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THE BROCKTON & PLYMOUTH STREET RAILWAY

The south shore of Massachusetts Bay has long been known as one of the most delightful stretches of country in New England. From Boston Light to Provincetown the coast abounds in historic association, picturesque scenery and maritime activity. The long sand dunes of Cape Cod exert a peculiar charm upon the visitor, and the refreshing climate draws many tourists yearly to this attractive region.

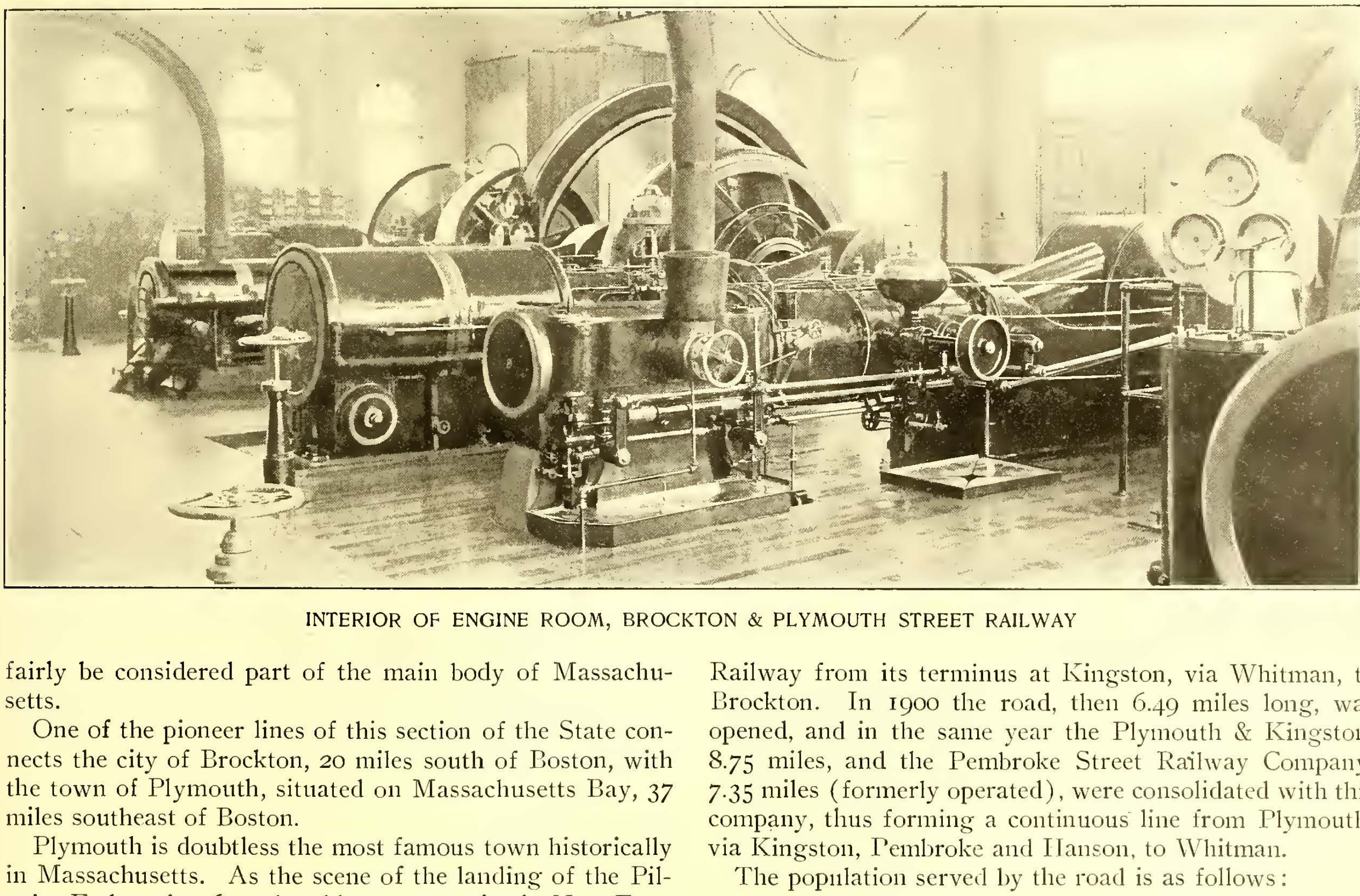
The southern portions of the cape are sparsely settled and in winter barren and bleak. Highland Light, Peaked Hill Bars and Chatham are yearly the scenes of furious storms, which line the coast with wrecks and necessitate the constant vigilance of the United States Life Saving Service. Electric railway development has been slow in these regions, but more extended in the north central towns of the cape, such as Plymouth and Fairhaven, which may fairly be considered part of the main body of Massachusetts.

One of the pioneer lines of this section of the State connects the city of Brockton, 20 miles south of Boston, with the town of Plymouth, situated on Massachusetts Bay, 37 miles southeast of Boston.

Plymouth is doubtless the most famous town historically in Massachusetts. As the scene of the landing of the Pilgrim Fathers in 1620, the oldest community in New England and the ground where the cornerstone of American liberty was carved in heroism and privation, the old town with its "Plymouth Rock," "Provide Hill," monument and museums, stands to-day one of the most cherished spots in the United States. Its population in 1900 was 9592. It has nine churches, five banks, a public library, two weekly papers and manufactures hardware, cordage, shoes and wire. The Forefathers' Monument is 81 ft. high, cost $150,000, and supports the largest granite statue in the world.

Brockton is a busy manufacturing city, over $6,500,000 being invested in the boot and shoe industry. Its population in 1900 was 40,063, and although it is a separate city from Boston it may fairly be said to fall within the suburban limit, as its industries are closely tied to the New England metropolis by powerful business interests. Practically all the leather employed in its shoe manufacture comes from Boston, and the recent transportation strike in that city threatened a paralysis in the shoe industry of Brockton in the few days of its life. Furniture, carriages, boxes and candy are also produced in large amounts.

The Brockton & Plymouth road was chartered in 1899 to build an extension of the Plymouth & Kingston Street Railway from its terminus at Kingston, via Whitman, to Brockton. In 1900 the road, then 6.49 miles long, was opened, and in the same year the Plymouth & Kingston, 8.75 miles, and the Pembroke Street Railway Company, 7.35 miles (formerly operated), were consolidated with this company, thus forming a continuous line from Plymouth, via Kingston, Pembroke and Hanson, to Whitman.



INTERIOR OF ENGINE ROOM, BROCKTON & PLYMOUTH STREET RAILWAY

The population served by the road is as follows:

Towns on Line.		Adjacent Towns.	
Brockton (city)	40,063	Abington	4,489
Whitman	6,155	Rockland	5,327
Hanson	1,455	Hanover	2,152
Pembroke	1,240	East Bridgewater	3,025
Kingston	1,955	Halifax	522
Plymouth	9,592	Plympton	488
		Doxbury	2,075
Totals	60,460		18,078

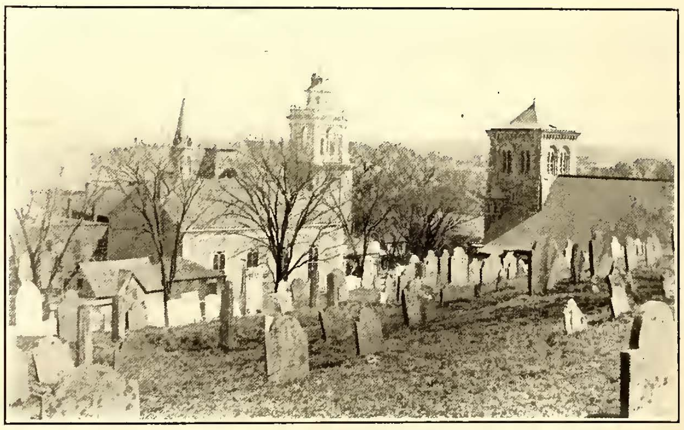
Grand total census of 1900, 78,538.

MONUMENT TO FOREFATHERS, PLYMOUTH

The total length of single track owned by the Brockton & Plymouth road is 23.68 miles. From Brockton to the Pilgrim House, Plymouth, is about 27 miles, the running time being two hours. The company has a traffic agreement with the Old Colony Street Railway Company (one of the properties of the Massachusetts Electric Companies) whereby the cars running from Plymouth are operated by the Old Colony road over its own tracks between Whitman and Brockton, the crews being changed at the former town. The line is supplied with power from a main power station in Plymouth and a rotary converter sub-station located at Bryantville, in Pembroke, in the Mayflower Grove Park, the transmission line being 13 miles long. The accompanying map shows the location of the track, which follows the highway throughout, the rails being laid at one side, their tops being level with the surface of the road. Excavation was made to the depth of the ties and rails, good chestnut and oak ties on 24-in. centers being put down, well tamped. Gravel ballast was used in Whitman, Hanson, Plymouth and in Kingston from Kingston car house to the Plymouth line. Sand ballast was employed in Pembroke and from the Pembroke line to the Kingston car house. Sixty-pound T-rail was used except in Plymouth, where girder rail was required. At road crossings the excavation was made to a greater depth and a stringer laid on each of the ties, the stringer being held by outside and inside angle-braces, the rails being secured with substantial tie-rods and the crossing paved flush with the rail. The heaviest piece of work is at a point about midway between Whitman and Kingston, where, to get a grade of about 6 per cent, a cut of approximately 8000 cubic yards was necessary, a portion of the expense being borne by the town of Pembroke. At the bottom of this grade is a substantial stone culvert. There are nineteen turnouts on the line, and the minimum radius of curvature of track is 35 ft. The 6 per cent grade above mentioned is 500 ft. long. An 8.8 per cent grade 300 ft. long occurs in Plymouth, and there are also grades of 5.3 per cent 700 ft. long and 3.4 per cent 1000 ft. in length on the line. The ties are 5 ins. x 5 ins. x $6\frac{1}{2}$ ft. and the joints standard four-bolt angle-bar. All new turnouts were made practically 200 ft. long. The ballast is about 8 ins. deep beneath the ties. Steep grades were also paved. No trestles or bridges were constructed. Fills 9 ft. wide were made at the tops of grades, sloping $1\frac{1}{2}$ ft. to 1 ft. There are 1.59 miles of double track on the line. No. 0000 Crown bonds were used between Whitman and Kingston, and the Clark bond of the Chase-Shawmut Company, of Boston, on the remainder. The only special work on the line consists of a Y-spur track running to the New York, New Haven & Hartford railroad station in Plymouth from Court Street, opposite the Hotel Samoset. A long turnout is built at Mayflower Grove Park which enables the traffic to be handled with expedition. The track is drained by a ditch at its side.

The power station stands on the shore of Plymouth Harbor, in the town proper and within a stone's throw of Plymouth Rock. It is built of brick on pile foundations. Each pile is of spruce, 25 ft. long, 10 ins. to 12 ins. in diameter at the butt end and 6 ins. to 7 ins. at the small end. All piles were chamfered for a few inches from the end and a wrought-iron ring placed thereon, the ring being made from 3-in. x 1-in. strap iron. The concrete capping of the piles forms the footing on which all foundations were started. Filling of broken stone or gravel was provided around the piles to grade up to the bottom of the concrete capping. The concrete consisted of one part best Portland cement to three parts clean, sharp sand and six parts broken stone, the broken stone passing through a 2-in. ring. Foundations of stone are built under the outside walls of the boiler house, boiler settings, heater and pumps. All stone masonry is composed of large stones with flat beds and builds laid solid in Roslindale cement mortar thoroughly bonded and bedded. Ledge rock was used in all cases. The stack foundation is of concrete, built in layers not over 12 ins. thick. Trimmings are of granite. Machinery foundations are of the best quality of hard brick laid in Portland cement mortar. The wells for condensing water and boiler feed-supply are built of brick with a concrete footing. The chimney is of hard brick, 125 ft. in height, capped with a cast-iron cap at the top, with a cast-iron clean-out door at its base. The inside diameter is 6 ft. 6 ins. throughout its entire length. All fire brick is laid in fire clay. All piers start on concrete bed. The boiler room paving is of brick laid on edge in sand, with a slope of about 6 ins. per 100 ft. toward the water pockets. All brick drain pockets are supplied with perforated cast-iron covers $\frac{1}{2}$ in. thick.

All floor timbers are of Southern pine. Each floor is laid with 4-in. plank and top board of $\frac{7}{8}$-in. birch or maple. The plank is spruce 7 ins. to 11 ins. wide, grooved $\frac{3}{4}$ in. square and furnished with hardwood splines. It was planed on one side to a uniform thickness of at least $3\frac{3}{4}$ ins. and is laid with close joints, planed side down, thoroughly spiked by two 7-in. spikes at each bearing. The floor boards were sawed in parallel widths of 3 ins. to 5 ins., 8 ft. to 12 ft. in length, laid at an angle of 45 degs. with the floor planking. The top floor is thoroughly oiled and levelled. The planking for engine room and boiler house roofs is of spruce 3 ins. thick, sound and free from wave and knots. The planks are grooved $\frac{5}{8}$ in. square, with 6 ins. maximum width. They are fastened with 6-in. spikes. The monitor is finished on the inside with Southern pine boards and clapboarded on the outside. All window frames and sashes are of white pine. Sashes are hung with 2-in. turned face steel axle pulleys, with Sampson cord and round balance weights, and are glazed with first quality double thick American sheet glass. Door frames are of Southern pine, with wrought-iron anchors, the doors being of white pine

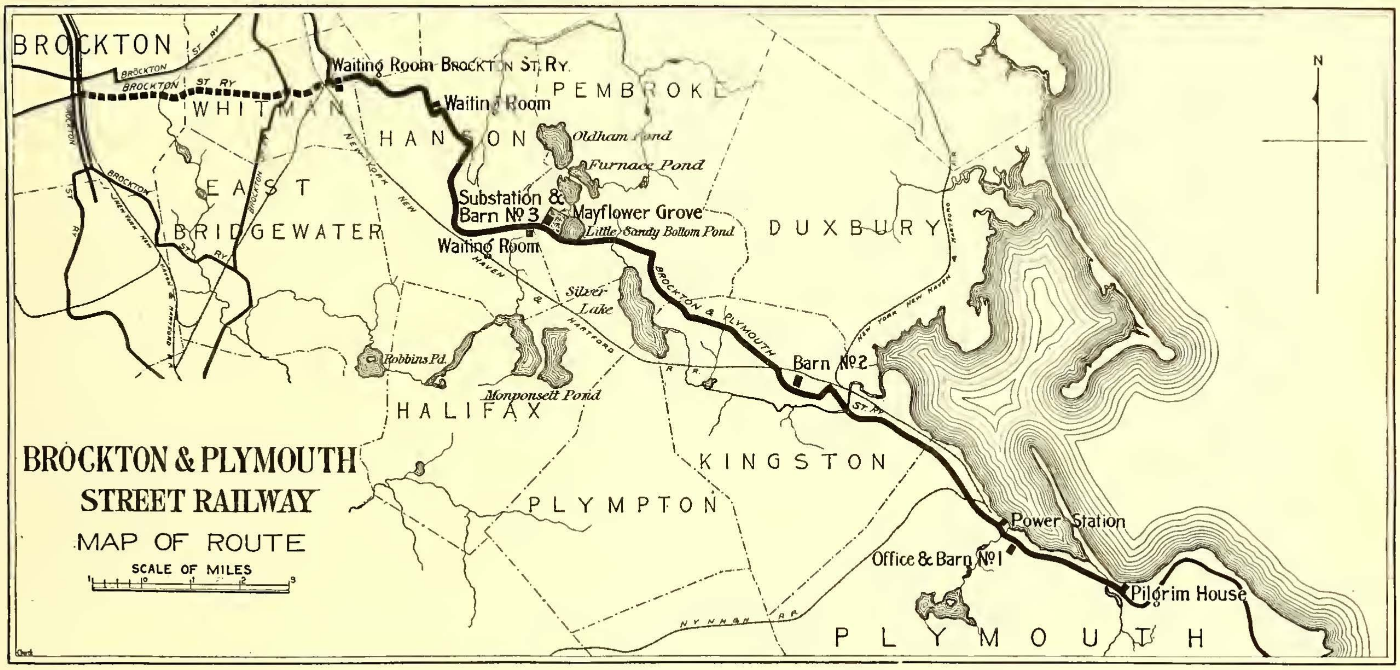


BURIAL HILL, PLYMOUTH

Stairways have 8-in. rises and 9-in. treads. All roofs are covered with tar and gravel, using 6-ply felt roofing with a gravel edge of zinc 5 ins. wide. Gutters are of 16-oz. 24-in. copper. Water conductors are of 4-in. galvanized iron pipe. The boiler house roof is flashed with lead weighing $3\frac{1}{2}$ lbs. per foot and is hipped to carry water by the ends of the monitor.

The power station is divided into two main parts, boiler room and engine room, separated by a wall. The engine room walls are painted with two coats of light drab above the window sills and with two coats of a darker color below. The boiler room walls are dark for 5 ft. from the floor and whitewashed above. Boiler settings are painted and whitewashed, and the walls in the engine room basement, foundations and piers are also whitewashed. Engines and generators are painted with two coats of dark seal brown and varnished. The smoke flue and boiler fronts are painted with black graphite paint. The under side of all roof planking was painted with two coats of white paint of pure white lead and linseed oil. An Akron inlet pipe was laid from the end of the power station wharf to the well, with bulkhead, strainer and gate at its end, with cement joints. All plumbing was done according to the city of Boston's regulations. There are four steel roof trusses in the engine room and four in the boiler room designed with a factor of safety of 4 against a total wind and snow load of 40 lbs. per square foot area exclusive of the roof itself. The boiler house trusses are designed for an additional load of 10,000 lbs. applied at any point of the bottom chord. Trusses rest on cast-iron plates built into the wall, and are held in place by anchor bolts, which are also built into the wall and come up through the plates, slots being left in the shoes at the end of each truss for adjustment and expansion. Trusses are braced laterally in the plane of bottom cords, and have a minimum bearing of 8 ins. The engine room span is 52 ft., the boiler room span being 40 ft. Steel was supplied by the Pennsylvania Steel Company. The extreme dimensions of the boiler room are 41 ft. 4 ins. x 63 ft. 10 ins. The engine room exterior is 54 ft. x 76 ft. 8 ins. The boiler room is lighted by eight windows 4 ft. 8 ins. wide, 10 ft. center to center, and 11 ft. 4 ins. high, in addition to the monitor, which can be opened and closed from the floor level.

