmen for their heavy mail pouches. Parcels of less than 28 pounds are exempt, as well as workmen's tools, under which latter exemption a clergyman sought recently to avoid payment on a parcel of theological books on the ground that they were the tools of his trade.

Up to the present time very little has been done in England with regard to the electrification of main lines of railroad, although the subject has been vigorously discussed. It is evident that the density of traffic and the shortness of the lines are conditions extremely favorable to electrical methods. One of the most successful of the few long lines in England is the Lancashire and Yorkshire, operating between Liverpool and Southport, with a total of 82 miles of single track, 80 motor cars, and 52 other cars, such as trailers, etc. This line is operated over its own right of way, by direct current from a large generating plant with substations. In the heart of each city are numerous stations for local trade, and a well-developed express business is conducted on separate tracks. During 1907 this road reported 5,012,013 electric-car miles. The results of operation of the system are said to be entirely satisfactory, especially when viewed from the standpoint of the management, the general manager of the road, Mr. Aspinall, having always maintained that the object of electrification is not so much to decrease the expenses of a railway company as to increase its earning power. Nothing but a greater acceleration and more frequent service could have enabled it to hold its own, and it is only electric traction that provides such acceleration. In an article on the electrical equipment of main lines of railroads in Europe,[1] Mr. Philip Dawson, C. E., remarks that frequent and rapid service would in most cases provide an efficient remedy, as is clearly shown by the satisfactory results obtained in the case of the Lancashire and Yorkshire Railway, just noted, and in that of the Northeastern Railway Company, which has electrified a section of its main lines in the vicinity of Newcastle and Tynemouth, where the competition of electric trolleys was strong and disastrous. This electrified system is operated with 3-phase alternating current at a pressure of 6,000 volts, and has a route mileage of 35 miles, including some four-track, double-track, and single-track, part of which appears to be for freight traffic only. The system maintains 58 motor cars with two 150-horsepower motors each, 44 trailers, and 2 electric locomotives. In 1907 an electric-car mileage of 3,839,264 miles was made. A comparison of half-year periods between 1903 under steam and 1905 under electricity shows an increase in passengers carried from 2,844,000 to 3,548,000, a gain of 24.8 per cent, while in the same periods the gross earnings increased 17.1 per cent and the running costs only 11.7 per cent.

A short section of the London, Tilbury and South End Railway, with 6 miles of track, and a short section of the London and Southwestern Railroad have also been electrified, while the electrification of a suburban line of the London, Brighton and South Coast Railway has been in progress during the preparation of this report, with a single-phase alternating-current system, and it is expected to be in operation shortly.

### HOLLAND.

The statistics of the Railroad Commission of Holland for the year ending December 31, 1905, deal with steam and street railways combined. The report shows that the total length of all railways in operation at that time was 1,237 miles. Of these, 26, with a length of 117.10 miles, were operated by horses; 35, with a length of 583.47 miles, were operated by steam; and 7, with a length of 402.8 miles, used steam and horses. One road, 48.5 miles, used a combined service of steam, horses, and electricity, and one, with a length of 27.87 miles, was operated by electricity and horses. Three, with a total trackage of 233.22 miles, were operated entirely by electricity. The companies or roads had a total of 1,118.49 miles of single track and 118.57 miles of double track. They used 411 locomotives, 1,010 horses, 1,926 passenger cars, and 1,642 freight cars. The total number of passengers carried was 90,745,793.

### SWEDEN.

A report on the subject of the adoption of electric traction on the main lines of government railroad in Sweden was submitted during 1908 to the Swedish Parliament by Chief Engineer Dahlander, as a result of experiments made on a 3.73-mile stretch of track between Tomeboda and Värtan, and a 4.35-mile stretch between Stockholm and Järfva. The electric trains have now been temporarily replaced by steam-driven trains, which will continue the service until electrical energy can be obtained from a water-power station. During the experiments energy was supplied from a steam-driven power station. The electrical equipment of the track between Järfva and Värtan is, however, kept ready for use for demonstration purposes.

It is interesting to note that the advantages of the single-phase system over the 3-phase system, with respect to the overhead equipment in particular, were considered sufficient to warrant experiments being carried out with the single-phase system only. Under the conditions prevailing in Sweden, the cost of the overhead equipment must play an important part in deciding selection of the system, and it was estimated

[1] Electric Railway Journal, June 6, 1908.

that a 10,000-volt or 15,000-volt single-phase system would cost less than a 3,000-volt or 5,000-volt 3-phase system.

The rolling stock used for the experiments consisted of two trailers, two 300-horsepower locomotives and two 230-horsepower motor cars. Each locomotive or motor car ran more than 6,214 miles in the course of the experiments. No trouble was experienced with the commutators of the single-phase motors, and the electrical equipment was found satisfactory. It was conclusively proved that forced ventilation is very effective in increasing the capacity of the motors and keeping the temperature low, and a forced lubrication type of motors effected a considerable saving in oil. The cable method of leading in the high-tension current was found unsatisfactory at high pressures, and a bare wire passing through the open window or through a porcelain collar was resorted to. The energy consumption varied between 22.4 watt-hours per ton mile for a 265-ton train and a speed of 19.51 miles per hour to 31.9 watt-hours per ton mile for a 144.5-ton train and a speed of 29.95 miles per hour. These values may be taken as relating to a level track, as the short upgrades on the experimental track were compensated for by the corresponding short downgrades. The momentum gained on the latter served in most cases to overcome the extra resistance due to the former. As, on account of the nature of the track, the speed of the trains was limited to 43.50 miles per hour, no experiments at high speeds could be carried out.

Experiments were also made to determine the relative costs of electric and steam car heating. The power consumption for electrically heating a passenger car was found to be from 0.2 to 0.3 kilowatt per degree centigrade difference between inner and outer temperatures. In order to compete with steam heating, the price of electrical energy would have to be not over 1 cent per kilowatt-hour. With regard to the most favorable frequency of the single-phase current, the opinion was expressed in the report that a frequency lower than 25 cycles would have more disadvantages than advantages, even considering the possible better working of the motors. The frequency for which the plant was designed, 25 cycles, would seem to be the best.

Various methods of suspending the contact wire were tried, apparently the most satisfactory method being the fixing of the contact wire on a swinging bracket without either suspension or cross wires. It was found necessary, even with catenary suspension, to put the contact wire under a certain amount of tension to insure satisfactory current collection, and owing to the wide variations in temperature, the method adopted on the Hamburg-Altona line of putting the wire under a constant tension by means of a hanging weight was used. For section insulation the arrangement of parallel or crossed wires with air insulation was found to be more satisfactory than porcelain section insulators, partly on account of the weight of the latter, but chiefly due to the reduction of the insulating power of the porcelain by smoke and dirt. The brown porcelain insulators were provided with iron pins which were cemented into them. It was noticed that insulators in contact with the live wires kept themselves free from soot, which was thickly deposited on other insulators.

Extensive investigations were made with the use of rails as return conductors. These showed that a large portion of the current was carried by the earth, this amounting, in some cases when the earth was moist, to as much as 80 per cent. A difference of phase existed between earth and rail currents, the measured power factor for the rails being in a few cases as low as 0.3. An attempt to increase the earth current, by means of artificially grounding the rails, failed completely. A number of tests showed that at 25 cycles, with a rail weighing 99.8 pounds per yard, the rail resistance without copper bonding amounted to from 0.2 to 0.3 ohm per mile of line, the resistance varying with the moisture of the ground.

In conclusion, the report states that the experiments have shown that the single-phase system can be considered to be the simplest, cheapest, and most satisfactory system for main-line working and that there is little chance of a better system being devised in the near future. The immediate commencement of the electrical equipment of the main lines and the utilization of the abundant waterfalls for supplying the energy are recommended.

### GERMANY.

The latest statistics obtainable for Germany are those of March 31, 1908,[1] and are therefore practically those for the year 1907. At that time the number of street railways in existence or in course of construction was 237, with 2,357 aggregate miles of track. Of these lines, 234, with 2,345 miles of track, were in operation, divided territorially as follows: Prussia, 162 roads,[2] 1,645 miles; other German states, 72 roads, 700 miles. An increase of 4 roads for the year was shown, 2 in Prussia and 2 elsewhere.