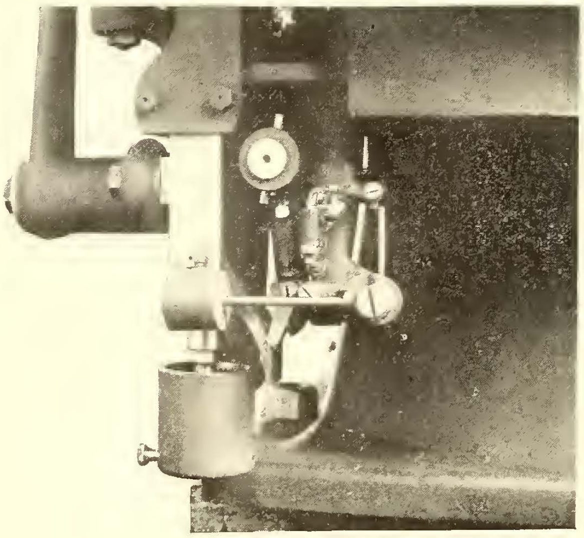
The boiler plant consists of four horizontal return tubular boilers, made by Edw. Kendall & Sons, of Cambridgeport, Mass. Each is 16 ft. long x 72 ins. wide, 17 ft. 2 ins. long over furnaces, contains 112 3-in. tubes and is rated at 125 hp. Shell plates and heads are open-hearth steel. The tubes are steel, the space between rows being a minimum of 1 in. All tubes are at least 3 ins. from the boiler shell, rivets $\frac{7}{8}$ in. diameter, and heads are stayed above tubes by through braces running length of boiler from head to head. Each boiler has two cast-iron nozzles 6 ins. internal diameter, for steam and safety valves riveted to the shell. There are also dry pipes in each boiler to prevent priming, perforated on the upper side with $\frac{1}{2}$-in. holes aggregating the steam nozzle in area and drained by two $\frac{1}{4}$-in. holes in the under side. Fusible plugs are provided with centers 2 ins. above the upper row of tubes. The blow-off pipes are $2\frac{1}{2}$ ins. in diameter. Each boiler also has one 12-in. brass steam gage, one combination water column and one internal brass feed-pipe 2 ins. in diameter. Two manholes, 11 ins. x 15 ins. and 10 ins. x 15 ins., are placed, one in the rear sheet on top of each boiler, the other in the front tube sheet under the tubes. The fronts are cast iron, with two fire doors each. The ash pits have revolving dampers, planed joints, drilled hinge holes and turned pins. The tops and sides of furnace mouths are lined with a special quality of fire brick. The grates are 6 ft. square and were made by W. W. Tupper & Co., with $\frac{5}{8}$-in. air spaces and $\frac{1}{2}$-in. iron bars. Each boiler is suspended by six cast-iron lugs riveted to the shell, is provided with one cast-iron uptake, air tight, and fitted with a hand damper to be worked from the floor. The boilers were tested at the works with warm water at 225 lbs. per square inch, the working test being a 10-hour run at 125 lbs. per square inch. The tube sheets are $\frac{1}{2}$ in. thick. Hand firing is used, coal being brought into the boiler room in small cars running on a track extending to the coal pocket east of the power house. Locke damper regulators are used. This pocket is a large wooden building built on 300 piles and has a capacity of 2000 tons. The building is 108 ft. long and 33 ft. wide, 41 ft. 7 ins. inside height. All timbers are hard pine with spruce planking, except on the roofing. All coal is weighed in the boiler room on a Fairbanks scale. The coal-handling apparatus was furnished by the C. W. Hunt Company. A boom 31 ft. long is mounted on a tower at the end of the wharf 42 ft. 3 ins. above the floor line, and coal is hoisted from the barges by an engine of the horizontal twin type size, about 10 hp. The engine takes steam



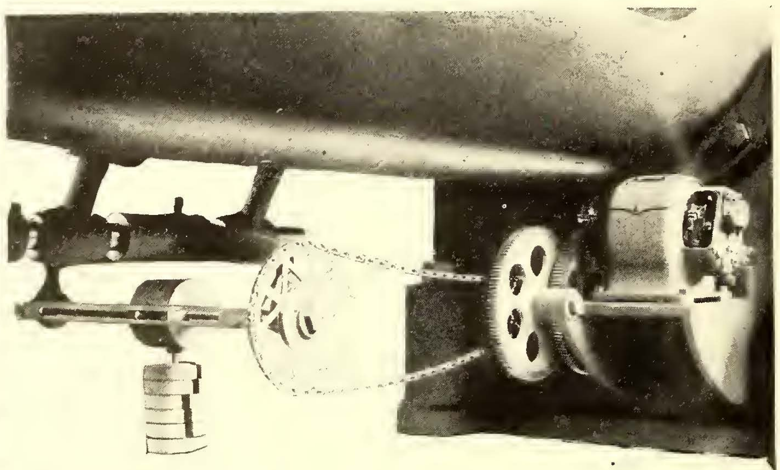
through a 2-in. pipe running to the boiler house. The hoisting tub holds 1000 lbs. of coal, and the coal on reaching the top of its hoist is discharged through a hopper into a coal car, which runs by gravity down an automatic railway until it is emptied into the pocket. The firing car also holds one ton, and the car house track divides into two branches beneath the pocket valves, where the coal is finally discharged and the car run into the boiler house by hand-power. Ashes are carried out by this car and are dumped into a hole behind the bulkhead.

Warren feed-pumps are used, and the feed-water is heated by two exhaust primary heaters supplied by the National Pipe Bending Company. Each has 200 sq. ft. of heating surface and are rated at 600 hp. There are no injectors.

All high-pressure steam pipes are made of lap-welded charcoal iron tubing, all work $2\frac{1}{2}$ ins. and above being flanged. The radius of bends is at least six times the pipe diameter, unless otherwise specified. Flanges are provided with raised faces and caulking recesses, all flange fittings being cast iron and high-pressure joints being made with corrugated copper gasket. Brass piping is used for all hot water connections between heaters and boilers. Low pressure piping is of flanged cast iron. Exhaust and water pipes in the main are of lap-welded iron. Akron pipe is used to carry the overflow from the hot well and is laid with cement joints. All straightaway valves are of the Chapman Valve Manufacturing Company's make. All valves used in high-pressure work are extra heavy, and if $2\frac{1}{2}$ ins. or above in diameter are made of a flanged iron body with bronze seats and arranged with outside screw and yoke. By-passes are provided on all high-pressure valves above 6 ins. Such valves have ribbed bodies, and all valves have composition spindles. Low-pressure valves above 5 ins. have a flanged-iron body with babbitt seats, stationary spindles and indicators, excepting main exhaust valves, which are furnished with outside screw and yoke, with floor stands having polished wheels and bodies. All valve stems are vertical as far as possible. Check valves are furnished in all connections to traps. The heater relief valve is set at 150 lbs. The heaters, tops of boilers, steam-supply pipes, drip pipes from the header, all feed pipes carrying hot water (except brass connections in front of boilers) and the exhaust pipes from the cross-compound engine to the condenser, including all valves and fittings, are covered with the best grade of Keasbey & Mattison sectional magnesia covering, using plastic covering not less than 2 ins. thick on larger pipes, heaters and boilers. The high-pressure steam and water piping has adjustable supports on roller bearings at least every six feet. The low-pressure piping is supported on non-adjustable hangers, brackets or piers. Drip connections are from $\frac{1}{2}$ in. to $1\frac{1}{2}$ ins. in diameter. Valves are provided throughout. The overflow from engine traps is carried into a main drip pipe $2\frac{1}{2}$ ins. in diameter. A 2-in. priming pipe valved at both ends is carried from the main feed pipe to the condenser. All bolts are of Burden's iron. Provision is made for inserting thermometers in the main feed-water pipe at the entrance and exit from the heater. All unions used are brass, and red lead is used wherever flanges are screwed on pipes. All piping is guaranteed to withstand a working pressure of 130 lbs. and was installed by Lynch & Woodward, of Boston. There are two Blake jet condensers in the station of the cross-compound vertical air pump type. The cylinder dimensions are $7\frac{1}{2}$ ins. and 15 ins. high and low pressure, 18 ins. water, 15 ins. stroke, and 6 ins. and 12 ins., 18 ins. and 15 ins., respectively. The condensing chamber is 24 ins. in diameter and the exhaust pipe 14 ins. The condensers are cross-connected, to operate together if desired. The water buckets of the condenser pump are of composition, fibrous-packed, and the water valves of medium rubber. Piston rods of the water cylinders are of Tobin bronze and the steamcylinder rods are steel, the latter cylinders being covered with 2 ins. of asbestos, lagged with Russia iron and brass bands. The condenser injection nozzles are composition-lined, and an automatic vacuum breaker is supplied to each one.



SAFETY STOP

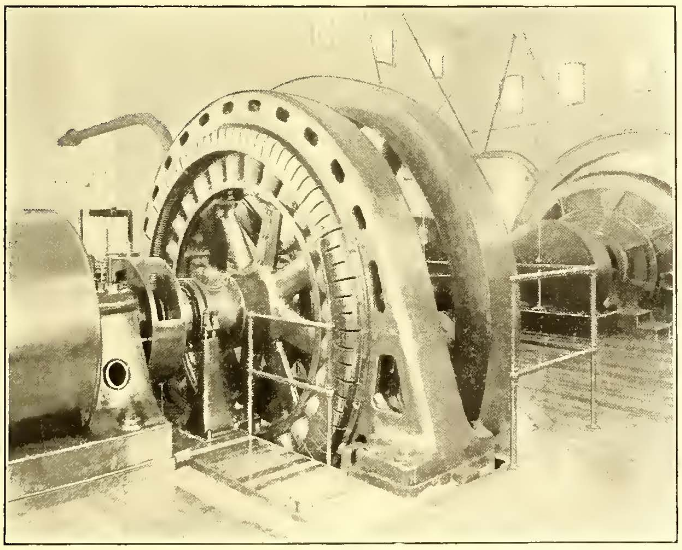


SPEED CHANGING OR SYNCHRONIZING DEVICE

The engine room contains at present three generating units. One of these supplies power to the transmission line and consists of a 300-kw General Electric three-phase alternator, revolving field type, direct-connected to a 450-hp horizontal cross-compound condensing engine made by C. H. Brown & Company, of Fitchburg, Mass. This engine operates at its normal rating at 125 lbs. steam pressure, with 26-in. vacuum, and is guaranteed to 14 lbs. steam per ihp-hour at full load. Its cylinders are 17 ins. x 33 ins. x 42 ins., and its speed 107 r. p. m. The cylinder wall thickness is $1\frac{1}{8}$ ins. high and $1\frac{3}{8}$ ins. low pressure. The clearance between the high-pressure cylinder head and piston 3-16 in., or 2 per cent, with $\frac{3}{8}$ in., or 2.5 per cent, on the low-pressure side of the engine. The horse-power inlet port area is 20 sq. ins., exhaust port 23.9 sq. ins., the corresponding horse-power area being 84.21 sq. ins. and 91.6 sq. ins. respectively. The piston rods are of steel, 3 ins. and $3\frac{3}{4}$ ins. in diameter respectively. The large and small sections of the high-pressure connecting rod are 23.75 sq. ins. and 13.36 sq. ins., while the horse-power rod areas are the same as the foregoing. The distance between centers of rods is 126 ins., and the cross-head pins are of open-hearth steel of $5\frac{1}{4}$ ins. diameter and length. The crank pins are of the same dimensions and material. The shaft is of Bethlehem steel, 12 ins. in journal diameter and 15 ins. diameter at the fly-wheel and armature. Length in journals, 22 ins. The guaranteed regulation is 2 per cent from zero to full load The fly-wheel is designed so that the angular variation from mean position to uniform motion shall not exceed .18 of 1 per cent at 150 per cent load. Cylinders are of the four-valve type, made of close-grained cast iron. The fly-wheel face is 16 ins. and the engine is lagged by 2-in. thickness of carbonate of magnesia covering.

The frame used on this engine, as will be seen from the view of the interior of the station, is of the heavy-duty Tangye pattern, to which the builders have given much attention since their advent into this field several years ago. The correctness of this design is well attested by the showing of this engine under an overload of 119 per cent, which occurred in this plant not long ago. This occurred during a snowstorm at a time when the other units were undergoing some changes, and was, of course, the result of accident.

A feature of this engine is its capacity for handling high speeds and changeable loads in direct connection with electric generators. The builders attribute much of their success in this direction to the use of a multiported gridiron valve, which enables them to reduce the valve travel and eliminate a great deal of the wear incidental to this motion and at the same time to realize the benefits of a full steam-chest pressure in the cylinder under all conditions. This latter result is partially due to the type of valve and partially to the double eccentric motion which is used on all sizes and which allows of the widest possible range for adjustment and a cut-off up to three-quarter stroke. Another point in connection with this valve design is that by making the valve seats removable and separate from the cylinders the material for these parts, as well as the valves, can be more carefully selected; and as the design is such as to allow an overtravel, there can be no shoulders formed, and the economic life of the engine is greatly prolonged.



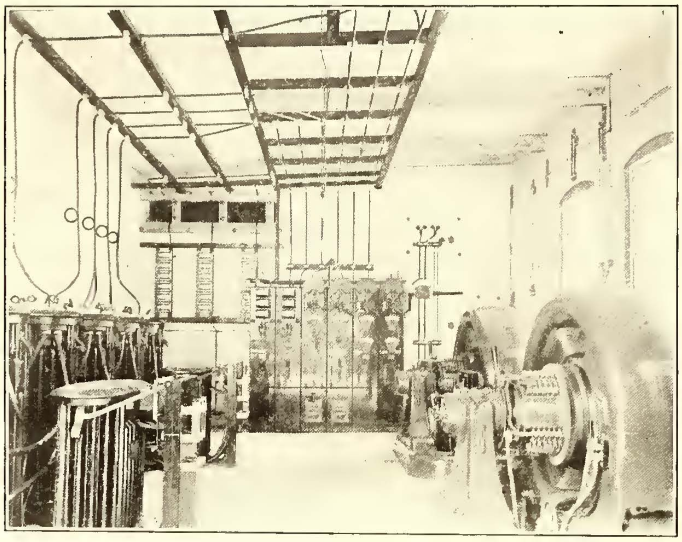
300 KW THREE-PHASE ALTERNATOR

The speed changing, or synchronizing, device, which allows the speed of the engine to be varied some 10 r. p. m. while in operation, is controlled by a small switch placed on the switchboard, the operation of which is as follows: This switch controls a type C A 1-6-hp General Electric motor, mounted on the engine frame underneath the guides, the motor being connected through a sprocket chain to a screw, which is in turn suspended from a trip-shaft directly underneath it, as shown in the cut. The function of this screw is to carry a weight from one side of the governor trip-shaft to the other, so as to increase or diminish the effect of the governor balls. As the governor trip-shaft extends right through to the back cylinder head, so as to control the cut-off on both ends of the cylinder, this arrangement makes a very simple connection. The device is giving the best of satisfaction.

There is in operation in this station quite a novel safety stop, which was used in this plant for the first time; it is very compact and does not detract from the appearance of the engine. This stop operates automatically to disengage the releasing gear in case of accident to the governor or belt, so as to entirely cut off the steam supply in less than one-half of one second. This same result can also be accomplished by pressing one of the several push buttons located at different points about the station. The particular point of advantage in this stop over those of the older type is that it acts on the releasing gear, becoming operative in less than the time necessary for one revolution, instead of closing the throttle, as with the other types.

BOILER ROOM

The alternator has twenty-eight poles, is separately excited by a 17-kw 125-volt generator, motor-driven from the 550-volt railway bus-bars. Its full-load current is 455 amps. per phase, voltage 380 amps., with 8 per cent regulation at 100 per cent power factor and constant speed. The guaranteed efficiencies are 50 per cent load 90 per cent, 75 per cent load 92.5 per cent, 100 per cent load 93.5 per cent. The revolving field weighs 9 tons, the stationary armature 12 tons, foundation plates 4500 lbs. The fly-wheel effect is 18,000 lbs. at 3¼-ft. radius. The alternator feeds the step-up transformers for the transmission line, and also supplies alternating current at 380 volts to a G. E. 250-kw three-phase 4-pole 750-r. p. m. 600-volt 25-cycle rotary converter, the voltage ratio being 1.58. The overload capacity for two hours is 50 per cent. The normal output is 417 amps. on the direct-current side, the no-load voltage being 550 volts. The converter is fitted with a pulley for operating it inverted as a direct-current generator. It is self-excited when driven from the alternating-current side. The field rheostat is designed to secure a range of power factor from 85 per cent to 100 per cent with either lagging or leading currents. The pulley and shaft are sufficiently rigid to permit the rotary to deliver 200 kw working as a motor. A belt-driven exciter, type I. B., 2—1$\frac{3}{4}$—1200, 500 volts, is furnished also. A 37.5-kw oil-cooled reactive coil is supplied for use in compounding. The efficiencies are as follows for 50 per cent, 75 per cent, 100 per cent and 150 per cent



INTERIOR OF BRYANTVILLE SUB-STATION

load: 91 per cent, 93.5 per cent, 94.25 per cent and 94.5 per cent. The total weight of the machine is about 21,000 lbs.

Additional direct current is supplied by a G. E. 300-kw, 8-pole, 550-volt, 545-amp., 105-r. p. m. railway generator, direct-driven by a 450-hp. Green-Wheelock horizontal cross-compound condensing engine, cylinders 16 ins. x 36 ins. x 42 ins., weight 120,000 lbs., equipped with Monarch stop. The high and low pressure clearances are 1.95 per cent and 2.7 per cent, and the inlet ports 18 sq. ins. and 90 sq. ins., the exhaust ports being 20 sq. ins. and 116 sq. ins. respectively. The high and low pressure piston rods are 3$\frac{1}{4}$ ins. and 4 ins. in diameter, the large and small sections of connecting rods being 21.6 sq. ins. and 12.6 sq. ins. The length between rod centers is 105 ins., the cross-head pins 5 ins. in length and diameter and the crank pins 5$\frac{1}{2}$ ins. in each dimension. The shaft is Bethlehem steel 14 ins. in journal diameter, 17 ins. in fly-wheel and 24 ins. in journal length. The fly-wheel weighs 17.5 tons and is 16 ft. in diameter. The intermediate receiver has a capacity of 58,000 cu. ins. and the throttle supply pipe is 6 ins. in diameter. The maximum cut-off is 80 per cent. Magnesia covering is used, and the guaranteed steam economy 13 lbs. at 105 r. p. m., 125 lbs. steam pressure and 26 ins. vacuum and most economical cut-off. The generator weighs 38.5 tons. The third generating unit is composed of a G. E. 200-kw, 550-volt, direct-current railway generator, direct-connected to a 250-hp McIntosh & Seymour engine.

The transformer equipment consists of six 90-kw, 380-13,000 volt oil-cooled G. E. units, guaranteed with overload capacity to supply two 200-kw overloaded rotaries at the end of the line. These are placed in the basement.

The switchboard is located at the west end of the engine room and contains one alternating-current generator panel with wattmeter and field rheostat as special features, one exciter panel with rheostat, one motor panel with automatic release rheostat, one alternating-current rotary panel, one direct-current rotary panel with rheostat, wattmeter and starting switch on sub-base, one transmission line panel containing six 1200-amp. quick-break low-tension transformer switches, two direct-current generator panels and two feeder panels. The usual complement of switches and instruments was furnished. In the high-tension circuit are two sets of 13,000-volt, 100-amp., triple-pole, single-throw oil switches, form K. Panels are of slate. Three sets of 13,000-volt lightning arresters are placed in the outgoing circuit.

The switchboard stands at a distance from the wall sufficiently large to permit easy access to its connections and bus-bars from behind, and all high-voltage wiring is kept as far as possible from attendants. The engine room is well lighted and exceptionally clean in appearance and convenient in arrangement. The power station was built by F. E. Gilbreth, of Boston.

The transmission line between the Plymouth power station and the Mayflower Grove or Bryantville sub-station consists of 13 miles of single three-phase circuit, designed to carry 400 kw at 13,000 volts with 5 per cent loss. Seven-strand No. 2 aluminium wires furnished by the Pittsburgh Reduction Company are used, with a conductivity of 61 per cent, equivalent in resistance to No. 4 copper. The line runs on the highway for 6.5 miles and on its own private right of way the remaining distance. Separate poles are used on the right of way, the regular railway poles being strung with the high-voltage circuit on the highway, the wires being on cross-arms above the direct-current feeders

TRACK OPPOSITE MAYFLOWER GROVE

and telephone wires. The full-load current is 18 amps per phase. The town regulations called for insulation on the high-tension circuit conductors, double-braid waterproof covering being put on. The wire weighs 488 lbs. per mile. Poles in the open are of chestnut, 30 ft. to 55 ft. in length, with 7-in. tops set 5$\frac{1}{2}$ ft. in the ground. The cross-arms carry four locust pins and are of Georgia pine. Washers are used under all lag screws and double cross-arms where the deflection is over $2\frac{1}{2}$ degs. to 3 degs. at highway and railroad crossings. The line is transposed every half mile, one wire dropping to a lower cross-arm for a single pole while passing beneath the others. Locke No. 3 chocolate porcelain insulators are installed, weighing 3 lbs. each and guaranteed to 20,000 volts. Ties are made by two No. 3 insulated aluminium wires 18 ins. long. Head and side guys of No. 4 or seven-strand No. 12 iron wire are used in all cases of unbalanced strain, as on curves and in swamps. Across the salt marshes, which are flooded at high tide, an additional frame support is attached to the pole base to avoid gradual settling. Straight spans are 125 ft. long, curves from 80 ft. to 100 ft., the sharpest curves having a 55-ft. span. Cross-arms are $3\frac{1}{4}$ ins. x $4\frac{1}{4}$ ins. x 7 ft. Ninety per cent of the poles are 30 ft. long. Special construction was employed in passing the works of the Plymouth Cordage Company. A box 4 ft. square and 6 ft. deep, inside measure, was sunk to its top in earth. The pole to be set was placed in this box and the latter filled with concrete, which was allowed to set thoroughly before any strain was applied to the poles. Each pole was double-side guyed at right angles to the line and fastened to two 2-ton anchor stones by $\frac{5}{8}$-in. eye-bolts, which show 18 ins. clear above the ground surface. Double-head guys are on all poles set in water, with anchor stones set at least 6 ft. in the ground. The line crosses the automatic coal conveyor of the Cordage Company by special construction, the high-tension wires passing through bushed porcelain insulators hung by iron wire fastened to insulators set on a cross-arm attached to a channel iron, the latter being clamped to 2-in. iron pipes 11 ft. high, these pipes being secured to the platform of the coal railway.

STANDARD OPEN AND CLOSED CARS

The Mayflower Grove sub-station is a one-story brick building with a tar and gravel roof, the exterior dimensions being 26 ft. x 36 ft. It is designed for two three-phase, 25-cycle, 200-kw G. E. rotary converters, with six step-down transformers, each rated at 90 kw, with a voltage on the primary of 13,000, secondary 380. The rotaries are capable of operating two hours at 300-kw, with a temperature rise not exceeding 55 degs. C., with the surrounding air at 25 degs. C. The temperature rise at continuous full load is 35 degs. C. The rotaries are similar in regulation and reversibility to those in the power station. Each rotary occupies a floor space of 50 sq. ft., or .25 sq. ft. per kw. The sub-station is amply lighted by five windows, as the clearness of the cut shows. The full-load rotary voltage is 600, and the no-load 550. Two 30-kw reactive coils are installed for compounding the rotaries. The efficiencies are, at 50 per cent, 75 per cent and 100 per cent load, 89 per cent, 92 per cent and 93.5 per cent. The total weight of each machine is 23,500 lbs.

The general course of the sub-station wiring is as follows: The high-tension wires enter the sub-station at the rear end under a shelter, passing through a slate slab drilled to receive porcelain tube insulators 7 ins. long, $4\frac{3}{8}$ ins. in diameter under head and $3\frac{3}{8}$ ins. under shank. They then are carried inward and downward on line insulators to the lightning arresters, which are mounted on wall immediately below the 6-in. x 8-in. beam shown in the photograph. They then pass to the oil switches, going thence to the transformers. The transformer secondaries run to the reactive coils and switches, then through tile ducts under the floor to the rotary converters, alternating-current side, lead-covered. The direct-current cables pass down into the trench beneath the converters and are carried on insulators mounted on the 4-in. x 6-in. supports to the direct-current rotary panels of the switchboard. The direct-current feeders run out of the wall at the right of the switchboard, facing it. Three No. 4 lead-covered wires are run from the transformers to the lightning arresters.

The switchboard is composed of six panels and is located in the center of the sub-station near the wall opposite the door. Two are for direct-current feeders, two for alternating-current rotaries and two for direct-current rotary service. No unusual features are encountered in the switchboard. Soapstone barriers are used in oil switches. A large park is operated by the company at Mayflower Grove. Little Sandy Bottom Pond has an area of about 66 acres, and the park is equipped with a theater, carousel, launch, canoes, boats, refreshment booths, facilities for checking bicycles and horses, etc. A rest room for women is provided in the keeper's house, containing rockers, cribs and an emergency medicine chest for physicians' use. The park patronage is rapidly growing. On the heaviest Sunday in June, 1901, the road carried 13,226 passengers, and about 3000 people visited the grove.

The rolling stock consists of twenty-seven cars, classified as six vestibuled 8-wheelers, four short box cars, eight 12-bench, three 15-bench, four 10-bench and two 8-bench open cars. There is also one tower, one work car and one flat car in service, two Taunton nose snowplows and one Peckham rotary plow, equipped with two Westinghouse 38-B motors for running the fan and two G. E.-57s for propulsion. The closed cars were built by the Laconia Car Company and are 39 ft. 8 ins. over bumpers, 38 ft. 8⅝ ins. over vestibules, seat forty passengers and have a 29-ft. 4⅝-in. body each. From center to center of seats is 32⅝ ins.; the seats over all are each 32 ins. and aisles 20 ins. wide. The width of body outside over posts is 7 ft. 11 ins., and the height from bottom of bolster to top of trolley plank 9 ft. 2¼ ins., from floor to top of window sill being 27 ins. On each side are ten windows, with two at each end. Double swinging doors are on the vestibules, sills and cross-timbers being hard pine or oak. The flooring is of ⅞-in. hard pine and in aisles is corrugated to a thickness of 1⅛ ins. Trusses are of ⅞-in. round iron. Two trap doors are built over each driving axle and are corrugated ⅞ in. thick. Treads are 1 in. thick, body framing posts ash, the upper deck has 7-in. overhang and the brake-staff is 1½ ins. in diameter below the ratchet. There are two sand boxes on each car. Card racks hold 11-in. cards. There are twenty No. 42 Wheeler reversible seats, four being corner seats, the remainder transverse. The corner seats are stationary and 36 ins. long. Outside each window are four iron window guards. Burrowes curtains are used, mounted on Hartshorn rollers. Each car has two signal balls and two steel foot alarm gongs 10 ins. in diameter. There are eight incandescent lamps inside each car, one in each vestibule; also two headlights in two circuits with a three-way switch at each end. Each car is equipped with four G. E.-52 motors, with K-12 controllers rated at 27 hp on the hour basis of 75 degs. C. temperature rise. The weight of the car body is about 13,000 lbs.

The trucks are of the double-motor swing bolster "8-B" type of the Laconia Company. The length over frame is 10 ft. 2½ ins.; length of wheel base, 4 ft. 4 ins.; axle length over all, 6 ft. 2⅝ ins. Axle diameter is 4 ins. Journals are of steam car type, 3⅛ ins. x 5⅛ ins. The truck width over frame is 6 ft. 2½ ins., the width over journal boxes being 6 ft. 8½ ins. From center to center of side bearings the distance is 4 ft. 2½ ins.; the wheel gage is standard, with 2½-in. tread, the wheel diameter being 33 ins. and the weight 390 lbs., "Rochester" type. The height from rail to top of center-plate is 32 ins. The frame is of wrought iron, the journal springs 1 in. x 5½ ins. x 4¾ ins. and the bearing springs 10-plate, elliptical, 42 ins. long, made up of 3-in. x ⅜-in. steel strips. The Christensen air brakes are inside-hung, and the motor gear ratio is 4.78. The brake-shoe beams are hung with link hangers in rubber cushions. The pilot board is suspended from iron hangers bolted to the frame and is 4 ins. from the rail on one side of the truck. Bolsters are composed of two pieces of 6-in. channel iron riveted to the side-bearing castings, suspended in a transom made of two bars of 1-in. x 4-in. iron. These are riveted to the transom guide castings and act as seats for the elliptic springs. The spring bolster is prevented from violent side thrust by a spiral spring located on each end. Yoke suspension of motors is used.

There are three car houses, as shown on the map. The Plymouth house has four tracks, is 50 ft. and 23 ft. x 111 ft. x 210 ft.; the Pembroke house is 24 ft. x 100 ft., with two tracks, and the Kingston house is 25 ft. x 60 ft., with two tracks. The operating offices are in Plymouth.

In 1901 the road carried 1,833,000 passengers. The transfer traffic was only 2 per cent of the regular paying traffic. In August, the heaviest month, the revenue passengers per car mile were 5.46; in December, 3.21. The winter headway on the Plymouth Division is one-half hour, and one hour on the Whitman Division. The average schedule speed of the cars in August, 1901, was 9.96 miles per hour; in December, 9.72. The 1901 car mileage was 436,300 and the mileage per car operated 65,500. Twenty-four regular conductors and motormen and sixteen other employees were on the pay rolls in December. The average coal consumption per kilowatt-hour of the Plymouth power station in 1901 was less than 3¾ lbs. In round numbers, about 400,000 lbs. of coal are burned per month. The Mayflower Grove sub-station operated 535 hours in December, 1901, its average load being 56 kw, with a maximum of 308 kw. The kilowatt-hours per car mile average less than 2¾ in the last ten months of 1901. Nine regular cars were operated in August and six in the spring and late fall.

The road is operated on the telephone despatching system. At each turnout along the line is a cut-out box where a portable instrument may be plugged in by the conductor, who carries a telephone on the car. All questions as to procedure at turnouts are referred thus to the despatcher in Plymouth, who adjusts the meeting relations of all cars which are behind or ahead of time. The road is operated from about 6 a. m. to 12 midnight. The telephone system was installed by Wentworth & Blake, of Boston. The officers of the company are: President, J. D. Thurber; vice-president, C. I. Litchfield; treasurer, E. J. B. Huntoon; manager, Gardner F. Wells. Stone & Webster, 93 Federal Street, Boston, are the general managers of the railway.

Wheel Wear on the North Jersey Street Railway

Some particulars were published in a recent issue of the wear of wheels during 1900 on the North Jersey Street Railway. The figures for 1901 are just available and show some interesting facts. The company discarded during 1901 1764 chilled iron wheels, of which it had complete records. These wheels made a total mileage of 63,982,731, or an average mileage of 36,271.

The records of the four wheels which made the highest mileages are interesting. The one with the longest life made a mileage of 92,346 miles. It first ran under a 25-ft. box car for five months and seven days, when it was skid flat and was reground. It was then put under another 25-ft box car, where it ran twenty-six months and nineteen days, when it developed soft spots. The circumference of the wheel when new was 8 ft. 8 ins., and when worn out 8 ft. 4¼ ins. The second wheel made a mileage of 91,669 miles, also under 25-ft. box cars, and was in service thirty-three months and three days. Its circumference when new was 8 ft. 8¼ ins., and when worn out was 8 ft. 3½ ins. Wheel No. 3 made a mileage of 91,688 miles. It was under a 25-ft. box car for eighteen months and twenty-five days and under an 18-ft. box car eight months and ten days. It was finally rejected on account of a cracked hub. The circumferences new and worn were, respectively, 8 ft. 8⅛ ins. and 8 ft. 4¼ ins. The fourth wheel ran for 90,143 miles and twenty-eight months and fourteen days. During this time it outlived three mates, two of which skid-flat and one wore out. It finally developed a double flange. Its circumference when new was 8 ft. 8⅛ ins. and when worn out 8 ft. 3 11-16 ins. These were the four highest mileages, but there were a number of wheels discarded during 1901 that had made over 80,000 miles.

The Elmwood Car House of the Rhode Island Suburban Railway Company

The new car house herewith illustrated has just been completed by the Rhode Island Suburban Railway Company and is located in the Elmwood district of the city of Providence. It is on the block bounded by Elmwood Avenue, Russell, Melrose and Thackeray Streets, a block about 830 ft. x 200 ft.

The building already constructed, which is the first portion of the structure which it is proposed to eventually erect on this block, is 360 ft. long by 200 ft. wide, and its front is set back about 100 ft. from Elmwood Avenue. The building is of brick with steel roof trusses and beams, covered with 3-in. splined plank. The roof, excepting the saw-tooth monitors, is nearly flat, and the flat portion is covered with tar and gravel. The monitors are covered with cop-

GENERAL VIEW OF ONE SECTION OF INTERIOR

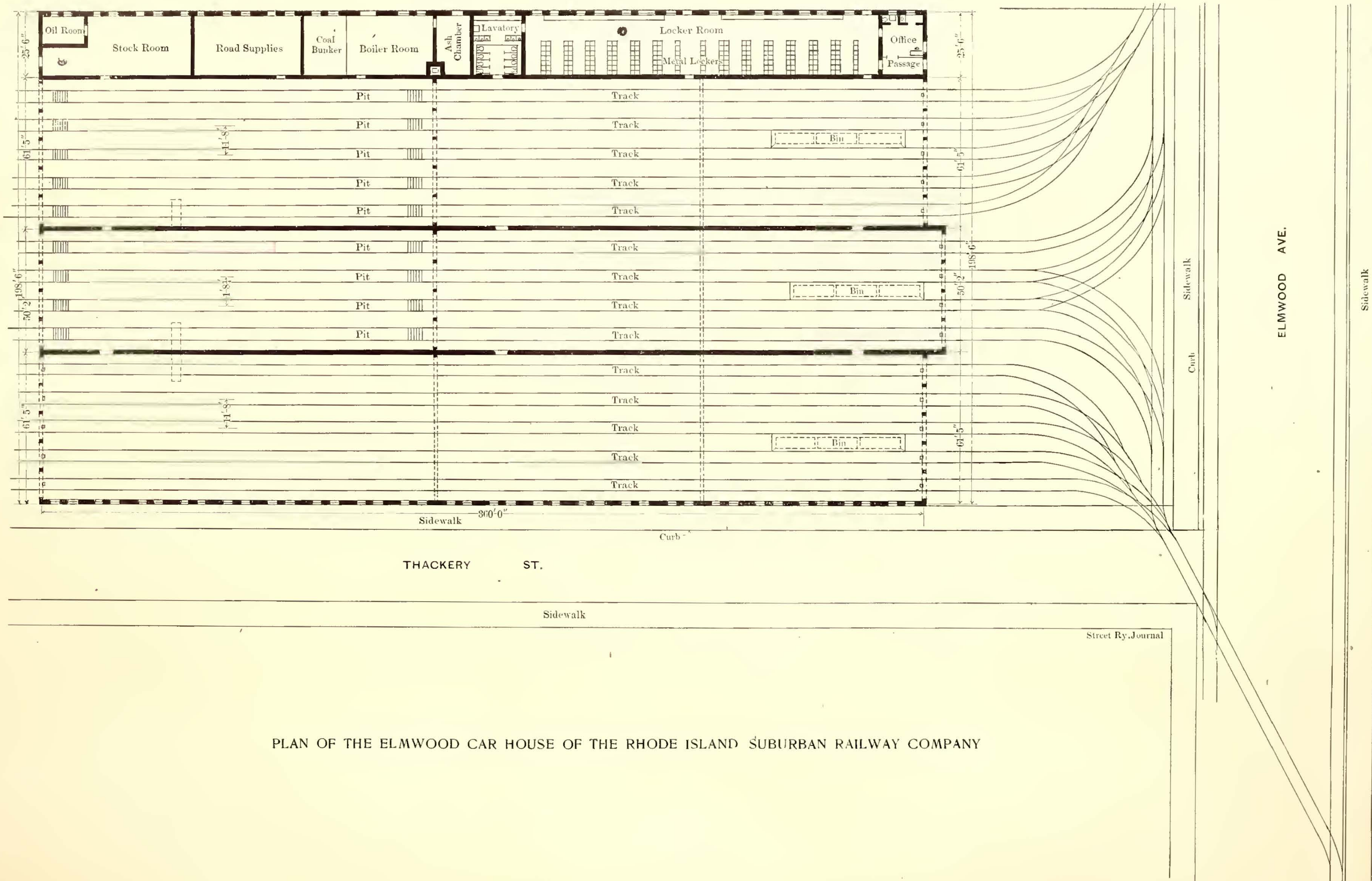
EXTERIOR OF CAR HOUSE

VIEW OF PITS

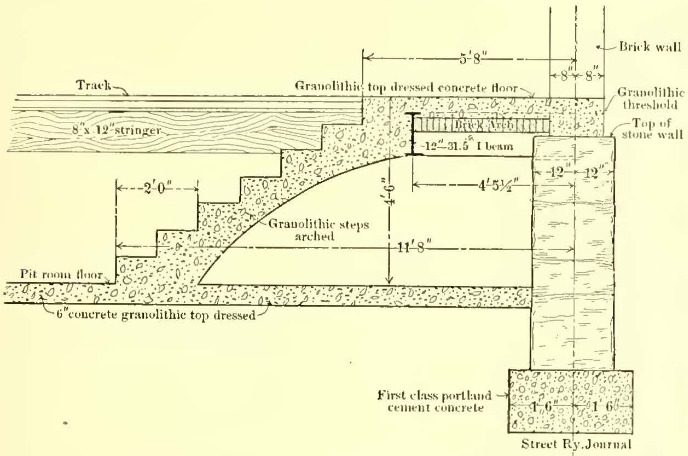
per. The portion of the structure used for the storage of cars is divided into three longitudinal sections by brick fire walls, which extend the whole length of the building and pass up through the roof to a height of about 5 ft. above the flat roof. The rain water from the middle bay of the roof passes to the sides of the building through scuppers left in the fire walls. A fourth bay of less height than the main portion is devoted to office, locker room, toilets, heating plant, storage rooms, stock rooms and oil rooms.

There are two pit rooms situated at one end of two of the track bays. The floors in the bottom of the pits, as well as the main floor, are granolithic dressed. The pit construction is shown on the drawings. The timber upon which the rail is laid can be removed and replaced, if desired, without disturbing the granolithic floor. The tracks have a pitch of 2 in. in each 100 ft. lengthwise of the house, and each track is 2 in. lower than the next adjacent parallel track crossways of the house. These inclined planes are hardly perceptible in a view of the premises, but materially helped in fitting the floor of the building to the grades of the surrounding streets. The rail used throughout the construction is 60-lb. T, A. S. C. E. section.

The pit rooms and all of the other service rooms are heated by steam. The entire building is equipped with automatic sprinklers, arranged for the dry-pipe system. The under side of the pit room floors is also equipped in this manner. The adoption of the saw tooth skylights was



PLAN OF THE ELMWOOD CAR HOUSE OF THE RHODE ISLAND SUBURBAN RAILWAY COMPANY due to the recommendation of the fire underwriters, it being held by them to be a better form of skylight, or monitor, as regards fire risk, than those with vertical sides. It is a much more expensive way to secure the light than the ordinary type, and whether it adds greatly to the safety of the building is a matter of opinion. It is intended soon to concured on car-wheel cost from different street railway com-



CONSTRUCTION OF STEPS TO PITS, ETC.

the building, to prevent the possible short-circuiting of the current by a trolley pole which left the wire.

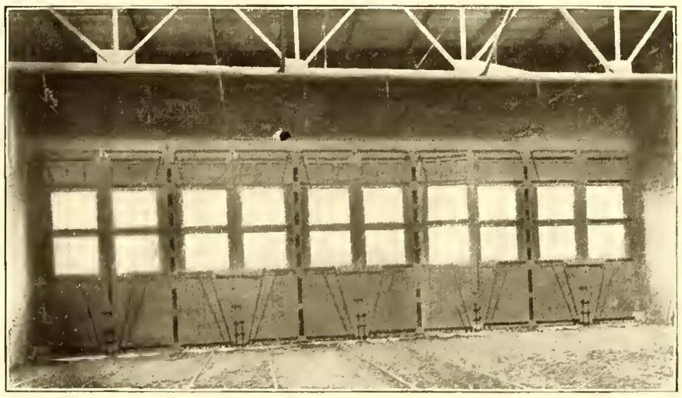
All of the interior door openings are provided with automatic fire doors of wood covered with sheet iron, the longitudinal fire walls having double fire doors at each opening. Exterior hydrants and hose are also provided. The locker room is provided with metallic lockers made up partly of sheet metal and partly of expanded metal. The exterior doors are of wood and are trussed by diagonal rods, as shown in the cut. The interior doors to the pit room are covered with tin and are similarly hung. This type of door is very strong and durable and cannot "settle."