The motive power of these systems was classified as follows: Prussia—steam locomotives, 13 roads, or 7.9 per cent; electric motors, 129 roads, 78.2 per cent; horses, 15 roads, 9.1 per cent; steam and electricity, 1 road, six-tenths of 1 per cent; horses and electricity, 3 roads, 1.8 per cent; cable, 4 roads, 2.4 per cent. Other German states—electric motors, 60 roads, 85.3 per cent; steam and electricity, 1 road, 1.4 per cent; cable, 4 roads, 5.6 per cent; 7 horse roads,

[1] Zeit fur Kleinbahnen, April, 1909.

[2] This number does not agree with the itemized account, according to motive power, in the following paragraph. Information not available to harmonize the figures.

7.7 per cent. These figures indicate the extent to which electricity has already replaced the other kinds of power, and the process is still going on. While on March 31, 1901, horses were employed in Prussia on 24 roads with 102 miles of track, they are now in use on only 15 roads with 42.2 miles, the average length showing these roads to be very small. Electricity, moreover, is now used on all tramways and elevated systems with dense traffic.

The rolling stock in service in Germany in 1907 comprised 81 steam locomotives, 57 electric locomotives, 9,906 electric-motor cars, 17,263 passenger cars (including motor cars and trailers), 69 package or express cars, 937 freight cars, 17 mail cars, and 1,124 special cars of all kinds, many of which were doubtless employed for the work of the roads rather than in hauling passengers or freight. The largest amount of rolling stock was reported by the Grosser Berliner Strassenbahn, with 2,544 cars capable of carrying 85,573 passengers, or slightly over 33 passengers per car, which indicates the prevalent use of a car much smaller than is generally used to-day in the leading American cities. Hamburg was second, with 1,269 cars having a capacity of 36,693 passengers, or 25 per car. As the rule against standing up is generally enforced, these figures would not indicate any considerable provision for dense traffic.

The majority of the roads in Germany are still owned by private companies, but there is a tendency toward municipal or government ownership. In Prussia 95 roads were owned by companies and 61 by municipalities or other public authorities. In other German states 42 roads were owned by companies and 24 by public authorities, and no increase in the other class. Eight German roads were owned by private concerns and 3 by the Kingdom of Saxony.[1]

The capital invested in all the German street railways was about $215,302,048, or about $91,346 per mile. The exact amount of dividends paid does not appear. The expenses include ordinary allowance for depreciation, but not amortization, of the capital account. Of all the German roads considered, 22 did not pay expenses. As to the interest earned on the capital invested in 145 Prussian street railways, it was nothing on 18 roads, up to 1 per cent on 6, 2 per cent on 14, 3 per cent on 9, 4 per cent on 14, 5 per cent on 23, from 5 to 10 per cent on 54, and above 10 per cent on 7 roads.

The total track length of all street railways and interurban light railways in Germany was 7,629 miles in 1907, an increase of 3.7 per cent over the preceding year. The capital invested was about $359,464,280, or about $47,118 per mile. The gauge of track was 4¾ feet on 61 roads, 3½ feet on 148 roads, and less than 3½ feet on 28 roads. The street railways and the interurban light railways in Germany, as elsewhere in Europe, are of essentially different character. Thus, while 63.6 per cent of all German street railways carry nothing but passengers, this is the case for only 1.9 per cent of the interurban light railways; while 96.1 per cent carry either freight and passengers or freight only. Moreover, while in street railways the increasing use of electricity is most noticeable, 76.2 per cent of all such roads now being operated electrically, not less than 91.2 per cent of the interurban light railways are still operated by steam.

Some interesting data are given as to the relations between track and population, and as to the amount of passenger traffic. There was 0.76 mile of track for every 10,000 inhabitants in Berlin, 1.43 miles in Leipzig, 1.59 in Essen-Ruhr, 1.62 in Dresden, and 3.25 in Hanover-Linden. For every 10,000 inhabitants in Cologne, 1,972,473 passengers were carried on street railways; in Frankfort, 1,925,462; in Leipzig, 1,873,457; in Dresden, 1,775,377; in Hamburg-Altona, 1,715,823; in Dusseldorf, 1,594,308; and in Berlin, 1,667,307. The highest figure would give an average of nearly 197 rides per inhabitant per year.

Reference is often made to the cheap fares prevalent in Germany, but on the other hand the absence of transfers is usually overlooked. Thus a passenger can ride 10 miles in Berlin for 2½ cents, under the conditions imposed on the Grosser Berliner Strassenbahn, but he must pay another 2½ cents every time he changes cars. With regard to the Berlin Stadtbahn, Government Councilor Kemmann says:[2]

> Low as are the single fares charged on the Stadtbahn, the commutation rates are simply ruinous. A private company which should undertake to operate under them would soon become bankrupt, and the Government has to earn the interest on the capital it has invested in the Berlin Stadtbahn, from the profits on long-distance riders elsewhere. This situation is clearly described in a statement made recently by the Minister of Public Works to a committee of the Chamber of Deputies when he said: "Many of the holders of commutation tickets pay only six-tenths to seven-tenths of a cent for a 2.4-cent ride. This is below cost price, and leads to the abnormal condition that outside taxpayers have to make good the deficiency from this cheap transportation to the extent of 1.2 cents per ride."

Mr. Kemmann furnishes also the following succinct statement as to fares in Berlin:

> It may not be out of place here to refer to the system of zone fares introduced by the Berlin Elevated and Underground Railway Company. The management of this company followed the state railways in introducing two classes of fares, second and third, in city rapid transit, each class having separate compartments for smokers and nonsmokers. This, seemingly, is too many classes for city transit, but it was difficult to see how to do without this two-class system, to which Berlin had grown familiar through decades. From 15 to 20 per cent of the passengers ride in the second-class in spite of the 1¼ cents higher fare. The third-class fare on the Elevated and Underground Railway is 2½ cents for 4 stations, 2¾ cents up to 7 stations, 5 cents up to 10 stations, and so on. For every 3 stations an additional 1¼ cents is charged, the average distance between stations being about half a mile. This works out to an average per

[1] This analysis leaves one road unaccounted for.

[2] Electric Railway Journal, vol. 34, No. 1, p. 13.

passenger of 3.3 cents with a line 10½ miles in length and with 23 stations. The average ride is 2½ miles, so that the average fare per passenger is 1.36 cents per mile, a figure which is fair and well adapted to Berlin conditions. Single tickets only are sold. There are no season, commutation, or through tickets, nor passenger tickets of any other kind, except so-called early-hour tickets and a certain rebate granted to children. Single tickets used before 8 o'clock in the morning—"early tickets"—cost 1¼ cents less than ordinary ones, the minimum, however, being 2½ cents. Children less than 6 years of age, under charge, are carried free. If there be added to this the statement that dogs are carried for 2½ cents up to the tenth station and 3¾ cents beyond, the entire tariff in force on the Elevated and Underground Railway has been stated.

Mr. Kemmann remarks that, as in New York City, for example, the most remote suburbs of Berlin cry out for subways and cheap fares, and are not concerned as to how the taxpayers in subsequent years shall meet the burdens imposed by nonpaying lines.

For the last ten years the Prussian State Railways' management has been interested in the possibilities of the equipment of some of its lines with electricity. Becoming convinced as early as a decade ago that direct current at ordinary voltages would not suffice for heavy long-distance service, the Government inspired the Zossen trials of 1901 to 1903 in which 3-phase current was used. These tests produced valuable results as to the resistance to train motion at very high speeds, but also indicated objections in the operation of two or three overhead conductors. The development of the single-phase system soon after the Zossen trials led to the cessation of the 3-phase experiments; and a project was drawn up for a single-phase line between Hamburg and Berlin. This was abandoned on account of the high cost. At about the same time the government railway officials inaugurated an elaborate series of experiments with single-phase motors on the Niederschonweide-Spindlersfeld Line. These were successful in every respect. Shortly afterwards the Hamburg-Blankenese Ohlsdorf single-phase line was built and placed in operation, and plans for the adoption of electricity were prepared by the management of the Berlin Stadtbahn and the suburban steam lines. The investigations showed that single-phase current only could be considered, as it was found that even high-tension direct current would require an uneconomical number of substations.