The total cost of the building, equipped with heat, light and sprinklers, including heavy foundations, was 7 4-10 cents per cubic foot. It was designed in the office of Chief Engineer George B. Francis, of the company, and under his direction, by J. H. O'Brien, assistant engineer in charge of the building work. The contractors were F. E. Shaw, Providence, R. I., for foundations; Horton & Hemenway, Providence, R. I., for superstructure; General Fire Extinguishing Company, Providence, R. I., for heating and sprinkler system, and William Wharton, Jr., & Company, of Philadelphia, for special track work.

In a recent suit for damages against the Union Traction Company, of Philadelphia, counsel for the contestants became involved in a controversy as to whether the car from which the plaintiff alleged he was thrown some five years ago had a center aisle. This question as to the construction of the car was raised so often that the representatives of the company decided to introduce the car as evidence. From where it was unearthed does not appear, but at the noon-day session the jurymen were requested to step to the south side of the City Hall, where the car was standing, surrounded by a curious crowd engaged in speculating as to its purpose.

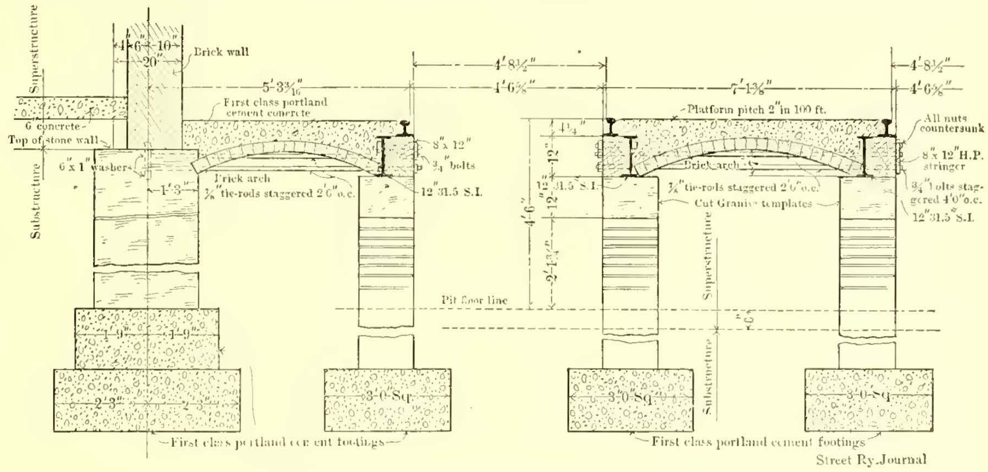
The Cost of Car Wheels

The recent communications published in this paper on the subject of the cost of car wheels suggested the importance of fixing upon some basis of comparison of cost of car wheels and the reference to this standard of statistics secured on this particular from different street railway com-



CAR HOUSE DOORS

panies. With this in view the editors have secured, through the courtesy of a number of different companies, the actual cost and car miles run on a large number of different lines, most of them operating between 500,000 and 1,500,000 car miles per year. The total cost of wheels per year, divided by the wheel miles, of course gives the cost per million miles. Seemingly this should tell the whole story. The figures, however, show that it does not. Other conditions



SECTION SHOWING PIT CONSTRUCTION

influence the cost. Some of these are shown by a consideration of the conditions of operation; others will be spoken of later.

A Western road reports the total cost of wheels for a year $479.72. There is no grinding nor replacing in this. The total car mileage is 1,284,606 miles. Supposing the cars to be all mounted on single trucks, this makes 5,138,424 wheel miles and the cost per million miles $93.33. The wheels weigh 400 lbs. and are 33 ins. in diameter. A Southern road reports that its wheels average 35,000 miles, and as they cost $7.50 pressed on the axle we may figure in round numbers that the figure per million miles is $214. A 30-in. 300-lb. wheel is used. A wheel-grinding machine has added materially to the life of wheels. They are ground without removal from the axle.

A road in the Middle States contributes some interesting figures. The cost of wheels only for the year is $1,099.42. The miles run are 1,773,170; the average life of a pair of wheels is 17,215 miles. The wheel miles may be 7,092,680 if the cars were on single trucks, or 14,185,360 miles if mounted on double trucks. In one case the cost would be $155.10 per million miles and in the other $77.55. The latter figure would be low in spite of the fact that there is no charge for changing wheels nor for grinding.

D. L. Huntington, superintendent of the Spokane Street Railway system, contributes some figures of unusual interest. The wheels used are 30-in. 300-lb. and 22-in. weighing 175 lbs. The car mileage is 1,129,337; the wheel mileage 9,034,696; the cost of wheels for the year $1,087; the labor in handling $358, making total cost of wheels $1,445. This gives a cost per million miles of $161. This is a remarkably low figure when the extreme cost of wheels is considered. Mr. Huntington says: "A wheel that costs us 1.65 cents per lb. at St. Louis costs us when delivered here 2.80, the freight being 1.15 cents per pound. This makes it difficult to compare our cost with that of an Eastern road." Without taking the freight into account, the figures are very good. Making fair reduction for freight charges, the cost per million miles will be about $111.

Another very interesting set of figures comes to us from the Pacific Coast, from H. C. Campbell, of the City & Suburban Railway Company, of Portland, Ore. The wheels used are 320-lb. 30-in. and 190-lb. 22-in. The mileage of the 30-in. wheels was 7,985,000, while that of the small wheels was 5,962,056, a total of 13,947,056 miles. The cost of the 30-in. wheels was $1,260.95 and of the 22-in. $349.40, making a total of $1,610.35 for the year, or $115.50 per million miles. Considering the greater mileage, nearly 50 per cent more, these figures compare well with those from Mr. Huntington.

A road not far from Chicago using four-wheel cars sends the following figures: Wheels 33-in., weighing 416 lbs.; cost of replacing wheels, including new wheels, $1,834.63; wheel mileage, 6,023,096. This gives the cost per million miles $304.50. This larger figure may be due to the fact that all costs were included.

Mr. Evans, manager of the Quebec Railway, Light & Power Company, has these figures: Standard wheel 33-in., weight 425 lbs. The wheel mileage for the year was 4,357,800. Four-wheel cars are used, and the total cost of wheels on the line $1,324.80. The cost per million miles comes out $304.

The Tri-City Railway Company, of Davenport, Iowa, uses 33-in. wheels which weigh 400 lbs. The general manager, James F. Lardner, reports the total wheel mileage at 9,177,392 miles. Total cost of wheels for the year 1901 is $1,948.10, or, say $212.20 per million miles.

From a railway company near Philadelphia we get the following figures: Car mileage, 2,288,386 miles, but the wheel mileage for the year is put at 2,892,059 miles. Evidently there is some mistake in the figures, for with four-wheel cars the wheel mileage would be 9,153,544, and with eight-wheel cars it would be twice that, or 18,307,088 miles. The costs per million miles, figured on these different bases, with a total cost for grinding and replacing of $1,512.37, is $523 for the first figures. On the supposition that the cars are on single trucks, the cost would be $165.23 per million miles, while the last estimate of car mileage gives $82.61. The more probable figure seems $165.

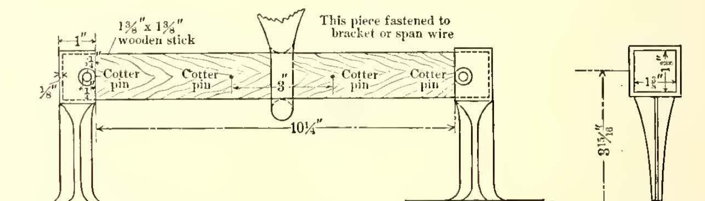
A road in the extreme East sends us some figures which make the last-named figure appear probable. This road uses 30-in. 300-lb. wheels, with cars on single trucks. During the year the company put fifty new wheels in service. The total car mileage was 579,485. The manager reports that the wheel mileage was not accurately kept, but it may be properly assumed at 2,317,941 miles. The cost of replacing, including grinding, was $365, or $157.31 per million wheel miles. The wheel used had a ¾-in. flange with a 2¼-in. tread.

Allowing for differences in the methods of keeping accounts and for the varying costs of performing similar operations on different roads, we still have wide variations in figures, i. e., from more than $1,200 to less than $100. It is evident from the smaller differences that location has much to do with the cost of wheels. A level road has an advantage over one with long grades, where the brakes have to be applied continuously while the car is in motion. It also appears that roads having a large number of short riders will wear out wheels faster, by reason of frequent stops, than one having through traffic and getting a large proportion of its loads at its termini. The roads carrying the greatest number of passengers should show the highest cost for wheels per million wheel miles. It may be found that the roads making the greatest daily car mileage will wear out their wheels most rapidly. Sharp grades, though not long, have a great influence on the wear of wheels.

It is not at present possible to compare the cost of wheels per million miles run with the number of passengers carried in the same length of time. In a mild climate, where the streets are kept clean and the superintendent can keep a careful watch upon his men and bring them up to a high standard, wheels will have a longer life than is possible under other conditions. Costs will be correspondingly reduced.

Trolley Wire Hangers Used at Minneapolis

A peculiar form of trolley wire hangers has been used by the Twin City Rapid Transit Company, of St. Paul and Minneapolis, for a number of years, a sketch of which is shown herewith. This hanger was designed in the first place to avoid the excessive breakage common with the old-fashioned rigid hangers used on bracket construction. The hammering of a trolley wheel against a trolley wire insulator rigidly fastened to the bracket of the center pole caused much trouble from breakages in the earlier days on this road as it has on all others. As seen from the sketch, the present hanger consists of two clips mounted on the ends of a wooden stick 1⅜ ins. square. The stick serves as the



FLEXIBLE TROLLEY WIRE HANGER

insulator. The clip castings are driven on to the ends of this stick and a split pin put through to keep the casting from slipping off. The stick is suspended from the bracket or span wire, as the case may be, by a square link which fits so loosely over the stick that it can move back and forth through the link. This movement, however, is limited to 3 ins. by split pins located as shown. This movement allows the strain on the trolley wire to equalize itself, which is a very valuable feature in preventing the breaking and tipping of insulators. As the blow of the trolley wire comes on the end of the insulated stick, which is 5 ins. from the actual point of suspension at the bracket, there is not as rigid a blow as with the old-fashioned hanger, because one end of the hanger can tip up slightly to cushion the blow. The wood is also likely to be less brittle than the insulating compound used in the ordinary hanger. This hanger gave such good satisfaction on bracket center-pole construction, of which there is a great deal, that it is now used on both span and bracket work.

Block Signals on Heavy Electric Railroads

The prospective equipment of steam roads for electric suburban service and the high-speed electric suburban and interurban lines which are now being projected and built for frequent train service make the subject of automatic block signal systems suitable to duty on such heavy electric roads of timely interest. There is in general much misconception as to the applicability of the block signal systems commonly used on steam roads to electrically operated roads. Automatic block signaling on steam roads has reached a high state of reliability, and it is the result of years of study and evolution. Electric roads will do well if they secure equally efficient systems, as the problem is a less simple one for electric than for steam railways. Steam roads in this country almost universally make use of the track for signaling purposes, insulating one block from the next by insulating rail joints and depending upon the small potential difference maintained between the two rails of a track by two gravity cells in parallel to operate the relay instruments which govern the signals. When the track is used for a return circuit, as in electric railroading, the use of any kind of a track circuit for signaling purposes is out of the question on most surface roads, though a notable application of track circuit signaling is seen on the Boston Elevated, described later. Being shut out from the use of the usual track circuit for block signaling, he who designs a block signal system for electrically operated roads which shall be as simple in its elements, substantial and reliable as present steam road track circuit systems, has a difficult task.

It may therefore be of value to review some of the principal work that has been done up to the present time on the electric elevated and subway roads of the country with a view to the possible application of such systems with proper modifications to lines operating on their own rights of way on the surface and in tunnels.

In the Street Railway Journal for September, 1901, was an article by Howard S. Knowlton on "Train Movement Signaling on the Boston Elevated Railway." This gave a good general idea of the system of signals there employed, but some of the technical details of the signal apparatus, which were not included in that article, will no doubt be of interest to those who wish to look into the matter more closely. The system employed on the Boston Elevated is an interesting modification of the electro-pneumatic system, which has been installed extensively on steam roads by the Union Switch & Signal Company, of Swissvale, Pa. This is the only electric road which has ever been equipped with a block signal system using a track circuit for the operation of signals.

Fig. 1 is a diagram of the signal circuits used at Boston, showing the apparatus by conventional drawings. From this it will be seen that one of the track rails is continuous and is used for the railway return currents in the ordinary manner, being bonded to the structure at frequent intervals. The other track rail is divided into sections or blocks for signaling purposes, with insulated joints between

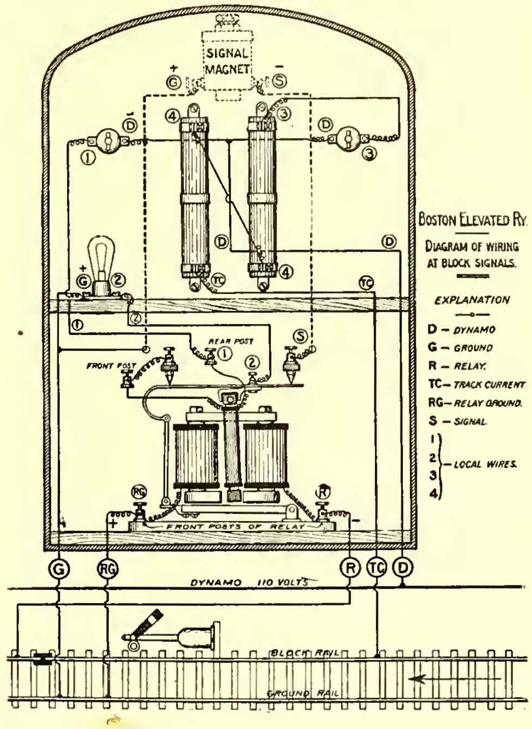


FIG. 2.—DIAGRAM SHOWING CIRCUITS OF RELAY

blocks. This block rail is, of course, kept insulated from the opposite return rail of the track by wooden ties, and care is taken to allow no electrical connection between the block and return rail. The train, upon entering a block, makes a short circuit through its wheels between the block rail and return rail. This short circuiting causes the electro-pneumatic semaphore behind the train at the block entrance to go to danger. The current for the track circuits, as well as for the operation of the signal air valves of this block signal system, is supplied by a motor generator giving 100 volts run from the railway circuit. At each signal the 100 volt main from this dynamo supplying the signals is connected to the block rail through two 100-ohm resistance coils, as seen in Fig. 2, which gives in detail the wiring at each signal. In this diagram, and also in Fig. 1, it is seen that a relay is connected permanently across between the track and block rail of the section or block, which the signal in Fig. 2 guards. Consequently when there is no train on that section to short circuit the relay a current will

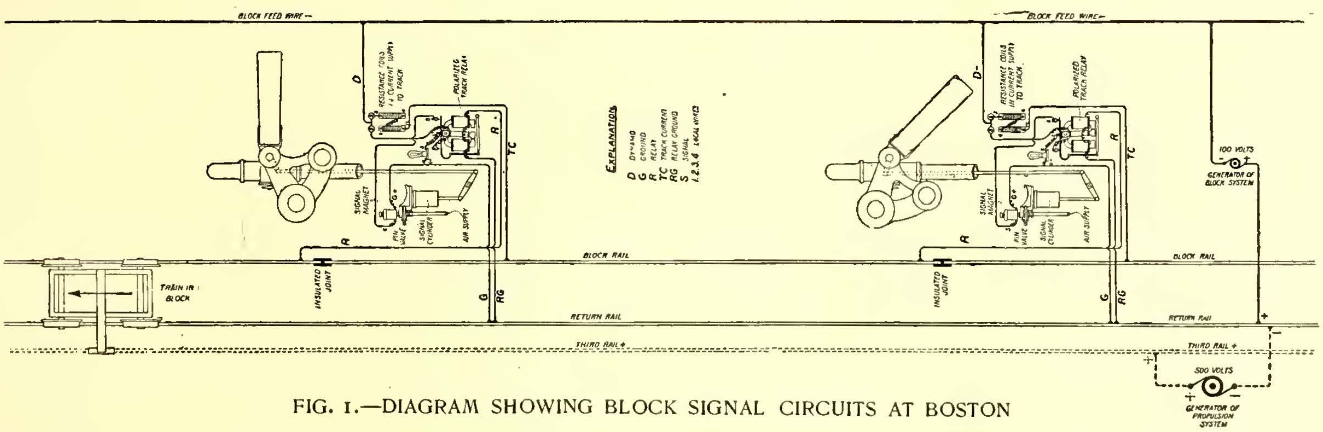


FIG. 1.—DIAGRAM SHOWING BLOCK SIGNAL CIRCUITS AT BOSTON

flow from the return rail, through the relay, to the block rail and to the negative side of the 100-volt signal circuit, through the 200-ohms resistance in the box of the signal next ahead of the one shown in Fig. 2. With a train on the section the current still flows through the resistance, but the relay is short circuited. When the relay is short circuited the signal under which it is placed is at danger, as the relay contacts are open and the circuit which closes the electro-pneumatic air valve of the semaphore is consequently open. When there is no train on the block and the relay connected to it is energized a circuit is established in Fig. 2 as follows: From the 110-volt dynamo signal circuit D D and 11 to the rear post of the polarized relay, through the swinging magnets of the relay and out to S through the two relay contacts, and thence through the signal magnet to ground. This signal magnet when energized opens a valve which admits compressed air to the piston of the semaphore and pushes it to "safety" or "clear." When no current flows through the signal magnet the valve opens itself and lets the air out to allow the signal to fall to "danger." In shunt with the signal magnet is an incandescent lamp. The relay is made polarized to provide against the possibility that the signal might be cleared by currents from the 500-volt circuit actuating the relay.

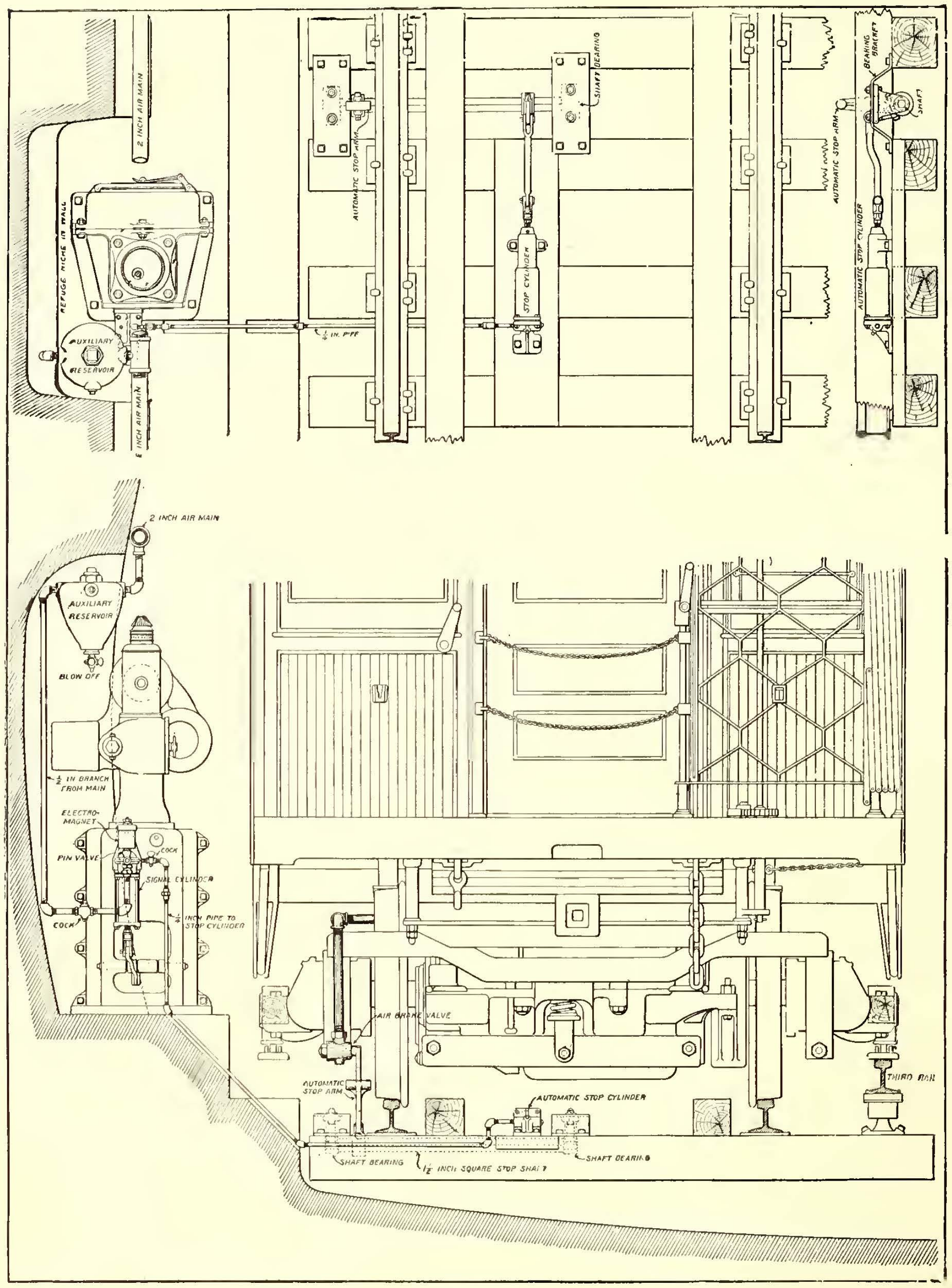


FIG. 5.—AUTOMATIC ELECTRO-PNEUMATIC BLOCK SIGNAL, WITH AUTOMATIC TRAIN STOP ATTACHMENT, AS APPLIED IN THE SUBWAY OF THE BOSTON ELEVATED RAILWAY COMPANY

Referring to Figs. 2 and 3 for illustration of the construction of this relay it is seen that it consists of two ordinary coils and a swinging coil between them. Under normal conditions the attraction of the armature under the main magnets makes both the contacts as indicated in Fig. 2. If the polarity of the main magnets is reversed by current from the 500-volt circuit (as it might be by the train running onto sand or ice with the current on) the swinging magnet has its lower pole attracted to the opposite pole of the relay from that shown in Fig. 2, and this has the effect of springing the contact plate so that the contact at S is broken and the signal cannot clear. These relay contacts are made through carbon blocks.

As usual in elevated railway practice the third rail of the road is made positive and the structure and return rail negative. The positive poles of the generators supplying the signal circuits are grounded and the negative poles are connected to the block rails through resistances as explained. This arrangement of polarity was made to secure the benefits of the polarized relay. By this arrangement should sand or ice on the rail cause imperfect wheel contact with the ground or return rail the 500-volt current would flow through the relay in a direction the reverse of normal, and it would simply open the contact S and keep the signal at danger behind the train. With a plain non-polarized relay such a condition would close the relay contacts and clear the signal behind the train, which would be a very dangerous condition.

The electro-pneumatic semaphore signals used are modifications of the pneumatic semaphores made by this company for steam railroads. They are held to "clear" by the pressure of air behind a piston, and fall to a "danger" position when the pressure is removed. The cylinder diameter is 3 ins. and the piston stroke 4 ins. The air is supplied from a compressed air main running the length of the structure. At each terminal are two Ingersoll-Sergeant compressors supplying air at 60 to 80 lbs. pressure and geared to 40-hp Westinghouse motors. Any one of these is sufficient to supply the whole road with compressed air for signal operation. The arrangement of relay and resistance coils in the base of a signal post is shown in Fig. 4 and the signal complete in one of the subways in Fig. 5. Fig. 7 is a drawing of a signal on the structure.

In connection with these semaphore signals, Figs. 5 and 6 show the automatic train stop attachment that trips a valve which applies the air brakes should the motorman disregard the signal and run past it. A truck equipped with the automatic train stop valve is shown in Fig. 6.

This is the first block signal installation to depend on the current derived directly from a continuously running generator for operation of signal magnets and track circuits. Since the motive power of these motor generators is in this case identical with the motive power of the road the signals are sure to be supplied with current as long as there is current to operate the cars.

The electrical energy required to work the electro-pneumatic valves of a signal is .025 ampere at 10 volts. The power required to supply electric current and compressed air to the 175 signals, sixty-one switches and fifty indicators of various kinds is about 40 hp for air compressors and 12 hp for motor generators.

For many locations where tracks are on the surface the use of a track circuit of this kind would be probably impracticable (aside from the undesirability of giving up the value of one rail as a return conductor) because of the leak-

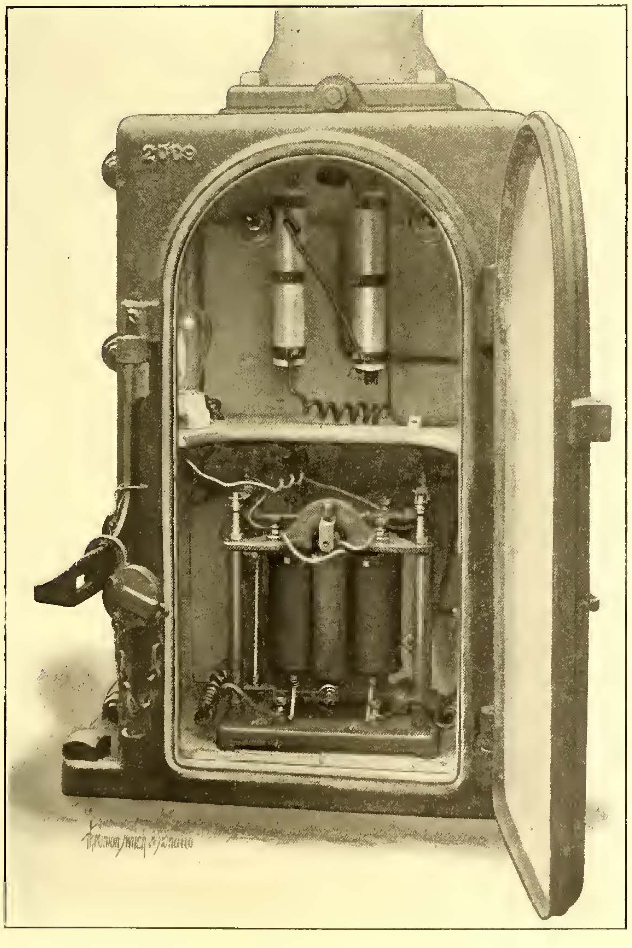


FIG. 4.—SIGNAL PEDESTAL CONTAINING POLARIZED RELAY, RESISTANCE COILS, ETC.

age from rail to rail, which would be so large with the high voltage used as to give false indications by opening the track relays. On the other hand, if the track voltage be made low, as in steam road practice, the interference of the 500-volt current would be prohibitive. On an elevated and underground road of this kind, however, where track leakage can be kept down there is nothing against its use save the loss of conductivity in the return circuit due to giving up one rail to block signaling purposes.

There are two automatic block signal systems in use on the elevated railroads of Chicago, both installed by the Rowell-Potter Safety Stop Company of that city. That on the South Side Elevated Railroad is a purely mechanical

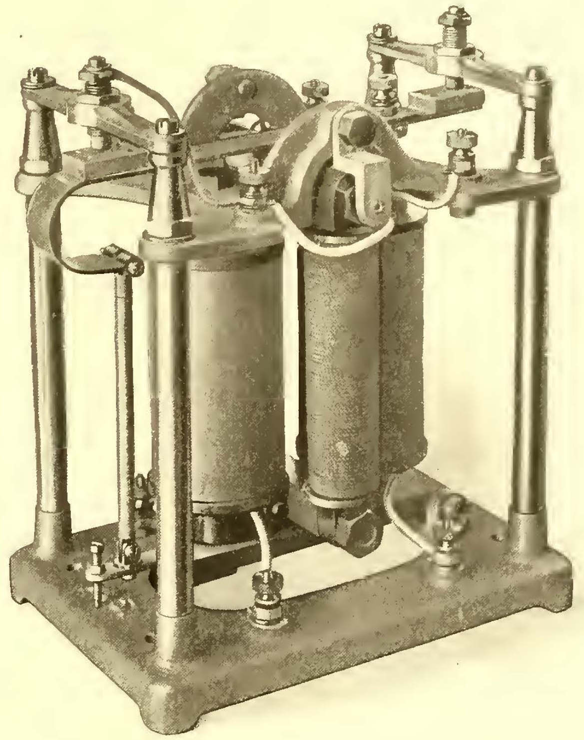


FIG. 3.—POLARIZED RELAY

system for the protection of trains when standing at stations only. This was put on the road in 1893. The system put on the Metropolitan West Side Elevated Railway in 1895 is a combination electrical and mechanical system.

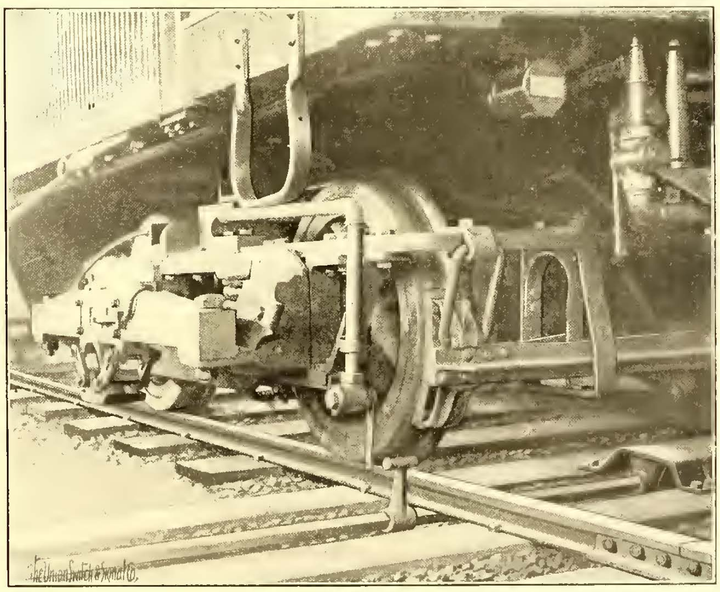


FIG. 6.—AUTOMATIC TRAIN STOP VALVE APPLIED TO TRUCK OF ELEVATED CAR IN POSITION FOR OPERATION BY TRIP ATTACHED TO SIGNAL

These signals on the Metropolitan have made a remarkable record for reliability, and only sixty failures to clear when they should are reported per 1,000,000 of signal operations. Some of these reported "failures" are probably due to false reports made by motormen to get out of a charge of running past a danger signal. No failure to show danger and stop a train with a train in the block ahead is reported. Although rear-end collisions have occurred in a fog on the Metropolitan road, none have occurred on that portion of the line equipped with the block signals. Only the crooked parts of the road have signals, the straight track is without.

On the South Side Elevated Railroad the mechanical system for the protection of the train at stations works as follows:

A distance of 300 ft. back from each station is a small semaphore signal. At this signal is a tread bar, which is in a position to be depressed by the wheel treads of the train. When the signal is at "clear" the tread bar is up so that the wheels can strike it. The tread bar is mechanically connected to the semaphore signal, and when the train goes by with the signal at clear its wheels strike the tread bar and throw the signal to "danger." About 300 ft. beyond each station, or 900 ft. from the danger signal, is another tread bar connected mechanically by a pipe line on rollers to the signal. When a train has left a station 300 ft. it operates this tread bar, which throws the semaphore to clear position. In connection with this system the Rowell-Potter safety stop was employed on the steam locomotives, which applied the brakes whenever an engineer disregarded and attempted to run by a danger signal. At the trial when these signals were accepted the engineer of the trial train was given orders to run into the train ahead at a station, if possible at every station, but the train was stopped every time automatically. When the road was electrically equipped, however, the cars were not supplied with the safety stop valve, so that as at present operated the visual danger signals only are used without the automatic safety stop.

The system used for protecting dangerous portions of the Metropolitan Elevated is a comprehensive automatic block system, comparable in completeness and efficiency to those used on steam railroads. It can be used on blocks of any length, as it is not dependent on the distance to which power can be transmitted by direct mechanical connection from a train to a signal in the rear. The signals on the Metropolitan are operated to danger mechanically by the wheels of passing trains depressing a tread bar, but are released to go to clear by electricity. Since the installation of the Metropolitan block system numerous improvements have been made in the system offered by the Rowell-Potter Safety Stop Company for this class of work. These improvements have been in the nature of a simplification and standardization of apparatus, and it will be more in order to describe the system and apparatus as it is offered to-day, as adapted for both elevated and surface electric roads operating on a private right of way than to describe exactly the older apparatus used on the system of the Metropolitan, because the latter, while very satisfactory and reliable, is not the latest development of this system of block signaling. The general principle of the system used on the Metropolitan is the same as in the latest development of the system which is about to be described.

The signals used are either standard or dwarf semaphores. Unlike other block signal systems the Rowell-Potter makes use of power derived from the passing trains for the operation of its semaphore signals. This power is stored in what is called a power storing machine, the standard form of which is shown in Fig. 8. The power is stored by a set of springs in the casing C, which are wound through a pawl and ratchet by the up-and-down motion of

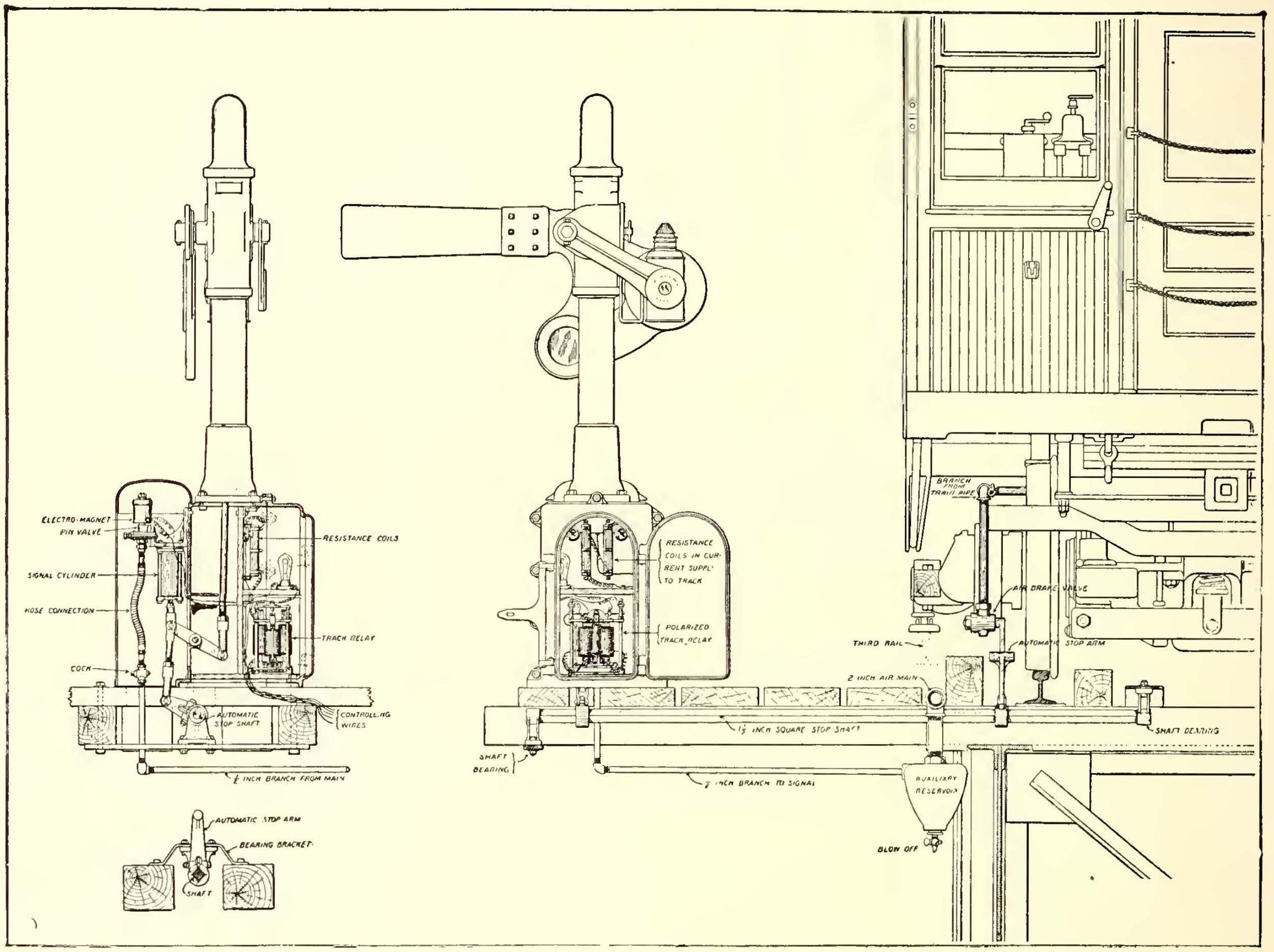


FIG. 7.—AUTOMATIC ELECTRO-PNEUMATIC SECTIONS OF BLOCK SIGNAL AS APPLIED TO BOSTON ELEVATED ROAD

a tread bar, which is deflected by the passage of a car wheel. This tread bar is shown in Fig. 9. Each passing wheel causes a movement which winds up the spring, and when the machine is fully wound the tread bar remains level with the top of the rail, so that no further movement takes place until the springs will bear winding again. The mechanism is released to throw the semaphore to clear or to danger by a catch controlled by two electromagnets mounted side by side, the top pair of which is seen in Fig. 8. If the signal is at clear, current sent through one of the magnets will release the power-storing mechanism to put the signal to danger, at the completion of which operation another catch holds the machine from further revolution until the other pair of magnets is energized, which allows the machine to revolve another half turn to safety. The amount of power stored up is much more than would be necessary to operate the signal. The power-storing machine is, of course, placed with reference to convenient mechanical connection to the signal. At each signal is placed a safety stop track instrument, Fig. 10, which is raised to an operative position when the signal goes to danger by direct mechanical connection with the signal. This safety stop track instrument takes the form of an inclined plane raised by a crank with spring-mounted shaft, and when raised presents to the valve-tripping mechanism on the car an inclined plane with a 5 per cent grade, having its highest point 4 ins. above the top of the rail. This inclined plane when raised will engage of the rod on the car truck equipment, Fig. 11, and throw a valve to apply the brakes, either straight air or automatic, as the case may be. If a motorman fails to regard a danger signal, and runs past it, the brakes will be applied so that he will be obliged to stop. Suppose, however, that the motorman finds the signal at clear and goes ahead. As soon as he reaches the signal the wheels strike a tread bar, closing a track push-button, which has the effect by means of relays and other devices described later of throwing current through the proper coils on the power-storage machine to send the semaphore to danger. The train is then protected by that signal and its safety stop while it proceeds through the block. Suppose, however, that by some defect in the apparatus the signal did not go to danger when the train passed, and consequently stood clear with a train in the block. To provide against this dangerous condition existing a second safety stop track instrument is put something more than a train length beyond the signal. This instrument is also directly connected to and operated by the signal. Unlike the first safety stop instrument, however, when the signal is at danger the stop is down and will not apply the brakes. When the signal is at clear the stop is up and will apply the brakes and stop the train. A train cannot therefore proceed into a block on the assumption it is being protected unless the signal has actually gone to danger behind it. In this respect this system of block signaling is radically different from all others, and necessarily so because in other systems any derangement or failure of apparatus acts to put a signal to danger, and a signal will fall by gravity to danger of itself unless constantly held clear by a combination of conditions. In the Rowell-Potter system the signals are put at danger only by the positive application of artificial force, the source of which may fail for many reasons by the breaking or sticking of parts. With-