The plans worked out by the Prussian officials in Berlin gave particular attention to the electrification of those lines which could be operated at a great reduction in cost, if the change in motive power were made. Owing to the high price of good coal in Germany, it was considered advantageous to make all estimates on the basis of using gas-engine generating sets. Large deposits of lignite are to be found in the Cologne district, and it was therefore proposed to equip with electricity one of the government railways which extends from Cologne to Trier and which hauls a great deal of freight over heavy grades. The subject was considered of such interest that in 1906 the Society of German Mechanical Engineers, of which several officials of the Prussian State Railways are members, called for a prize essay on the best method of electrifying a 124-mile line operating in a mountainous country and involving the movement of freight trains weighing up to 600 tons. One condition was that the power station should use gas engines for generation. Four theses, of which three were given prizes, were entered in the competition. It is noteworthy that in all the four plans offered preference was expressed for single-phase current transmitted at 40 cycles, 60,000 volts, and used at 10,000 to 20,000 volts on the trolley wire.

Although the feasibility of this project was shown by these four independent reports, the war department would not, for strategic reasons, allow the electrification of this line, since, being so near the French border, the department held that in case of an invasion it would not be difficult for an enemy to blow up the power house and so destroy the power-transmission systems. Nevertheless, the Prussian State Railways asked the Allegemeine-Elektricitats-Gesellschaft to build a single-phase freight locomotive for the Oranienburg experimental division, and experiments with this have demonstrated that single-phase locomotives can successfully and economically cope with heavy traffic.

More recently the Government has been giving its attention to the proposed equipment of the Leipzig-Bitterfelde-Magdeburg Line, which is 79.60 miles long, and the Leipzig-Halle Line, 22.49 miles. It is proposed to use a working potential at the trolley of 10,000 volts.

An interesting development in electric-railway work is that carried out by the Prussian State Railway department in the use of storage-battery cars in sections of the country and on light railways where it would not pay to operate regular trains with steam locomotives and full train crews. There are now 80 of these cars in service, and the results of nearly two years' use are said to be satisfactory. The ordinary lead-lead battery has been used. The unit train is composed of two double coaches, i. e., two nearly identical car sections coupled closely together. Each car has at its outer end a tank or bonnet section only half as high as the passenger sections of the coach, in which the batteries are contained. The battery consists of 168 cells, half of which are carried in the front tank and half in the rear; and the cells are so thoroughly isolated that there is no annoyance to the passengers from the fumes. The tanks give an extreme length to the car, but this objection has been met by the subdivision and the coupling of the two sections, which enables them to take short curves easily.

These coaches are equipped with two 80-horsepower motors, operating at a potential of 310 volts. They weigh about 55 long tons each, have a seating capacity of about 100, with an extra compartment for the train crew; and can attain a maximum speed of 31 miles an

hour. One charge of the batteries will run them for about 65 miles. The subdivision of the battery serves as a measure of safety, and the coach can be operated with one-half of it in case of necessity. The cars are equipped with electrical, air, and hand brakes.

The annual report of the Public Service Commission for the first district of the state of New York, for the year ending December 31, 1908, contains an elaborate review of the laws and regulations applying to street and interurban railways in Prussia, where control is primarily the function of the central government and is very strictly enforced through the Minister of Public Works and the Minister of the Interior. The latest general regulations are those which went into force in January, 1907. The same report contains a summary of the methods of supervision that are applied in England, chiefly through the board of trade, the local authorities having means also for securing liberal terms from a company when granting its special act or order which answers to the American franchise. The report says with regard to both countries:

> To an American, the striking feature of state supervision of street railways in England and Prussia is that it is devoted chiefly to the prevention rather than to the correction of abuses. Supervision does not wait until an abuse develops. It attempts to insure the adoption of such safeguards that serious abuses will be unlikely to develop. Supervision begins with the initiation of the enterprise. Plans of construction are subjected to a searching inquiry, and must be altered where necessary to protect other private or public interests or to insure the safety or convenience of the public. The plans of cars and equipment must also be submitted for approval to the state authorities. Before the new line is opened it must undergo a thorough inspection. Future essential changes in construction, cars, or other equipment must also be submitted for approval. In addition, certain definite regulations are laid down for the maintenance and operation of the enterprise.

Those who are connected with private companies in either country complain that regulation is overdone and that the conditions imposed check the industry and tend to deprive the public of needed service to an extent not appreciated in America, where much greater freedom prevails.

*Bavaria.*—In the kingdom of Bavaria the government has given much attention to the matter of electrification, and has recently published the results of an investigation extending over the entire Bavarian State Railway System. It is estimated that in the year 1906 the railways, including all the state railways in Bavaria proper, but not those in the Pfals, if electrified, would have required 517,839,000 kilowatt-hours. It is further estimated that generating stations with an aggregate rating of 606,000 horsepower would have been necessary in 1906, and that the country possesses sufficient water power to furnish the entire amount.

Of course, from the standpoint of the management, only considerations of economy can justify electrification, that is, those lines must first be electrified where waterpower is cheapest and coal most expensive, and also where the density of traffic is comparatively great. The investigation has shown that, as the water power is nearly all in the Bavarian Alps, electrification is more economical for lines of small density of traffic in the southern half of the country, near the slope of the Alps, than it would be for northern lines with much greater density but where long transmission lines would be required. In some instances the density of traffic in northern lines should be twice as great as in southern lines to get the same economy. The critical price of energy per kilowatt-hour in the south is between one-fourth and one-half cent, against three-fourths cent in the north.

It is now stated to be the intention to equip a number of lines. A beginning will be made with the line from Salsburg through Reichenhall to Berchtesgaden and from Garnisch to Griesen, as well as with a new line which is being built between Garnisch and Scharnik. For the fast passenger trains locomotives are to be built each having four pairs of driving wheels and being capable of moving a 175-ton train exclusive of locomotive weight, with a speed of 50 miles per hour. The mountain grade of 4 per cent between Kirchberg and Hallthurm, which has a length of 3 to 4 miles, can be run with a train of 90 tons at a speed of nearly 19 miles per hour. The schedule running time between Salsberg and Berchtesgaden will be shortened by thirty-five minutes.

The Bavarian Government proposes an expenditure of $1,435,000 during 1909 for the first installment of the railway electrification. The electro-motive force will be 10,000 volts and single-phase will be used throughout, as in Prussia.

### SWITZERLAND.[1]

The Swiss Government has just issued its railway statistics for the year ending 1907. There were then 36 street railways in operation, with a total length of 249 miles (402 km), of which 31 meter-gauge lines having a combined length of 162 miles (261 km) were served by electric apparatus only. The only 4-foot 8½-inch-gauge street railway reported in Switzerland is a 1.8-mile (2.9 km) line in Lucerne. The street railways carried 97,367,553 passengers and 184,648 tons (181,561 metric tons) of freight over 14,304,664 train-miles (23,072,029 train-km). Their total gross income was $2,376,492 (12,313,430 Fr.) and the total operating expenses were $1,824,874 (9,455,353 Fr.). These results were obtained with 2,848 employees, 8 steam or electric locomotives, 109 freight cars and 859 passenger coaches, of which 661 were motor cars.

There were in service 42 interurban narrow-gauge railways, of which 21 roads, with a total length of 258.3 miles (416.6 km), were operated exclusively with electricity, while three others, with a total length of 15.3 miles (24.7 km), used a mixed service with steam locomotives. All of the electric and mixed lines were

[1] Electric Railway Journal, Jan. 1, 1910.

of 39.37 inch (meter) gauge. The total length of the steam narrow-gauge lines was 318.7 miles (514 km). The combined railways carried 11,317,588 passengers and 801,005 tons (787,616 metric tons) of freight over 3,463,768 train-miles (5,586,722 train-km). Their total gross income was $2,616,645 (13,402,307 Fr.) and the operating expenses were $1,645,731 (8,527,-102 Fr.).

The rack and pinion railways numbered 12 and totaled 60 miles (97 km) in length. Only three lines, having a combined length of 10.5 miles (16.9 km), were all-electric and three more, totaling 16.44 miles (26.1 km), were mixed steam and electric. The 12 roads carried 1,031,006 passengers and 71,179 tons (69,989 metric tons) over 187,573 train-miles (302,538 train-km). Their total gross income was $732,200 (3,793,781 Fr.) and the operating expenses were $391,115 (2,026,505 Fr.).

The cable railways numbered 36 and had a total length of 19.63 miles (31.66 km), mostly of meter gauge. Of these lines, 22 having a total length of 13.22 miles (21.32 km), were operated electrically. They carried 6,060,926 passengers and 166,481 tons (163,698 metric tons) of freight over 353,833 train-miles (570,716 train-km). Their total gross income was $362,785 (1,879,714 Fr.) and the operating expenses were $202,628 (1,049,889 Fr.).

### FRANCE.

The latest available report on tramways and light railways, that of 1905, issued by the Minister of Public Works, divides these lines into three definite groups. The first of these is that of "roads of local interest," the second is that of tramways for passengers and goods, and the third is that of tramways for passengers and express or for passengers only. The last division is subdivided in the statistics along the line of distinction indicated. The first group of roads of local interest consisted essentially of ordinary steam railroads of short distance but not differing particularly from main steam lines. It included, however, the Paris Metropolitan Underground, whose figures reported separately show gross earnings equal to 25 per cent of those given for all the regular tramways of France. This group is credited with a total of 4,301 miles built and 1,092.5 miles under construction or planned.

The second group of lines not included in street-railway statistics is that of tramways for passengers and freight, which are again of the interurban type and depend largely upon steam. This group contained 3,050 miles in operation and 1,010 miles building or planned. In this group were included a few roads with electric traction and one or two short funicular roads or "inclined planes." The third group of recognized tramways is credited in the summary with 1,252 miles in operation and 216 miles building or planned. The actual tables show, however, a total of 1,645 miles in operation, as exhibited in the following statement:

*Tramways of France: 1905.*

| | Class 1.—Tramways with express, etc. | Class 2.—Tramways for passengers only. |
|---|---|---|
| Number of lines | 33 | 76 |
| Length of line in operation, miles | 499 | 1,146 |
| Number of passengers | 214,587,056 | 657,117,421 |
| Receipts | $5,546,012 | $15,150,232 |
| Number of employees | 6,240 | 23,348 |
| Number of cars | 1,885 | 4,865 |

Of these lines 87 used electrical power, 20 used steam power, 9 used horsepower, and 9 used compressed air, while a few employed both steam and electricity, or compressed air and storage batteries.

The gross earnings of these systems were, as shown above, $20,696,244, while the net earnings were reported as $5,706,736, and the percentage which the total operating expenses formed was placed at 73.4 per cent. The motor cars included in the above total numbered 3,851, and the other motive power consisted of 167 locomotives and 2,712 horses.

The Metropolitan Underground Road of Paris reported the following figures for 1905:

| | |
|---|---|
| Length of track (miles) | 20.62 |
| Number of trains run | 781,388 |
| Distance run (miles) | 4,083,121 |
| Total cars | 663 |
| Locomotive cars | 305 |
| Trail cars | 358 |
| Employees of all kinds | 2,784 |
| Passengers carried | 178,784,767 |
| Gross receipts | $5,107,470 |
| Net earnings | $1,304,136 |
| Operating percentage | 60.1 |

Up to the present time very little has been done in the way of introducing electricity on the main lines of the country. One example is the installation made on the Paris-Orleans Railway, one of the large trunk lines reaching from the capital to Bordeaux and other large cities in central and southwestern France and connecting with the Southern Railway (Chemin de Fer du Sud) which reaches Spain. The newer terminal near the Quai d'Orsay is approached through a long tunnel which rendered steam objectionable, and hence electricity was adopted. The distance to be covered in this manner is 2.4 miles, and the locomotives must draw 160-ton trains over this distance on a schedule of eight minutes, and over a profile containing one grade of 1.1 per cent for a distance of 1,440 feet. Eleven electric locomotives were furnished for this equipment, each weighing 55 tons and equipped with four motors of a nominal rating of 225 horsepower each. Electrical energy is supplied to the locomotives in the form of direct current at 575 volts, through third-rail, side-

rail, or overhead conductors, as local conditions demand.

This system and that of the Paris underground have now been working for some years successfully, but no further step in the adoption of electricity was taken until quite recently, when the Midi Railway, running through southern France, gave out contracts for a project which includes 250 miles of its main track from Bordeaux to Toulouse. This installation, the first important one of its kind in France, will use the alternating, single-phase current of 15 cycles frequency.

### AUSTRIA.

Figures published by the Government of Austria for 1905 show that the total length of all electric railways in that country was 293.29 miles, of which 70 per cent was standard-gauge and the remainder narrow-gauge. About 50 per cent of this mileage was double-track, due to the fact that practically all of the electric lines are operated in cities. However, only 7.3 per cent of the light steam railroads (corresponding to the service of American interurban lines) was double-track. Passenger service only was given on 91.6 per cent of the electric railways, mixed service on 7.85 per cent, and freight service alone on 0.53 per cent. The rolling stock of the electric railways consisted of 5 locomotives, 172 snowplows, 1,624 motor cars, 1,248 trailers, and 49 freight cars. The total seating capacity of all passenger cars was 106,170. The average annual train-mile was 124,453 per mile of track; average passenger-mile, 1,891,029 per mile of track; average ton-mile, 12,603 per mile of track. The average gross earnings per mile were $26,709; average operating expenses, $16,974 per mile; average interest on investment, 7.22 per cent. There were 36.5 employees per mile of track.

At the present time considerable interest in the electrical equipment of steam railroads has awakened in Austria, especially in the Alpine Province of the Tyrol. The first single-phase railway in the world, the Stubaitalbahn, was built in the Tyrol, and the absence of coal and the large amount of available water power have given added impetus to the construction of electric roads. Statistics indicate that there are about 5,500,000 horsepower available in the water powers of Austria, or 187 horsepower for each 1,000 inhabitants. This amount is surpassed only in Switzerland, where there is 454 horsepower for each 1,000 inhabitants. The figures showing the percentage of utilized to available water power are, Switzerland, 25 per cent; Germany, 20 per cent; France, 18 per cent; Italy, 14 per cent; and Austria, only 9 per cent. A commission appointed by the Government has been systematically studying the subject of utilizing all of the available water power for electric traction.

The next step in the conversion of steam railways to electric traction will probably take place in the Tyrol, where several large water-power stations are to be built with capacities for furnishing from 2,000 to 12,000 horsepower. The longest electric line in the Tyrol is that between Trient and Malè, 38 miles in length, operated by direct current at 800 volts. A more interesting line recently under construction is the Maria Zell road, now nearing completion in Lower Austria. This is the longest single-phase railway on the Continent, being 57 miles long, and has 600 volts current on the trolley wire. Water power is used to drive the generators. The overhead line is equipped with a catenary similar to that of the Hamburg-Blankenese Railway, with strain adjustments every mile or mile and a half. For the present service 14 locomotives, each equipped with 2 single-phase, 250-horsepower motors will be used. Owing to the narrow-gauge, the motors are located above the trucks, and drive on the wheels by means of connecting rods.

### HUNGARY.

The following figures are taken from an official report on the Hungarian electric railways, for the year ending 1907, from which it will be seen that the total mileage of the interurban railways was practically 17.40 miles of single-track, and the total mileage of the city railways 130 miles of single-track. During 1906 the electric-railway mileage of the Vizinal Railway system was reduced about 3.11 miles of single-track, owing to the suspension of electric service on the Szatmar-Erdöd Railway. Since January 1, 1907, this system has been a part of the Hungarian State Railways. The city railways show a total increase in length of 5.28 miles, principally in Budapest and vicinity.