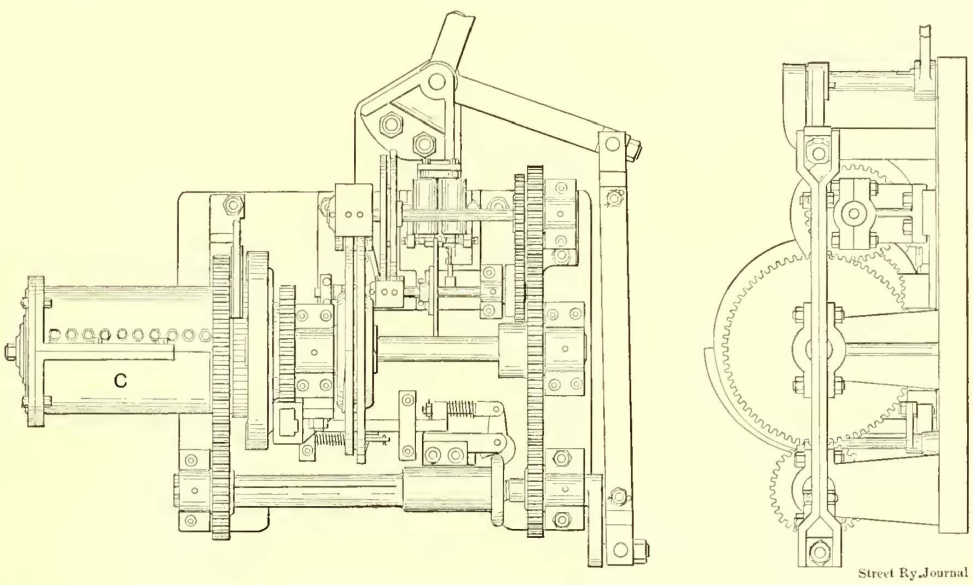


FIG. 8.—POWER STORING MACHINE

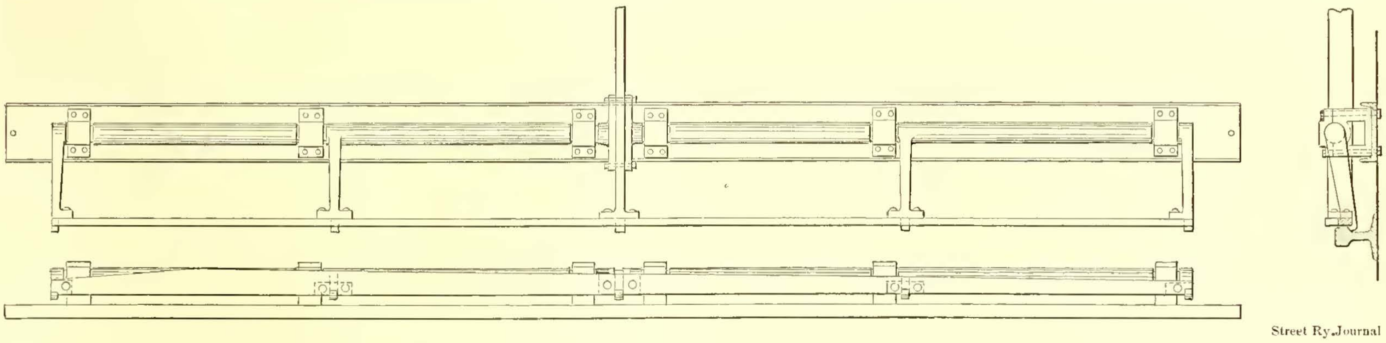


FIG. 9.—TREAD BAR FOR OPERATING POWER STORER AND CONTACT APPARATUS

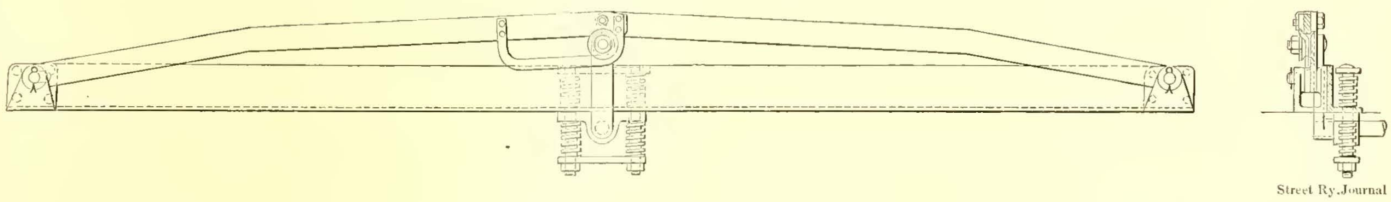


FIG 10.—FLEXIBLE SAFETY STOP

out the provision of the second safety stop, which will allow no train to proceed unless there is a danger signal behind it, it would be quite possible for a signal to fail to act and show clear with a train in a block. While the system at first glance would appear to have glaring defects because of the fact that positive force must be applied artificially to move a signal to danger, it will be seen upon a study of the question that the presence of the second safety stop insures safety in spite of this.

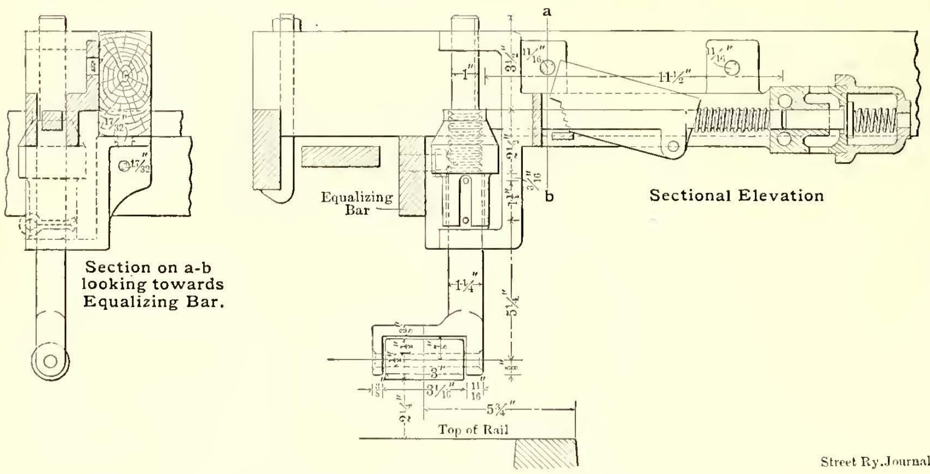


FIG. 11.—OPERATING ROD ON CAR

A train having passed through a block and into the following block a sufficient distance, so that the signal of the following block would protect it against a rear-end collision should it come to a standstill (a distance of 300 to 500 ft. on the Metropolitan Elevated), the signal at the entrance to the block just passed is cleared by the train depressing another tread-bar, closing a track push-button, making an electrical contact, with the effect of establishing a circuit through the clearing magnet on the power-storing machine. The signal is then thrown to clear. A simple device called a train counter is introduced into the circuits, which moves one notch away from safety position for every train entering a block and one notch toward safety for every train leaving a block. By means of this counter any number of trains up to sixteen might pass into a block, but the signal would not clear at the entrance to the block until the last train had passed out. Of course with the safety stop in action not more than one train could pass into the block at once without being stopped. However, it is a supposable case that a train might overrun a danger signal and be stopped by the safety stop instrument, and that the motorman would then possibly proceed on into the block when the signal had been cleared by the passage out of the block of the preceding car or train. Having done this, if there were no train counter in the signal circuit the second train in the block would be without signal protection because the second train would have passed the electric contact track instrument at the entrance to the block which puts the signal to danger before the passage out of the block of the preceding train had cleared the signal. The train counter is a very simple electromagnetic device, Fig. 12, which revolves the contact wheel N one notch in one direction for every train that enters a block, and one notch in the other direction for every train leaving the block. The signal clearing circuit is open and the danger circuit closed except when the notched wheel N is at zero, which position it assumes only when as many trains have passed out of a block as have passed into it.

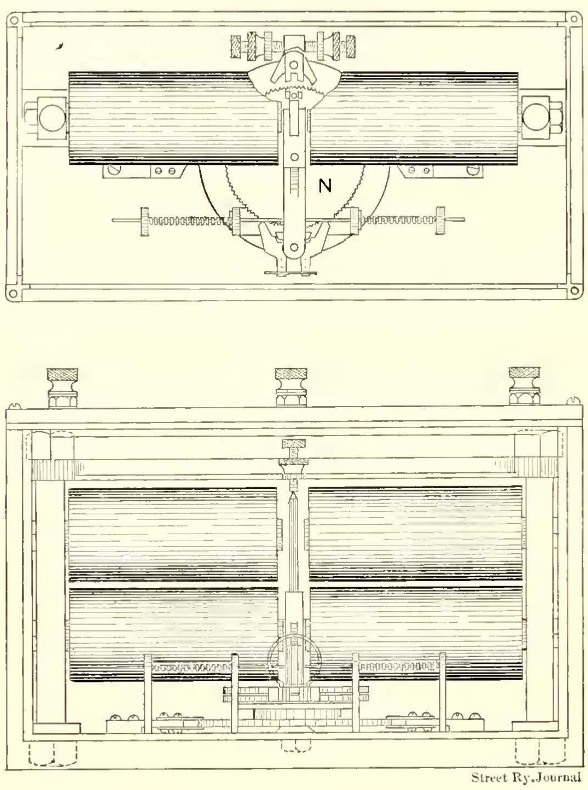


FIG. 12.—TRAIN COUNTER

This train counter does away with most of the serious objections that have always existed against block signal systems depending on the operation of track instruments rather than on track circuits. To be sure, the track instrument system will not show the presence of a broken rail in the block or a car broken away from the train, but in electric railway work these features are not as important as in steam railroad work. To completely protect a road equipped with track instruments of this kind all switches onto the main line must have signals and safety stops operated in connection with the main line signals so that no train can enter the main line without a clear signal, and when it so enters will block all trains attempting to enter that section.

There yet remains to be mentioned the unsetting relay which is put in each track push-button circuit to prevent every pair of wheels of a train being counted as an entire train by the head counter. The unsetting relay allows only the first wheel of a train which strikes a track instrument to operate the counter. This unsetting relay is shown in Fig. 13. When current is sent through coil R by the closing of the track push-button, armature 1 is attracted to make a relay contact at C, and armature 2 falls by gravity and locks armature 1 so that armature 1 cannot again operate until current is sent through the coil marked "Set" and armature 2 is attracted so as to

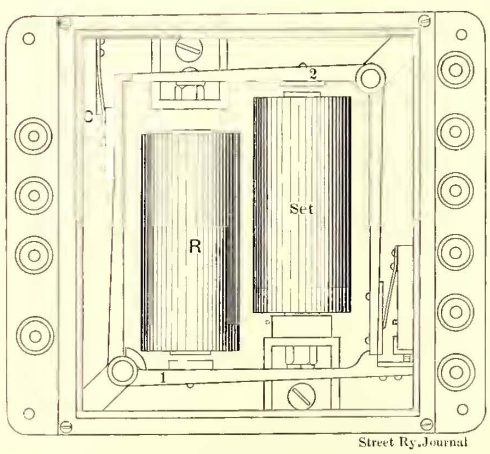


FIG. 13.—UNSETTING RELAY

unlock 1 and break contact at C. The batteries may be either primary or storage. On the Metropolitan Elevated American storage cells are used, and are charged from the 500-volt circuit at certain hours of the day. At some points, however, the batteries are connected permanently in the 500-volt circuit with lamp resistance, and charge and discharge as the signals require current, being thus at all times charged.

The track instrument by which a passing train makes electrical contact to operate the signals is simply a knife switch form of push-button, operated by one of the standard form of tread bars. The tread bar for operating the switch is of course lighter and smaller than that used to wind the power-storing machine.

In Fig. 14 are given all the electrical circuits employed in the scheme of double-track blocking just described. In Figs. 15, 16 and 17 the complete diagram shown in Fig. 14 is divided up to enable a better understanding of the circuits. Like letters refer to like parts and wires. The magnet S of the train counter is the one which is energized when a safety circuit is completed by a train passing out of a block and the magnet D being the one operated by the circuit completed as a train passes into a block. On each side of the train counter are unsetting relays. Current Current sent through the coil R by a train entering a block establishes a circuit through the relay contacts, which is only broken by the energizing of the "set" magnet of the unsetting relay, which is done when the train passes the overlap push-button instrument. The D and S magnets, which are next to the signals, are the danger and safety magnets on the power-storing machine, which allow the signal to go to danger and safety.

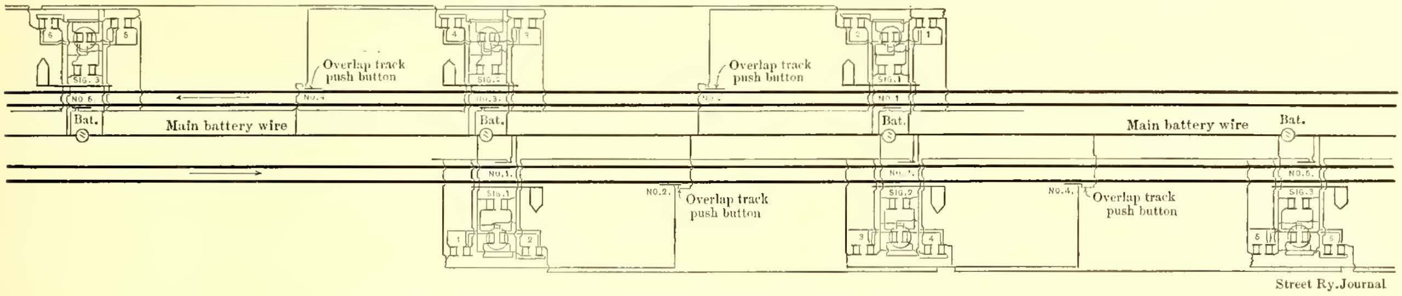


FIG. 14.—DIAGRAM OF CIRCUITS IN DOUBLE TRACK BLOCKING

Fig. 15 gives the danger and safety circuits of Fig. 14 separated from the tangle of circuits on the complete diagram. A circuit is established through the S or safety coil of the signal only when the contact disk of the train counter stands at safety. Current then flows through A A, and the contacts in front of coil S of the train counter. At all other times the contact wheel of the train counter closes the circuit B B, and the danger or D coil of the signal and power-storing machine is energized.

In Fig. 16 is the circuit of the unsetting relay and push-button which puts a signal to danger, and in Fig. 17 the unsetting relay which clears a signal. The circuit established by the electric track instrument or track push-button in either case momentarily energizes coil R of the unsetting relay, which relay closes the circuit to one or the other of the train counter coils, as the case may be, and locks the circuit closed to prevent the counter being operated repeatedly by every wheel in the train. The "set" coil of the relay unlocks and opens this circuit so following trains can register on the train counter when the first train passes the overlap.

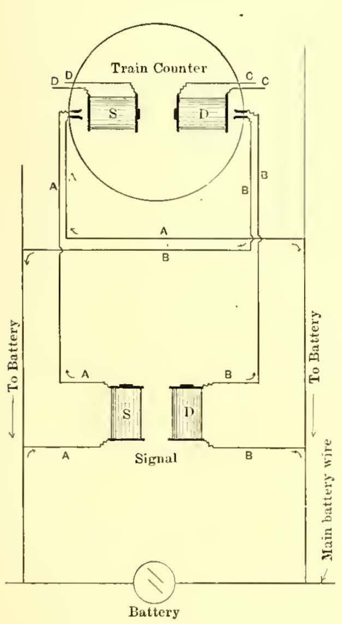


FIG 15.—DANGER AND SAFETY CIRCUITS OF SIGNALS

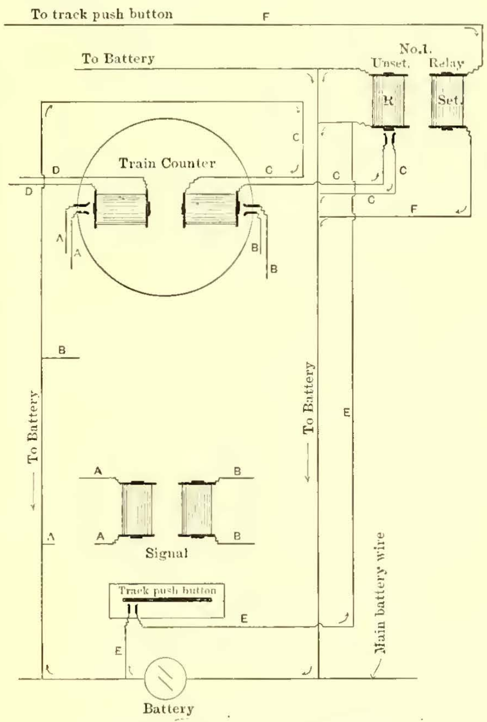


FIG. 16.—CIRCUITS OF TRAIN COUNTER AND UNSETTING RELAY NO. 1

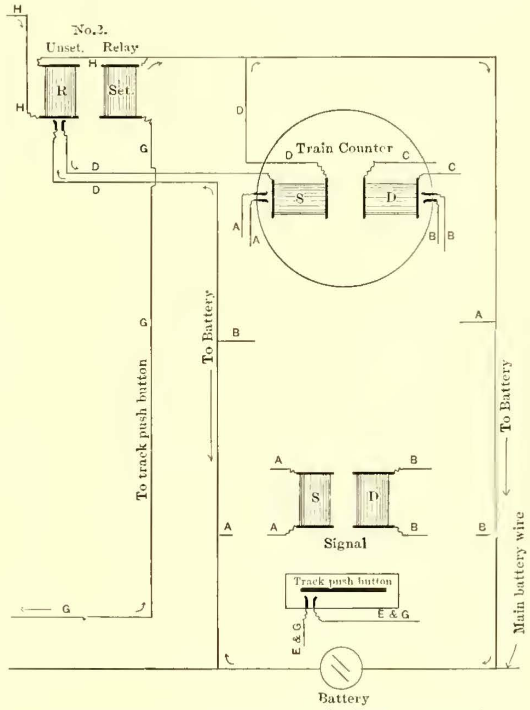


FIG. 17.—CIRCUITS OF TRAIN COUNTER AND UNSETTING RELAY NO. 2

A clear comprehension of circuits used in block signaling requires close, hard study by those not accustomed to deal daily with such circuits. While further explanation of the circuit diagrams of block signal systems in this article might be made, even to the taking up of an entire issue of this paper, it is probable that a close, careful study of the diagrams presented will serve the reader who wishes to thoroughly understand the circuits as well as further explanations, for it is only by such study that they can be got clearly in mind.

The first requirement of any system of automatic block signaling is that it shall never give a false safety indication —that is, shall never show clear with a train in the block. It may be permitted to fail occasionally and stop a train for a short time by displaying a false danger signal with no train in a block, but show safety when there is danger, never. Both the systems described in this article it will be seen answer these requirements probably as closely as it is possible for commercial apparatus to come up to them. In the consideration of any new or untried system the impossibility of false safety indications should be the first point looked into.

Municipal Tramways in Great Britain

BY A CITY AUDITOR

The annual return of the street and road tramways of the United Kingdom for the year to June 30, 1901, has just been issued by the Board of Trade. This return, although issued very late, contains much useful information both in regard to company and municipal tramway undertakings. As the figures given are still compiled on the lines adopted on the introduction of tramways into England, thirty years ago, the information is not given in such a way as best to serve the purpose in view. I understand that representations have repeatedly been made to the officials of the Board of Trade to amend the form of the return so as to meet the altered circumstances, but, of course, these officials cannot see any reason why any change should be made. It is very likely that one of the tramway associations will require to tackle the publication of the correct figures, so that all the necessary figures may be placed in the hands of those interested in tramways.