TABLE 178.—*Mileage of electric railways of Hungary: 1907.*

| | Total track (miles). | Double-track (miles). | Length of route (miles). |
|---|---|---|---|
| *a. Vizinal Railway system.* | | | |
| Total | 17.38 | 4.92 | 16.85 |
| Budapest-Budafok | 4.87 | ..... | 5.39 |
| Budapest-Szentlorinze | 7.37 | 4.92 | 7.15 |
| Miskolcz-Diosgyor | 5.14 | ..... | 4.31 |
| *b. City railways.* | | | |
| Total | 129.98 | 86.83 | 127.16 |
| Budapest locomotive line (0.82 mile out of service) | 44.65 | 42.16 | 44.65 |
| Budapest | 27.87 | 27.36 | 27.83 |
| Franz Joseph Subway (in Budapest) | 2.30 | 2.30 | 2.30 |
| Budapest-Ujpest-Rakospalota | 10.25 | 7.00 | 10.69 |
| Budapest and vicinity | 4.25 | 2.31 | 4.21 |
| Fiuman | 2.74 | ..... | 2.47 |
| Miskolcz | 4.54 | ..... | 4.09 |
| Nagyszeben | 1.49 | ..... | 1.49 |
| Nagyvarad | 9.52 | 1.12 | 7.77 |
| Pozsony | 4.97 | 1.56 | 4.85 |
| Sopron | 2.84 | ..... | 2.38 |
| Szabadka | 6.21 | ..... | 6.21 |
| Szombathely | 1.88 | ..... | 1.75 |
| Temesvar | 6.47 | 3.02 | 6.47 |

It appears from other sources of information that no new electric railway was opened in Hungary. The number of all roads is still 14, but the track length has increased from 124.90 miles to 129.98 miles. The track length of all electric street railways in Hungary forms 68 per cent of all street railways in that country,

the others being operated by horses or by cable. The total capital invested in the 14 roads is $22,424,524, or $172,523 per mile. The average profit was 8.2 per cent of the invested capital.

RUSSIA.

According to latest information available, there were in Russia 28 cities with electric street railways and 2 suburban lines.

The total length (single track) of all street railways, exclusive of 2 which failed to report track, was 447.40 miles, and the total length of the suburban lines 12.58 miles.

The cities of St. Petersburg and Kharkov own their entire electric-railway systems; the city of Moscow owns 83.26 miles out of a total length of 89.48 miles; the city of Yekaterinoslaw owns only 4.35 miles out of a total of 18.27 miles. In addition thereto the street railways of the health resort of Piatigorsk are owned by the administration of the Caucasian mineral waters, which is a government institution. The aggregate length of all electric railways under public ownership is 170.26 miles.

The roads have been built and equipped mostly by foreign contracting firms; in St. Petersburg and partly in Moscow the contracts were given by the municipalities to the Westinghouse Electric and Manufacturing Company.

The total number of motor cars is 2,069, the total number of trailers 604; in addition thereto there were 2 electric locomotives for freight traffic and 4 snow sweepers. Each motor car is equipped with at least 2 motors; in Moscow and Kiev there were in all 84 additional motors.

The gauge of the tracks is not uniform; the prevailing width is 3.28 feet (1 meter), but in 9 cities, including St. Petersburg, Moscow, Warsaw, and Riga, the width is 5 feet; in Rostov on the Don it is 4.71 feet; in Nizhni-Novgorod the city proper has a narrow-gauge track 3.28 feet wide, and the annual-fair section (on the other side of the river) a wide-gauge track (5 feet).

The prevailing voltage is 550 volts, direct current; in Moscow it is 575 volts, and in 10 other cities 500 volts, direct current.

ITALY.

The progress of work in applying electricity to the main lines of railway in Italy has been more rapid than in some other countries, but is not so much in evidence from the fact that some of the most notable examples have been newer roads that were electrified at the start. The only two lines which have been converted to electric traction and which are now in operation are given in the statement in the next column.

A long period of cessation from active work followed the opening of the Lecco-Chiavenna line in September, 1902. Several projects have been under way for the last two years, however, and are rapidly nearing completion. The government budget calls for the conversion of a total of 186 miles by the end of 1912, and a large part of this was well under way during 1907–8. The two centers of the government's activity in electrifying its steam-railway system are Genoa and Milan. Around Milan four projects have been started. The first is 16 miles of the Milan-Ceresio suburban line from Gallarate to Avone Junction, a new single-track railway running along the west shore of Lake Maggiore, connecting with the Simplon tunnel line at Domodossola. Another project is 20 miles of the road from Gallarate to Laveno on the St. Gotthard line. North of Domodossola it is proposed to electrify the remaining 11 miles up to the mouth of the Simplon tunnel at Iselle, on which the prevailing grade is 2½ per cent. Still another project is the electrification of the suburban lines northeast of Milan, connecting Lecco, Usmate, Colozio, Ponte, and San Pietro, and having a total length of 50½ miles.

| DATE OF OPENING. | Name of line. | Nature of service. | Form of power. | Miles in operation.[1] |
|---|---|---|---|---|
| October 16, 1901.... | Milan-Varese Porto Ceresio. | Local suburban... | Steam... | 45 |
| September 4, 1902.. | Lecco-Colico, Sondrio-Chiavenna. | Country local tourist. | Water... | 66 |

[1] Total mileage of lines for suburban and local traffic in operation up to December, 1908, 112.

In southern Italy the Naples-Salerno line, together with a short branch, totaling 31.6 miles, is to be operated electrically if suitable water power can be developed for generating purposes.

Several small projects, consisting chiefly of short sections on heavy grades in the Ligurian Alps, and comprising in all 32 miles, will be completed in northern Italy by the end of 1911. One of the longest of these lines is the section from Savona to San Guiseppe di Cairo, a distance of 12 miles.

The most important electrical project of the Italian State Railways, involving nearly 20 miles of track, is the conversion of the line from Genoa to Busella, on the road to Milan and Turin, in connection with the proposed electrification of the entrance tunnels in Genoa. The road to be electrified was formerly part of the main line between Genoa and Milan. The grades on this road were excessive and there was one tunnel near the summit. Several years ago another line was built having much easier grades, and this new line, at the present time, carries the major part of both freight and passenger traffic. The old line has been used only as a relief track when congestion was severe on the new line, and will when electrified, be used very largely for freight. This will be the first line in Italy on which electric traction will be employed under conditions closely approaching main-line traffic, as the trans-Alpine service is conducted on Swiss territory.

Current for operating the electric locomotives is to be generated in a steam-power station in Genoa. Two steam turbogenerators of 5,000-kilowatt capacity have been installed, and a third unit will be added when the underground lines in Genoa are electrified. The generators deliver 3-phase 15-cycle current at 900 revolutions per minute. The generator voltage is 13,000, and current is transmitted at this voltage over transmission lines to four substations equipped with static transformers to reduce the potential to 3,000 volts between phases on the line. The two trolley wires have each an area of 100 square millimeters, which is slightly less than that of No. 0000 B. and S. wire gauge. The rails are electrically bonded for the return circuit.

The 3-phase electric locomotives used on this line are remarkable for their great weight. Each locomotive has five driving axles coupled together, and carries two 800-horsepower motors which are connected to the wheels by a system of rods and cranks. The two motors are of the 3-phase type and have eight poles. With a frequency of 15 cycles they are designed to drive the locomotive at a constant speed of 28 miles per hour when running in parallel, or 14½ miles per hour when connected in cascade. The locomotives have an adhesion weight of 60 tons, which can be increased to 75 tons by adding ballast. It is the intention to operate one of the locomotives at the head of a freight train and another in the rear, and it is believed that it will be possible to run trains of 20 freight cars each averaging 20 tons, or a total train weight of 550 tons, at a constant speed of 28 miles per hour up the long grades, which exceed 3½ per cent. As the line is divided into three-block sections, it is expected that it will be possible to haul 1,680 cars over the line in twenty hours, allowing a ten-minute interval between trains.

Traffic on these lines is heavy in both directions, and the adoption of 3-phase locomotives makes it possible to replace much of the energy expended in hauling trains to the summit by regenerating current and feeding it back into the line as the locomotives and trains descend the grade into Genoa. Provision has been made whereby a maximum of 4,000 kilowatts regenerated by trains descending the steep grade can be absorbed at the power house through an automatic rheostat.

According to a recent authority there were in 1907–8 some 60 street-railway undertakings in Italy. The available statistics relating to these railways are, however, very meager. The length of track and the number of motor cars for 50 of the 60 roads were reported as 1,026.38 miles and 2,472 cars. As measured by trackage, the majority of these roads are comparatively small—only 1 having over 100 miles; 6, 50 to 100; 6, 25 and under 50; and 37, under 25 miles.