From the return we gather that the total expenditure on capital account as at June 30 last was nearly £27,000,000, and that out of 213 tramway undertakings 99 were owned by local authorities, over 30 of the 99 being operated by the owning corporations. I have closely examined the figures which have been given to the Board of Trade by the various corporations in order to ascertain, if possible, the exact financial position of the various municipal tramway undertakings. Since 1894, when Leeds and Glasgow led the way, nearly all the principal cities and towns of Great Britain have municipalized their tramway systems. Various reasons were adduced by those corporations for taking the working of the tramways into their own hands, but the chief reason was that the local authorities would have in the tramway undertaking a veritable gold mine, out of which they would be able annually to relieve the rates. I do not know that any corporation in Scotland has yet devoted any part of the tramway profits for the relief of rates, but many corporations in England have already done so, and I have been anxious to find whether, in every case, these sums have really been earned, or whether sums have been paid over in relief of rates that should have formed a charge against the tramway revenue and should have been carried forward to meet depreciation.

HUDDERSFIELD

I think the Corporation of Huddersfield was the first municipality in the United Kingdom to operate its own tramways, and from the returns which have been from time to time published it would seem that the corporation has found the working of the tramways no easy task. I find that the net receipts, after deducting working expenses for the year to June 30 last, amounted to £4,493. This sum does not agree with the balance brought out in the last-published report of the corporation, and it would appear as if a rough-and-ready balance had been prepared for the Board of Trade instead of giving them, as is usual, the figures appearing in the published accounts. The balance of net revenue in the accounts of the corporation for the year to March 31, 1901, was £5,161, but when we find that from this sum has to be paid interest and sinking fund amounting to £15,000, and that at least £5,000 must be provided for depreciation, it looks very much as if a tramway rate would very soon require to be again levied on the ratepayers of Huddersfield. This belief is strengthened by a report which has recently been issued by the corporation for the nine months' working to Dec. 31 last. From this statement it appears that, although the steam cars are earning 13¾d. per car mile, the result of the working of this department is a heavy loss; and, strange to say, that although the electric system is earning over 11d. per car mile, there is a heavy loss here also. Surely any electric system which cannot pay handsomely at 11d. per car mile must be tremendously overcapitalized or very badly managed.

LEEDS

The city of Leeds was the next to take over the working of its tramway system. The corporation commenced operations in February, 1894, and since that date the working of the tramways by the city has been very successful. The figures given in the Board of Trade return agree with the published accounts for the year to March 25, 1901. The gross balance for that year, after deducting working expenses and certain sums for depreciation, amounts to £61,797. From this balance have been deducted interest and sinking fund charges amounting to £31,058. This sum is further reduced by £1,000 for income tax, £9,000 for renewal of electric plant, leaving £21,058 which has been carried to the relief of rates. I would point out that the only sum spent on the track during the year amounted to £2,564, and no provision has been made for the renewal of the 33 miles of line. If the corporation of Leeds had made such provision I do not think there would have been anything left for the rates.

GLASGOW

The Glasgow Corporation took over the working of the tramway system during the summer of 1894—a few months after the Leeds Corporation had commenced to work its tramways. The tramway system at Glasgow is the largest in the Kingdom, except that of the North Metropolitan Tramway Company, in London. The financial results are given to May 31, 1901, and show net receipts, after deducting working expenses, amounting to £117,388. On a perusal of the published accounts we find that the working expenses include a full allowance for the renewal of permanent way. The following is a copy of the net revenue accounts:

	£ s. d.	£ s. d.
Balance of net revenue		117,388 10 6
which was applied as follows:		
Rent of Govan & Ibrox lines	5,057 14 7	
Interest on capital	38,979 0 0	
Sinking fund	19,470 13 4	
Depreciation	29,758 16 7	
Payment to common good	12,500 0 0	105,766 4 6
Balance carried to reserve fund		11,626 6 0

This seems a very small balance on such a large turnover, but it is explained in the report that for nearly a whole year the bulk of the system was operated with horses, and that the interest and sinking fund charges on the cost of the new electrical equipment is charged against the year's revenue. The corporation has acted wisely in accumulating all its reserves, which at May 31, 1901, amounted to £183,428, and this sum is to be applied in wiping off the old horse car system, so that the capital account will, in future, only contain the net cost of the electric system.

HALIFAX

The Corporation of Halifax commenced to operate its tramways in June, 1898, so that by the end of March, 1901, they had completed nearly three full years' working. The net receipts for the year amounted to £9,110, but after meeting interest and sinking fund charges only £14,059 remained, which sum was carried to the borough fund. It is not stated whether the corporation actually applied this sum in relief of rates, and it is hoped that it did not, for during the year no provision was made for the renewal of the permanent way or for depreciation of plant. It looks very like as if in a few years a tramway rate will require to be levied to assist the corporation in meeting the interest and sinking fund charges. In looking back over the past three years' working I find that for the first nine months the net revenue was stated at 3.21d, per car mile; for the next year it was stated at 1.36d., and for the last complete year it only amounted to .48d. per car mile, and this unsatisfactory result was achieved on a tramway system with a traffic revenue of nearly 13d. per car mile. We cannot understand how any system earning such a handsome revenue cannot make a good profit.

LIVERPOOL

One of the largest municipal tramway systems in the United Kingdom is that of Liverpool. The corporation acquired the undertaking in 1897, and began to operate the system in September of that year. The corporation year ends on Dec. 31, and the figures in the Board of Trade return are those for the year to Dec. 31, 1900. More recent figures are, however, available, as the accounts of the corporation for the year to Dec. 31, 1901, have just been published. The balance carried to net revenue account for last year amounted to £148,621. The interest and sinking fund charges amounted to £95,799, leaving a balance of £52,822. This sum is little enough on such a large system, including as it does the old horse car system purchased from the Liverpool Tramway Company to meet depreciation of permanent way, cars, etc., but the corporation propose to take out of this balance the sum of £17,-607 for the relief of rates.

LONDON

The London County Council commenced to operate the tramways, which were purchased from the London Tramway Company, on Jan. 1, 1898, and the figures for the year to March 31, 1901, are given in the Board of Trade return. The total revenue for the year amounted to £462,-896, and the working expenses, including £7,000 carried to the renewal fund, amounted to £400,186, leaving £62,-710 to meet interest and sinking fund. After meeting these charges, the sum of £14,325 was carried to appropriation account. It is presumed to be applied in relieving rates. It is a little difficult to understand why the London County Council should pay over this small balance in the relief of rates, as the sum standing in the renewal fund amounts only to £14,308, and very shortly the Council will be commencing operations for the conversion of the present system for electric traction. The present debt on the South London system is about £850,000, which represents the cost of the horse car system purchased three years ago. When the cost of the conversion to electric traction is added to this large sum it is to be feared that, instead of having a small balance of £14,308 to hand over in relief of rates, a tramway rate will require to be levièd to meet a deficiency.

DOVER

The total length of the Dover tramways only measures 4½ miles. The corporation obtained powers in 1896 and laid the first tramway lines through the town. From the first the undertaking has been very successful, and the corporation has handed over the credit balance year by year in relief of rates. The city appears to have overlooked the fact, however, that it is necessary to make provision for the renewal of the track and the replacement of the cars. The credit balance is year by year decreasing, and the ratepayers of Dover need not look for much more relief from the tramways, as it will be absolutely necessary to retain the whole balance for renewals.

HULL

The Hull authorities obtained their powers to work the tramways in 1896, and on March 31, 1901, they had about 9½ miles of route opened for electric traction. After meeting all working expenses and fixed charges there remained a balance of the last year's working of £37,061. Of this sum, £14,061 was carried to a reserve fund and the balance of £23,000 handed over in relief of rates. The Corporation of Hull has acted wisely in retaining this sum of £14,061 in its own hands, as no provision whatever has been made in the accounts for depreciation. They call this sum a reserve. It is surely not really a reserve, as it will undoubtedly be required for the renewal of the permanent way and plant.

BLACKPOOL

For the year under review the Blackpool Corporation had a credit balance, after paying working expenses, of £13,479. This balance was appropriated as under:

Interest and sinking fund	£4,642
Instalment of cost of doubling line	1,403
In relief of rates	7,434
	£13,479

The corporation has a small reserve fund of £2,678, but as no provision is being made for the renewal of the track and plant, it seems strange that the corporation should pay over the whole balance to relieve rates.

SHEFFIELD.

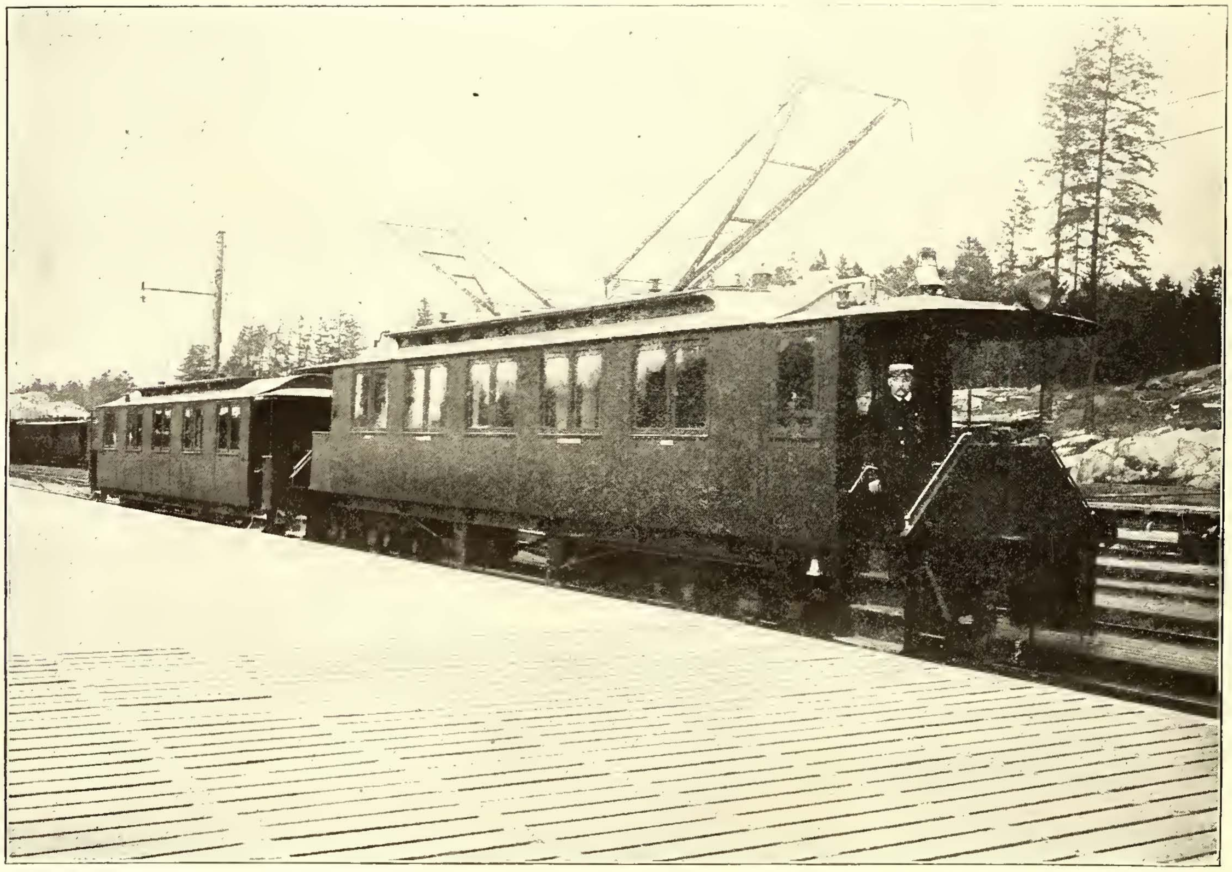
Sheffield Corporation took the working of the tramways into its own hands in 1896, and on March 31, 1901, had 22 miles of route in operation. The corporation is equipping the whole system for electric traction. The average revenue per car mile is very high, but the expenditure is corresponding high, especially for a new undertaking. The working expenses for the electric system are given at 7.725d. per car mile. I do not think there is any electric tramway in the Kingdom working at such a high figure as this. The gross profit both for the horse and electric lines for the year to March 25, 1901, amounted to £48,657. After deducting interest and sinking fund from this figure there remained a balance of £21,817, of which £15,000 was placed to renewal fund. The balance was carried to the relief of rates.

The corporations of Bolton and Bradford in England and Aberdeen in Scotland seem to be doing very well. On the other hand, I understand that there is a considerable loss at Blackburn, Plymouth and Portsmouth, so that in the case of these corporations there is no question about paying away funds in relief of rates that should be applied in maintaining the tramway plant and equipment.

I trust that an examination of the returns of the Board of Trade, so far as they relate to municipal tramway undertakings, may cause corporations in England to be more careful in their financing. They ought certainly to be quite sure of their ground before giving away tramway revenue, which is not real profit.

The Electric Railway between Stockholm and Djursholm Sweden

This railway, which is owned by the Stockholm-Rimbo Järnvägsaktiebolag, has a total length of 13 km, of which 1 km is inside the city limits, and is single track, with turnouts. The gage is .891 m. The maximum grade inside the city limits is 4.8 per cent, while outside the city limits the maximum grade is 2.5 per cent. The rails weigh 27 kg per meter and are thoroughly bonded with protected bonds at each joint and cross-bonded every 100 m.



ELECTRIC TRAIN ON STOCKHOLM-DJURSHOLM RAILWAY, SWEDEN

The power plant is situated about midway between the two terminals of the line. Two cylindrical, single-flue, horizontal boilers furnish the steam. The combined heating surface of these two boilers is 125 sq. m. The boilers furnish steam for three compound engines which make 220 r. p. m. Each of these engines is of 130 effective horse-power and drives with belting a two-pole dynamo of the Mather-Platt make, which is rated at 150 amps. for 550 volts pressure. At 5 km from the power station at the Stockholm-Ostra station is an accumulator battery which contains 264 cells, and which, during three hours, gives a current of 184 amps.

Five bare feed wires extend from the power plant. The current is carried to Stockholm by two of these wires, each having a cross-sectional area of 100 sq. mm, and to Djursholm by the three other wires, one of which is 100 sq. mm and the other two 60 sq mm in cross-sectional area. These feed wires are connected to the trolley wires every 500 m, and at these points lightning arresters are installed. The trolley wire is of hard-drawn copper 8.7 mm in diameter. The trolley wire in the city is suspended from iron poles, and outside the city it is suspended from wooden poles. The largest span between the poles lengthwise of the road is 40 m.

The motor cars weigh 21 tons without load, and are provided with four motors and pull a trailer which weighs 11 tons without load at an average speed of 30 km per hour. The controllers are of the series parallel type. Some of the motors and controllers are made by Mather & Platt and some by the Allmanna Svenska Elektrisk Aktiebolaget in Vasteraas, Sweden. The motors from this last named factory are four-pole machines with single reduction gears and are each 35 hp. Iron trolleys of a peculiar form, as shown herewith, are used, and are reported to be giving good satisfaction at all the speeds. The maximum speed allowed within the city limits is 12 km per hour. The motor cars are provided with seating capacity for forty passengers and standing capacity for thirty, and the trailers have the same capacities. The cars are all equipped with the Christensen air brakes, which were first tested thoroughly before the entire equipment for all the cars was ordered. The cars are exceptionally well built, being almost entirely of iron and present a very massive appearance. The distance between the terminals at Stockholm and Djursholm is made in the schedule time of thirty-five minutes, including the time for stopping at the seventeen stations along the road. The road is in charge of Lieutenant Victor Stohle as general manager and G. Karth as engineer.

A bad head-on collision took place March 29 on the Chicago & Joliet Electric Railway, near Sag Bridge, Ill. The road is double-tracked, but one of the tracks was recently washed away, so that where the collision occurred the road was temporarily being operated as a single-track line. There was a dense fog at the time of the collision, and a disregard of orders is given as the cause of the accident.

Wheel Sections

A considerable part of the difficulty which street railway men have with wheels may be traced to light weights and improper sections. Much of the breakage and wear which is attributed to grooved rails, badly designed special work and steam railroad crossings is often due to poor wheel sections, shallow chill and weakness, which, in turn, are largely the fault of bad design.

Half a dozen years ago conditions were much worse than at present. Then wheels were often found so light that there was not sufficient strength available even in the spokes and hubs. The rims were proportionately small. There was not metal enough to make either a strong or durable wheel. A deep chill was out of the question. With no chill whatever there was an insufficient amount of metal to stand the service.

Matters have been greatly improved. This is shown by the fact that guarantees are much larger than they were in 1895. The records prove that, in spite of heavier cars and greater speeds, wheels are lasting longer than they did then. This improvement has been made possible by the more general adoption of heavier wheels. One obstacle has been in the way of the wheelmakers in their attempts at wheel improvement. This has been the whims of general managers, engineers and others who have the design and purchase of wheels in their control. Each one thinks he has good ideas in regard to wheel sections. Then there is the general desire for something special different from what other people have; something that may be pointed out to a board of directors as "my own design," "belongs exclusively to this road." These various ideas, which do not deserve a more dignified name than whims, differ by just enough in regard to treads and flanges to make any great improvement impossible. So long as there is no uniformity so long must the manufacturer confine himself to making wheels to specification.

Speaking of this state of affairs Wm. W. Lobdell, president of the Lobdell Car Wheel Company, says: "All that the wheel manufacturer can do is to insist that the thickness of the flange shall be as great as conditions of the service will permit. The flange of a motor wheel, which has sufficient chill on the tread to render good service, will always be chilled through, and consequently cannot be nearly as strong as the soft fibrous unchilled part of the wheel. Engineers and superintendents in many instances do not give due consideration to this fact and in consequence the best results are not obtained."

Because the flange is chilled through, and is therefore compartively fragile, it does not follow that there is no way of imparting additional strength to it. An increase of thickness above the root makes the support of the root of flange wider. This is possible even on a wheel for a grooved rail.

For the most durable wheel a hard chill about three-quarters of an inch deep is necessary. To obtain such a deep chill and at the same time retain sufficient strength for motor car service it is necessary to use a thick rim. Such a wheel will have a rim practically as thick as that of the Master Car Builders' standard for steam roads. It will have very little resemblance to the sections formerly popular. The reason for this is obvious. The chilled portion may be well considered as possessing no strength whatever. In addition to the chilled metal there must be also a sufficient quantity of metal added to provide the necessary strength in the tire.