### SPAIN.

Very little definite data can be obtained with regard to the development of street and electric railways in Spain. Thirteen cities in the Kingdom appear to have street-railway systems, all of which are reported as electrical, and in some of these cities, such as Madrid, Bilbao, and San Sebastian, more than one company is in operation. The total length of track in miles for these roads is 286.1, and the number of motor cars is reported as 1,123. This probably includes trail cars as well. Of this number, Barcelona appears to have 400 cars; Madrid, 350; Bilbao, 110; and Seville, 70. As a general thing these systems are operated with direct current, 550 volts. Many of them have been developed with English and German capital, and use also apparatus from those countries.

### JAPAN.

A number of electric-railway systems have been installed in the Empire of Japan in such cities as Osaka and Tokyo. Table 179 presents all the statistics available relating to the street and electric railways of Japan. The conditions are somewhat adverse to street-railway development, the bulk of the population being forced to live upon incomes far below those of the working populations of America and Europe. Moreover, the streets of all the cities are extremely narrow and the universal use of jinrikishas as a cheap means of conveyance limits the amount of possible patronage from the well-to-do. As progressive a country as Japan, however, is not likely long to be without these conveniences of modern life and, as a matter of fact, Tokyo has had a street-railway system since 1882. The first line used animal traction. In 1903 the number of companies operating was reduced to three, and all the roads were electrified, while in 1906, following American methods, all these roads were unified under one management, that of the Tokyo Electric Street Railway Company.[1] This corporation, operated under a perpetual franchise from the city, was organized by Japanese and is managed by them in all its departments, and it is noteworthy in that its capitalization is entirely in common stock, of which there was $16,500,000 at the end of 1907. It is understood that practically the entire amount is held by local investors, who have been receiving an annual dividend at the rate of 9 per cent, paid twice a year. The total operating expenses are 50 per cent of the gross receipts. Of the net receipts, 10 per cent annually is required to be placed in a reserve fund and one-third of the remainder goes to the city as compensation for the use of the streets. During 1907 the gross receipts were $2,490,000 and the amount paid to the city was $164,340.

[1] The following data relating to this company do not agree with that shown for "Tokyo Ry. Co." in Table 179. The data were obtained from different sources.—Census Bureau.

An extraordinary example of the influence of a new invention or service, similar in effect to that of the tunnels around New York on the ferry-boat service, is shown in the reduction of the number of jinrikishas within a few years from 40,000 to 20,000 in Tokyo; though even the smaller number would seem a liberal provision for a city of 2,000,000 population. A more striking illustration of the displacement of human motive power by machinery could hardly be cited. The popularity of the street-railway system is also shown by the rapid increase in the number of passengers carried, which at the beginning of 1908 had already an average of 300,000 daily. The fare is equal to about 2½ cents American.

A car crew consists of three men and, as a matter of fact, the system generally would seem to an American manager heavily overmanned, the total number of employees being about 7,000, or 10 per running car. Of these, in 1907, 246 were inspectors, 1,873 were motormen, 1,910 conductors, 189 apprentices for work as car employees, 57 power-station men, 30 lighting-station men, 152 barn mechanics, 337 switchmen, 583 yard men, 376 linemen, 277 trackmen, 274 construction men, and 445 painters and carpenters.

The employees on the cars, dressed in the conventional blue uniform with brass buttons, work on an average ten hours a day, with the exception of the motormen and conductors, whose time depends upon the number of miles in their respective runs. These latter are expected, however, to run about 60 miles in a day of eleven hours and are paid extra for time beyond eleven hours. The runs are continuous and are not broken by the two-hour relief crew, as in America. For lunch only twenty minutes are allowed, but at the end of each round trip the men have six minutes for smoking. Motormen and conductors receive wages, a guaranteed portion of which is based upon a minimum of $5.98 per month up to $10.46 per month for the sixth class. The other portion is based upon a cooperative plan, regulated by the net receipts of the company, 9 per cent of which is set aside to be distributed as wages. After deducting from this the aggregate sum of the guaranteed wages, the remainder is distributed in the form of a bonus, which is apportioned to each conductor and motorman according to his classification in rank.

The system had an equipment in 1907 of about 700 cars in daily use, all of the closed type and all constructed in Japan. These were of various sizes and were operated over 90 miles of narrow-gauge track, to which an extension of 80 miles was then proposed. The narrow-gauge track is due to the contracted nature of the streets, but the cars themselves have wide bodies and nearly fill up the thoroughfares.

Cars are started by the ringing of two bells and one bell is rung for a stop. The cars do not stop at calls on every corner, owing to the great inequality in the length of the blocks, so that stopping places, which are indicated by notices painted on the trolley poles along the streets, sometimes appear in the middle of a block. Each car, except the smallest one, has two conductors—one inside to collect the fares and one at the back to keep an eye on the trolley and on the tickets and to help passengers get on and off. The conductor on receiving the coin holds it up, states its amount, and inquires as to whether one or more tickets are required, or a transfer, conducting the transaction aloud with the passenger. The object of this is to prevent disputes and short change and the conductor is compelled to make good personally in any case of dispute. The fares received are deposited in a small leather satchel suspended from the neck of the conductor, after a manner not altogether unfamiliar in America. The inside conductor gives each passenger a punched ticket, which is collected by another conductor on the rear platform and is deposited in a box carried on the car there for that purpose. The passenger can not alight before he has produced and given up his ticket. The tickets are numbered consecutively, but there is no fare-registering system. Transfers are given to all intersecting lines and even a transfer upon a transfer if desired. There are few strap hangers, but those who do stand up rest for support on bamboo loops, instead of leather straps, placed above the seats. The floors of the cars are not covered with grating as in this country, as the clogs worn by most of the people would catch in the cracks and make walking in the cars very difficult.

The visit of the American fleet to Japan in 1908 gave many Americans an excellent opportunity to make practical trial of the suburban and interurban developments. The Pacific Coast Chamber of Commerce made a special report of its trip over the double-track road between the cities of Osaka and Kobe, situated 20 miles apart, with cars operating on a three-minute headway. The interurban company operates some 50 cars, each 44 feet from end to end, mounted on double trucks; and in his reception speech to the chamber the managing director called attention to the fact that the cars, trucks, motors, controllers, air brakes, rails, steel girders, overhead construction, generators, engines, boilers, pumps, and condensers all came from the United States. He also called attention to the fact that the whole system was designed and operated under a Japanese chief engineer who was a graduate of an American university and that the promoter and president of the company had acquired his knowledge of interurban-railway development from a trip made through the United States for the purpose of studying railway problems.

In Osaka, with a population of 1,700,000 (the second largest city in Japan), the transportation and lighting systems are owned by the Osaka Electric Railway Company. The street-railway system has the equiva-

lent of 22 miles of single track, and the rolling stock comprises 100 cars, of which 70 are in daily service, each car averaging 97 miles a day. The fare ranges from 1 to 5 cents. Workmen's half-price tickets are good until 7 a. m.

TABLE 179.—STREET AND ELECTRIC RAILWAYS IN JAPAN.

| Number. | NAME OF ROAD. | Single-track mileage. | CARS. Single-trolley. | CARS. Double-trolley. | Generating capacity (kilowatts). | Motive power. | Capital paid. | Loan. | Receipts. | Expenses. | Earnings. | Date of operation. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total | 324.6 | 1,308 | 204 | [1] 23,857 | ..... | $27,868,630 | $605,891 | $4,304,018 | $1,995,473 | $2,308,545 | ..... |
| 1 | Bungo Electric Ry. Co | 7.1 | 17 | ..... | 150 | Steam, water. | 79,680 | 340 | 26,047 | 16,144 | 9,903 | May 10, 1900 |
| 2 | Hanshin Electric Ry. Co | 36.5 | ..... | 37 | 800 | Steam | 1,494,000 | 263,741 | 417,332 | 228,409 | 188,924 | Apr. 2, 1905 |
| 3 | Imperial Government Rys. (Kobu) | 16.0 | 32 | ..... | 600 | Steam | 400,082 | ..... | ..... | ..... | ..... | —— —, 1905 |
| 4 | Ise Electric Ry. Co.[2] | 11.8 | 24 | ..... | 242 | Steam | 348,600 | ..... | 56,384 | 25,276 | 31,107 | Aug. 5, 1903 |
| 5 | Iwamura Electric Ry. Co.[2] | 15.3 | 3 | ..... | 90 | Water | 54,780 | 28,998 | 7,369 | 6,463 | 906 | Dec. 5, 1906 |
| 6 | Kawagoye Electric Ry. Co.[2] | 8.0 | 8 | ..... | 100 | Steam | 149,400 | ..... | 26,477 | 20,576 | 5,901 | Apr. 16, 1906 |
| 7 | Keihin Electric Ry. Co.[2] | 34.5 | 32 | 23 | 1,375 | Steam | 1,587,375 | ..... | 320,333 | 139,518 | 180,815 | Jan. 21, 1899 |
| 8 | Kioto Electric Traction Co | 19.5 | 71 | ..... | 525 | Steam | 883,950 | ..... | 139,519 | 71,465 | 68,054 | Jan. 31, 1895 |
| 9 | Nagoya Electric Ry. Co | 7.0 | 38 | ..... | 500 | Steam | 498,000 | ..... | 70,532 | 35,223 | 35,309 | May 6, 1898 |
| 10 | Nankai Ry. Co | 18.8 | ..... | 24 | 1,000 | Steam | 569,099 | ..... | ..... | ..... | ..... | Aug. 21, 1907 |
| 11 | Odawara Electric Ry. Co.[2] | 8.1 | 34 | ..... | 300 | Water | 435,750 | 24,900 | 70,711 | 41,536 | 29,175 | Mar. 21, 1900 |
| 12 | Osaka Municipal Electric Ry.[2] | 3.0 | 10 | ..... | 3,000 | Steam | 2,071,517 | ..... | 31,392 | 22,183 | 9,209 | Sept. 12, 1903 |
| 13 | Seto Electric Ry. Co | 10.2 | 16 | ..... | 80 | Bought | 114,540 | 36,164 | 18,626 | 11,033 | 7,593 | Mar. 17, 1907 |
| 14 | Sunzu Electric Ry. Co.[2] | 4.1 | 9 | ..... | 275 | Water | 136,050 | 75,945 | 23,777 | 14,301 | 9,475 | Nov. 28, 1906 |
| 15 | Tamagawa Electric Ry. Co.[2] | 9.4 | 30 | ..... | 450 | Steam | 249,000 | 94,620 | 19,023 | 11,004 | 8,018 | Mar. 6, 1907 |
| 16 | Tokyo Ry. Co.[2] | 91.0 | 914 | 120 | 13,920 | Steam | 17,554,500 | ..... | 2,926,200 | 1,257,938 | 1,668,262 | Aug. 15, 1903 |
| 17 | Tosa Electric Ry. Co.[2] | 9.3 | 30 | ..... | 225 | Steam | 357,457 | 6,474 | 37,481 | 29,984 | 7,497 | May 2, 1904 |
| 18 | Yenoshima Electric Ry. Co.[2] | 6.8 | 12 | ..... | 225 | Steam | 136,950 | 74,700 | 19,547 | 10,066 | 9,482 | Sept. 1, 1902 |
| [3] 19 | Yokohama Electric Ry. Co | 6.4 | 28 | ..... | 300 | Steam | 747,000 | ..... | 93,268 | 54,354 | 38,915 | July 15, 1940 |

[1] The items of generating capacity do not add to the total. Information not available to harmonize the figures.
[2] Companies are operating both lighting and railway services. Capital, loan, receipts, expenses, and earnings for lighting and railway are not separately known.
[3] The following roads are under construction: No. 20, Bungo Electric Ry. Co.; No. 21, Illogo Electric Ry. Co.; No. 22, Ina Densha Ry. Co.; No. 23, Iwakuni Electric Ry. Co.; No. 24, Keihan Electric Ry. Co.; No. 25, Kobe Electric Ry. Co.; No. 26, Kure Electric Ry. Co.; No. 27, Minomo-Arima Electric Ry. Co.; No. 28, Naniwa Densha Ry. Co.; No. 29, Seiso Electric Ry. Co.; No. 30, Wakayama Water Power Electric Co.

## BRITISH ASIA.

Table 180 is presented herewith, giving statistics of electric and steam railways in operation in various parts of the British Empire in Asia, with the date of the latest figures obtainable. Several of these roads have been put in with the assistance of American electrical engineers and some of them use American apparatus. The Bombay system may be taken as typical of the work of this character and is interesting from the fact that it was equipped for animal traction in 1874 with money furnished by New York capitalists. Electrification was begun in 1907 and was finished early in 1908. The route mileage of the system is 20.38 miles, double track, with the exception of a half mile. One interesting feature of the overhead construction of these lines is the clearance of 21 feet to 21 feet 9 inches, which is necessary to avoid interference with the portable shrines and mosques carried in procession during religious festivals. As most of the natives can not read, destination markers for the cars are carried in the form of colored disks in the daytime or colored lamps at night, in addition to the lettered destination signs on the cars. The number of passengers carried in 1907 by horse and electricity was 25,766,916, with a car mileage of 2,825,385 miles and gross passenger receipts of $512,744, or an average fare per passenger of 1.86 cents.

The general traffic conditions of the system, like those in other cities in the British possessions in Asia, differ very materially from those of America or Europe. Most resident Europeans of the upper class and many of the rich natives keep their own carriages, which are not expensive of maintenance, and a large proportion of the laboring class is altogether too poor to ride frequently, hence the tramway passengers are drawn chiefly from the ranks of the artisans, the shopkeepers, and the middle-class traders. Another limitation that prevailed in the earlier days of horse traction was due to the reluctance of high-caste Hindus to mix with those of lower castes, while Hindus of the lowest caste have not been permitted to enter any cars at all. The caste prejudice has broken down to a considerable extent, however, so far as the higher castes are concerned, and the practice of street-car riding is growing very rapidly among all classes. The highest rate of fare on the Bombay lines on ordinary cars is 3¾ cents, for which passengers can ride 7 miles, half rates being granted to children only. It will be noted, however, that the average fare per passenger carried was less than 2 cents. The fare on first-class cars was about 50 per cent higher than on the ordinary cars, but the better cars do not seem to have proved altogether satisfactory, as the cheaper cars are so comfortable that Europeans and upper-class Indians are quite satisfied to patronize them. The company has therefore converted all the classes to one ordinary type.

TABLE 180.—*Electric and steam railways of British Asia: 1907–8.*

| PLACE. | Capital. | Gross earnings. | Track miles. | Cars. | Passengers carried. | Car mileage. |
|---|---|---|---|---|---|---|
| Bombay, India, 1907 | (1) | $529,700 | 41 | 162 | 25,766,916 | ..... |
| Mandalay, Burmah, 1907 | $959,875 | ..... | 13 | 24 | 2,619,221 | 543,387 |
| Calcutta, India, 1907 | 6,034,300 | 852,380 | 69 | 450 | 27,488,431 | 4,338,562 |
| Colombo, Ceylon | 1,254,200 | ..... | 14 | 36 | ..... | ..... |
| Delhi, India, 1908 | 652,000 | ..... | 10 | ..... | ..... | ..... |
| Hongkong, China, 1907 | 2,600,000 | 213,525 | 14½ | 36 | 8,564,055 | 1,122,342 |
| Georgetown, Penang | ..... | ..... | ..... | 15 | ..... | ..... |
| Cawnpore, India, 1908 | (2) | ..... | 7 | ..... | ..... | ..... |
| Madras, India, 1907 | 897,809 | ..... | 15½ | 67 | ..... | ..... |
| Rangoon, Burmah, India | (2) | ..... | 25 | ..... | ..... | ..... |
| Singapore, Straits Settlements, 1907 | 3,563,860 | 306,490 | 26¼ | 60 | 13,270,000 | ..... |

[1] Tramway and lighting. [2] Light and traction.

AUSTRALASIA.

Table 181 is presented in this section, comprising all that can be ascertained with regard to the street-railway systems of Australia, New Zealand, and Tasmania. Several of these systems are electrified, although Melbourne, the most important city in Australasia, still depends chiefly upon its extensive cable system. Recently a special study has been made by English experts of the electrification of the Melbourne suburban lines by the Victoria Railways Commission, but it is understood that the proposal to electrify will not be adopted for the present. The report in question deals with the travel, both tramway and railroad, in Melbourne and its suburbs and gives the number of journeys and the receipts per head of population. Melbourne has a very large population as compared with that of the whole state, its 526,000 inhabitants being over 42 per cent of the entire population of the colony of Victoria, as compared, for example, with the population of London, which is 20 per cent of that of England; of Paris, which is 6.9 per cent of the population of France; and of Berlin, which is only 5 per cent of the population of the German Empire. Moreover, the inhabitants of Melbourne are widely scattered over the district about the city, the density of the population being 2,064 per square mile, as against 11,195 for New York and 9,510 for Greater London. In the other cities of Australasia, such as Sydney, Perth, and Wellington, the populations are denser than that of Melbourne; hence it comes about that in Melbourne a large part of the transportation business, which in an American or European city would be handled by electric street-car lines or electric-railway systems, is handled by a distinct system of suburban railways. According to the report quoted, the tramways in and around Melbourne carried 60,558,098 passengers in 1907 and the suburban railways no fewer than 64,162,344, making a total of nearly 125,000,000, an average of 236 journeys per capita. The total receipts were $5,650,000, giving an average receipt per capita of $10.70.

As in Victoria, so in several of the other Australian colonies, the street-railway systems are not in the hands of the municipalities, but are under the control and ownership of the state government itself. This is the case with regard to Sydney, where the street-railway system for which data are given is owned and operated by the government of New South Wales. The system is operated along familiar English lines, using the overhead trolley with both center-pole and span-wire construction, although it is noteworthy that a very large portion of the equipment, including the generators and the steam plant, was obtained in the United States. Of the 777 cars reported, no fewer than 678 were of the single-deck type. Current for the system is generated at 6,600 volts alternating, and is distributed to 7 substations and 4 battery houses, from which it is delivered direct to the supply wires at a potential of 600 volts. During the year ending June 30, 1908, the number of passengers carried by this system was no fewer than 155,017,982, while the car mileage was 18,069,810. The consumption of current is not determinable, as the units used for traction and lighting are not reported separately.

One of the largest systems in Australasia is that of Auckland, New Zealand, which is operated by the Auckland Electric Tramways Company, Limited, a corporation which took over the rights and system from a British concern and which uses apparatus generally of British design and construction. Auckland, with a population of only 75,000, had a service of 87 cars furnished to it by this corporation, which during the year 1907 carried no fewer than 22,474,537 passengers, making a mileage of 2,050,386. The average receipts per passenger were reported as 2.94 cents and the average cost per passenger as 1.76 cents.

Another fairly large system in New Zealand is that of Christchurch, which is also operated under private management. This city, with a population of only 68,920, was served by 99 cars, which were used in 1907 by 10,002,367 passengers.

In connection with Australasian development, and in fact with that of the Far East generally, the following remarks of Sir Clifton Robinson before the Tramway and Light Association in 1908 may be quoted appositely:

> Australia has no extensive systems of mechanical tramways outside Melbourne and Sydney. The Melbourne cable tramways are worked by a company under arrangements with a joint board of municipalities. The Sydney tramways, mostly electric, are worked by a department of the state, and the voluminous reports issued are well known. Tramways in other towns are electric, except in Adelaide, where a large horse system has been taken over by the local authorities and is now being extended and electrified. In New Zealand there are only a few tramway systems, mostly electric; they await further population in order to develop, but, in proportion to the existing population, they do a remarkably large business. The construction and equipment, both in Australia and New Zealand, are similar to those in England. The same remarks apply to South African tramways, which, unfortunately, are suffering from the trade depression there.
>
> I was much struck during my recent journey with the development of electric tramways in Tokyo, Yokohama, Shanghai, Hongkong, Singapore, Colombo, etc. These follow western models; indeed, most of them have been built and equipped by British engineers. In Japan, however, they are run by native officials; but in China Europeans are in administrative command, as in those towns in India where tramways have been installed. The natives take well to the innovation. The cars are usually divided into two classes. The main obstacle to greater development in eastern cities is the narrowness of the streets. This is particularly noticeable in Tokyo, the capital of Japan. The city is a network of electric tramways, either in operation or proposed, though there are several important main arteries of traffic too narrow to admit even a single line of rails. The greatest possible impetus is given to the promotion of important lines of electric railways extending from Tokyo and connecting with the large, and in some cases far-distant, provincial business centers.

TABLE 181.—STREET RAILWAYS OF AUSTRALASIA: 1907.

| | Capital. | Gross earnings. | Net earnings. | Track miles. | Cars of all kinds. | Passengers carried. | Car mileage. |
|---|---|---|---|---|---|---|---|
| Auckland, New Zealand | $3,165,000 | $702,255 | ..... | 36.45 | 87 | 22,474,537 | 2,050,386 |
| Adelaide, South Australia | 2,300,000 | ..... | ..... | 75.00 | ..... | ..... | ..... |
| Brisbane, Queensland | 6,000,000 | 803,900 | ..... | 57.00 | ..... | ..... | ..... |
| Christchurch, New Zealand | ..... | 455,900 | $290,400 | 53.00 | 99 | 10,002,367 | 1,355,202 |
| Dunedin, New Zealand | 1,300,000 | ..... | ..... | 20.77 | 49 | ..... | ..... |
| Ballarat, Bendigo, Victoria | ..... | ..... | ..... | 25.50 | 48 | ..... | ..... |
| Freemantle, Western Australia | ..... | ..... | ..... | 8.50 | 14 | 2,291,055 | 484,071 |
| Hobart, Tasmania | 530,000 | ..... | ..... | ..... | 24 | ..... | ..... |
| Kalgoorlie, Western Australia | 2,200,000 | 250,000 | ..... | 20.50 | 30 | 3,052,241 | 650,530 |
| Sydney, South Australia | ..... | ..... | ..... | 141.50 | 777 | 155,017,982 | 18,069,810 |
| North Melbourne | ..... | ..... | ..... | ..... | 25 | ..... | ..... |
| Perth, Western Australia | 1,135,000 | 379,000 | ..... | 50.00 | 50 | 7,790,034 | 1,178,716 |
| Wellington, New Zealand | 2,500,000 | ..... | ..... | 33.00 | ..... | 16,897,034 | 1,711,096 |

SOUTH AFRICA.

A table of the street-railway systems of South Africa, compiled from various sources, is given below. It is believed that the list is fairly complete, although from the lack of any central source of information it is difficult to ascertain precisely all the facts. The chief systems are those of Cape Town, Durban, and Johannesburg, the last of which is reported to have had no fewer than 128 cars in operation at the time of the report. The system of Cape Town proper is credited with over 12,000,000 passengers carried during the year, and that of Durban with over 11,000,000. Several of these systems were originally horse railways, as, for example, that at Johannesburg, where the change in motive power from horses to electricity was made during the period 1905 to 1907, when the length of the line was increased from 12 miles to the total of 26, which it is now reported to exceed by 3 or 4 miles.

TABLE 182.—*Street railways of South Africa: 1907.*

| | Capital. | Track miles. | Cars of all kinds. | Passengers carried. | Car mileage. |
|---|---|---|---|---|---|
| Camps Bay | ..... | 7.80 | 14 | 921,837 | 222,686 |
| Cape Town | $5,168,000 | 32.74 | 85 | 12,503,303 | ..... |
| Port Elizabeth | ..... | 12.00 | 20 | 3,676,035 | 477,500 |
| Durban | 2,000,000 | 30.03 | 65 | 11,493,228 | 1,219,806 |
| East London | ..... | 5.25 | 15 | 1,653,307 | 165,330 |
| Johannesburg | ..... | 26.00 | 128 | ..... | ..... |
| Kimberley | ..... | 5.80 | 6 | ..... | ..... |
| Kimberley | ..... | 2.00 | 10 | ..... | ..... |
| Pietermaritzburg | ..... | 6.57 | 16 | ..... | ..... |
| Delagoa Bay | 2,230,000 | 7.76 | 15 | ..... | ..... |