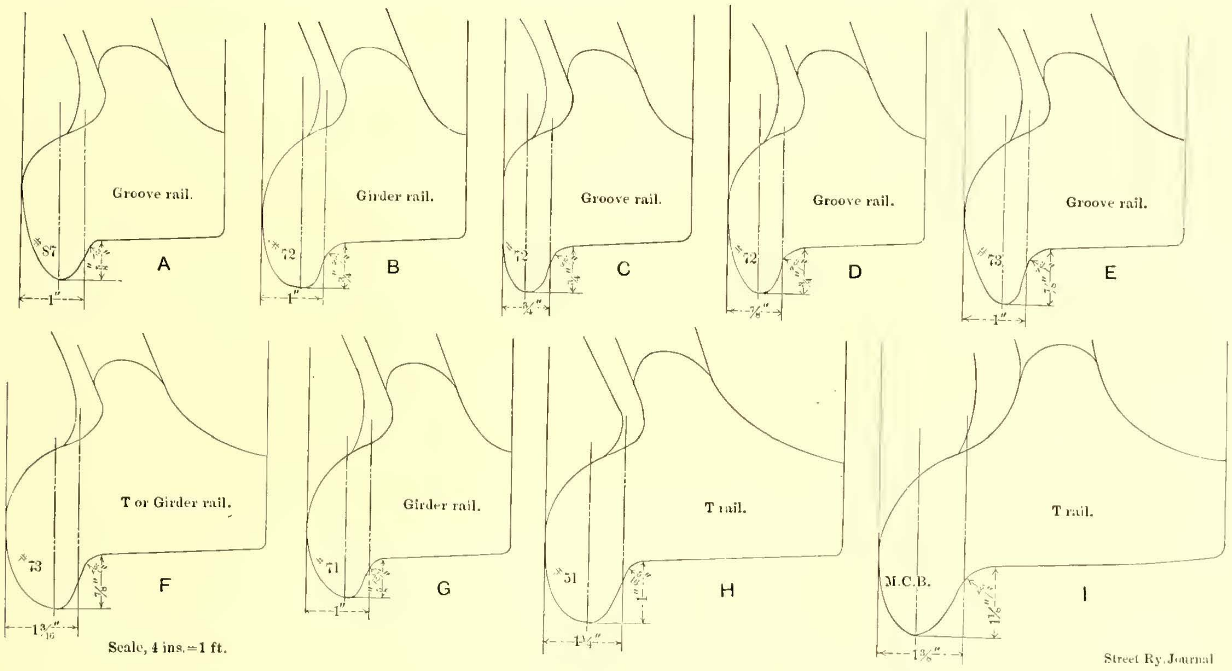


FIG. 1.—STANDARD WHEEL SECTIONS OF THE LOBDELL COMPANY

The engravings given in this article are from a number of sources and illustrate a great variety of forms now in use. They represent wheels in nearly every form of service from the standard T-rail to tracks with the narrowest of grooves. The first of these, Fig. 1, shows nine sections made by the Lobdell Company. In this diagram we have four sections, *A*, *C*, *D* and *E*, intended for grooved rails, while the last one, *I*, is the Master Car Builders' standard. A comparison of these at once shows what a disproportionate thickness of rim there is between the two styles.

Comparing the grooved rail wheels with each other one remarkable feature is at once seen. The amount of metal used to reinforce the flange is practically nothing in diagram *C*, while in *E* it is considerable. The flanges *C*, *D* and *E*, in Fig. 1, are practically the same and could be operated in the same groove to all intents and purposes, but the strength of the flanges will be widely different. The quantity of metal above or outside the point where the flange comes above the rail is of substantial use in supporting the flange, yet that portion of the flange below the top of the rail is no larger.

Of course there are some conditions which preclude the thickening of the wheel at this point, but in general this form can be adapted to almost any form of track. Fig. 2 shows two sections and the outline of three sizes of wheel, showing how this additional metal may be applied to wheels of rather unusual outline. The diameters are respectively 20 ins., 30 ins. and 36 ins. The wheels are standard on the Augusta Railway & Electric Company's line, Augusta, Ga. The 30-in. wheel weighs 300 lbs. While the outlines show rather heavy and deep flanges the additional metal is very valuable. It adds strength at the very point where it is most needed, making the flange much better able to resist shocks of all kinds and tending to prevent the annoying dropping off of large sections.

The coning of these wheels is much greater than usual, amounting to 5-16 in. on the $2\frac{1}{4}$-in.tread. The Lobdell wheels in Fig. 1 have about $\frac{1}{8}$ in. Coning was formerly supposed to be an advantage in enabling wheels placed upon one axle to pass curves more easily, the theory being that the outside wheel rolled upon its large diameter, while the other bearing at a point where the wheel was smaller would have less slip. Unfortunately for the theory only one pair of wheels in a truck behave in this way. The trailing wheels instead of bearing hard against the outside rail so that coning is an advantage are prone to hug the inside rail so that the small diameter has the longer distance to travel. The trailing axle of a trailing truck is usually hard over to the inside of the curve so that the more modern theory is that coning does harm rather than good. so far as curve work is concerned.

The cone, however, has a real advantage in steadying the trucks on tangents and preventing them from running from side to side or "hunting." Coning, to some extent, also reduces flange wear on ordinary rails. It is something of a question, however, whether a coned wheel is of any advantage on a grooved rail where the groove allows only $\frac{1}{4}$-in. play to the wheels at best and where dirt, etc., practically leaves the wheels without play. Under such conditions "hunting" is out of the question. In many cases the wheel takes its bearing at the bottom of the groove.

The wear of wheels on curves has long been a study among steam railroad men. After innumerable experiments with independent wheels for the sake of reducing friction when passing curves and the employment of excessive coning in order to avoid having one wheel slip the moderately coned wheel solid on the axle has been found best. With a narrower tread this wheel has formed the basis upon which many of our best forms of street railway wheels have been modeled.

Fig. 3 shows a section of a street car wheel used by several prominent street railway companies. It is a very good section where a flange so thick at the root can be used. The rounding of the corner of the tread of the outer edge is a good point and has been found very effective against chipping. It could be adopted in all cases with advantage were

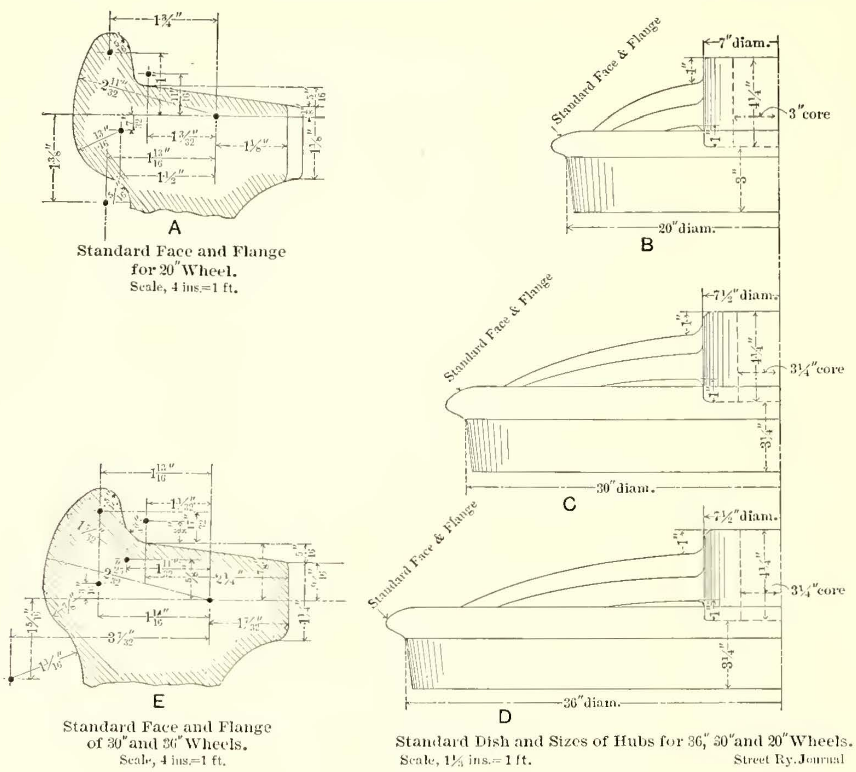


FIG. 2.—STANDARD WHEELS AT AUGUSTA

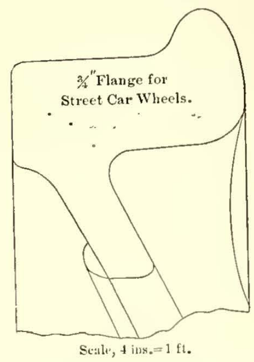


FIG. 3.—A SECTION OF WHEEL WITH ¾ IN. FLANGE

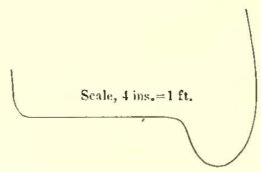


FIG. 5.—SECTION FROM OMAHA

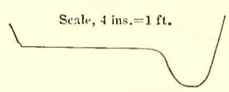


FIG. 6.—SECTION FROM GRAND RAPIDS

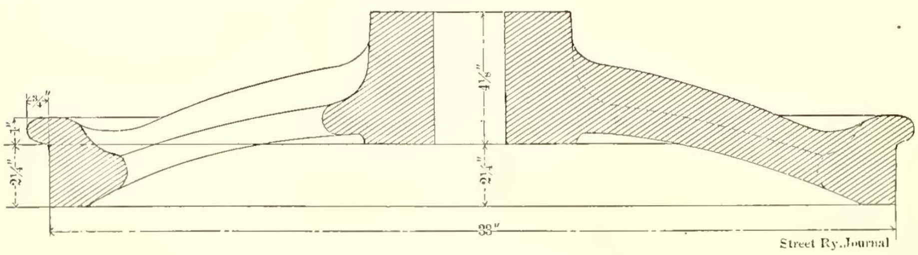


FIG. 4.—SECTION FROM NORTH JERSEY STREET RAILWAY

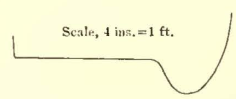


FIG. 7.—SECTION FROM GRAND RAPIDS

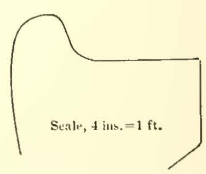


FIG. 8.—NARROW TREAD WHEEL

it not for the fact that it adds to the width of the rim, and in many places this is entirely inadmissible. The thickness of the rim could, however, be increased to advantage. With chill ¾ in. deep there is hardly enough fibrous metal behind it to give the requisite strength.

Mr. Bodler, of the North Jersey Street Railway Company, has supplied the section shown in Fig. 4. This is the standard section of flange on that road. It will be noted that the rim is thick and that there is an unusual quantity of metal in the base. There is, however, no extra metal in the rim outside the root of the flange. The reason for this is found in the dimensions. The flange is ¾ in. high and 1 in. thick, measured from the back of the flange to the center of the fillet. This makes a "fat" strong flange. The weaker chilled metal is supported by a body of soft metal

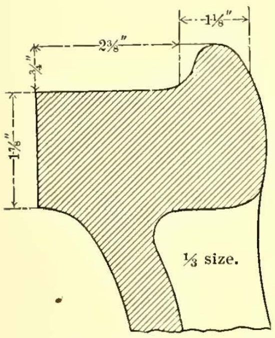


FIG. 9.—SECTION FROM DAVENPORT

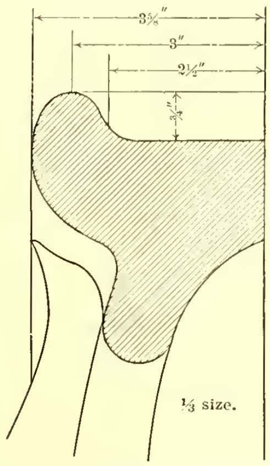


FIG. 10.—SECTION FROM QUEBEC

above and outside of it. A long list of these wheels removed for various causes does not show one which had failed from broken or chipped flanges.

Fig. 5 is a section from W. B. Tarkington, superintendent of the Omaha & Council Bluffs Railway & Bridge Company. The flange of the wheel is ¾ in. thick. This flange is strengthened by the body of metal placed in the rim above and outside of it. Rounding the corner of the tread also tends to prevent chipping. The standard wheels are 33 ins. in diameter and weigh 400 lbs.

The sections in Figs. 6 and 7 come from the Grand Rapids Railway Company. Fig. 6 is of a type the opposite of those just mentioned. The flange itself is small and there is no reinforcing of the metal above the root on the inside of the wheel. The weight of this pattern is 400 lbs., diameter 33 ins. The flange in Fig. 7 is of the same depth and the wheel of the same diameter but 20 lbs. lighter, yet the flange has considerably more metal at the root than the other. This metal does not increase the size of the flange where it enters the groove but adds strength at the root.

Fig. 8 is a ½-in. flange 1 in. thick at the base. The tread is scant 2 ins. The form is peculiar, yet from its small depth and considerable thickness should be strong.

Fig. 9 shows a wheel section from the Tri-City Railway Company, of Davenport, Ia., sent by J. F. Lardner, the general manager. Although it appears large for most grooved rails, yet the form is strong. The heavy body of metal at the outside of the flange above the level of the tread increases the strength of the flange materially. Reducing the thickness and height of the flange but retaining the metal at the point named would give a strong flange for grooved rails. Compare this with some of the sections of Lobdell wheels and a strong resemblance will be seen. This flange and section is not unlike that of Fig. 10, which is the standard on the Quebec Railway.

In spite of the fact that street railways are badly handicapped in selecting wheels by shallow, narrow grooves, they can obtain fully good results by using a wheel of proper section. The addition of metal on the inside or back of the flange can usually be done with very little or no inconvenience and the result is satisfactory in all cases.

CORRESPONDENCE

Dr. Hutchinson's Paper

NEW YORK CITY, March 4, 1902.

EDITORS STREET RAILWAY JOURNAL:

I have read the editorial in your last monthly issue, discussing my paper read before the American Institute of Electrical Engineers.

The most ardent adherent of high initial acceleration has not claimed anything in its favor other than the saving in energy. Every other consideration is distinctly in favor of low acceleration from the point of view of operation, cost of equipment and the comfort of the passengers. If you had kept in mind the fact that my paper did not discuss the best schedule speed to adopt, but discussed only the best initial acceleration after a particular schedule speed had been decided upon, I think that much confusion would have been avoided.

I wish to direct your attention forcibly to the fact that you misrepresent me in quoting me as saying, "The proposed schedule speed of the express service of the New York Rapid Transit line would prove impracticable." I said nothing of the sort. What I did say, as you will see by referring to the paper, is: "This table shows the practical impossibility of accomplishing such a schedule *on the assumptions of this discussion*." If you will refer to the paper you will find that one of the assumptions of the discussion was that the motors were operated at their one-hour rated capacity during the period of initial acceleration; any other assumption regarding the load of the motor during the initial period will change the motor capacity required for the schedule.

Hence your statement that "If this schedule were in fact visionary one may as well bid farewell to all dreams of electrical rapid transit in New York or any other place" is a distortion of the facts, for which there is not the slightest basis in my paper. CARY T. HUTCHINSON.

Reply to the Question of a Peculiar Break in a Cast Welded Joint.

NEW YORK, March 26, 1902.

EDITORS STREET RAILWAY JOURNAL:

It seems to me as if the break in the cast-welded joint described by Mr. Hands in your last issue is not a very difficult one to explain. My theory is that the break in the rail itself was the first to occur and that it was caused by the cold snap which Mr. Hands mentioned in his communication. The break through the joint casting was then caused by a sudden blow on the protruding short end of the rail, struck either by an especially heavy car or by some heavy dray which was driven along the track. The lower part of this short rail was, of course, not supported, and if the nearest tie was some distance away from the break there would naturally be a considerable leverage to the blow. The resulting break occurred in the weakest part of the joint, *i. e.*, in the middle. I have never heard of a parallel case, however, and this explanation is theoretical only

R. P. MASON.

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NOTICE.

Papers and correspondence on all subjects of practical interest to our readers are cordially invited. Our columns are always open for the discussion of problems of operation, construction, engineering, accounting, finance and invention.

Special effort will be made to answer promptly, and without charge, any reasonable request for information which may be received from our readers and advertisers, answers being given through the columns of the Journal *when of general interest, otherwise by letter.*

Street railway news and all information regarding changes of officers, new equipment, extensions, financial changes, etc., will be greatly appreciated for use in our news columns.

All matters intended for publication in the current issues must be received at our office not later than Wednesday of each week.

Address all communications to

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The science of accounting has attained such importance in street railway work that we have decided to establish in the Street Railway Journal a special department on the subject. This department will be in charge of J. F. Calderwood, auditor of the Twin City Rapid Transit Company, who, despite his many and important duties as auditor of that corporation, has consented, for the benefit of his co-workers in the field, and for the establishment of correct methods of accounting, to conduct this department. The first article by Mr. Calderwood, in initiating this department, will appear in our next monthly issue, and he and the editors of this paper cordially request the co-operation, not only of street railway accountants throughout the country, but also of railway managers, in making this department a success by suggestions or contributions from their experience on all matters pertaining to street railway accounting.

The official opening last week of the third-rail system on the Baltimore & Ohio Railroad is a noteworthy event in heavy electric railroading. It is a somewhat remarkable coincidence that Baltimore, which was the scene of the Daft experiments in 1885 with a third rail for electric railway service, should have also been the city in which heavy electric locomotives were first put in successful operation, and now is the first place in this country in which the third rail is used for tunnel operation. Although the B. & O. electric locomotives have been in use for eight years, they are still the largest which have been built; and while experience has indicated several particulars in which their design might be improved in detail, the fact that they have been handling the service successfully during this time is an exceedingly high testimonial to the ability displayed in their design. The chief trouble with the overhead construction which was at first installed was its vulnerability to the locomotive gases in the tunnel, so that the adoption of a third-rail system, which is, of course, enormously cheaper to install, and cheaper also to keep in repair, was a necessary step. The problem of protecting this third rail against accidental contact while passing through the passenger stations at Mount Royal and Camden seems to have been satisfactorily solved by locating it in what is practically an open slot conduit, and it was this portion of the work, now successfully accomplished, which has delayed the change from the overhead system until the present time.

Pittsburgh is the latest city to adopt the rule of stopping the cars at the "near side" of the crossing, instead of at the further side. Several cities have attempted to initiate this practice, but so far as we are aware have had to give it up, except in isolated cases, where special conditions have made it necessary to stop at both corners. From an operating standpoint there are several good reasons why the first corner is much more desirable as a stopping point than the further crossing. The principal advantage, of course, is that a car must necessarily slow down somewhat in coming to a cross street in order to avoid possible collision with vehicles on that street, and must often come to an absolute stop; if, then, it stops again at the second crossing for passengers, valuable time is lost. On the other hand, if the rule was to stop at the first corner only, the motorman could select his time for crossing the street, could proceed on the early notches of his controller, then accelerate when the street was passed and the straight run ahead was open to him. The two chief objections to this plan are, first, that the public is not used to this method, and, second, that passengers leaving by the rear platform do not have a crossing to step on, but have to leave the car at a point which may be, and often is, muddy. The first objection is not serious, but the second is important if it cannot be overcome; for even if the company is not responsible for the condition of the streets, the passengers will strenuously object to being landed anywhere except at or near a dry crossing. There are two ways of overcoming this trouble. One is to have crossing flags laid from the curb to the point at which the rear platform of the car will stop. This is not a serious undertaking if done while a street is being repaved, and if this plan of stopping was well understood and in use, would be done as a matter of course. The other plan is to use the front platform as an exit and entrance; we do not mean exclusively, for there would be many who would still board and leave the car by the rear platform, but as an additional way of receiving and discharging passengers. Steam railroad cars are loaded and emptied at both ends and there seems to be no valid reason why electric cars, under most circumstances certainly, should not make more use of the front door than they do, as it would greatly shorten the time of loading and unloading. The only serious objections to this plan are possible interference with the motorman and less supervision of the boarding and leaving of cars by the conductor, who would have two platforms to watch instead of one. The actual extent of the danger introduced by the latter consideration would be hard to estimate, but we do not think it would amount to much, if anything, because on many cars now, as for instance on Broadway, New York, both entrances are used, while safety gates could be employed, as in Minneapolis, if necessary. Some provision would usually have to be made for screening the motorman, but this need not be difficult. He could either be placed in a cab on the further side of the platform, as on the Chicago elevated cars, or else at the front end of a long platform, separated from the rest of the platform by vestibuled doors. In either case the doors could be made to slide or fold back against the sides of the car or vestibule when he changed to the other end of the car in order to give the full amount of standing room.

We took occasion, in a recent issue, to refer to the evils resulting both to the public and to legitimate electric railway interests by the indiscriminate giving away of street railway franchises by public bodies. We use the words "indiscriminate giving" advisedly, for while this phrase is usually used to designate the award of public franchises for small returns, we believe that just as much, if not more, harm is done by requiring too large a return from an individual or company requesting track rights. It might be argued that a company proposing to build a line would not offer for the right more than the privilege was worth, and if it did no one would suffer except the company itself; but both of these propositions are untrue, as will easily be seen upon consideration. When a city or town disposes of a street railway franchise it does so primarily because it believes that the community as a whole will be benefited by the construction of the road; the return promised by the builders, if any is to be paid, is a minor consideration only. Any step, therefore, which the town takes to delay the completion of the project, or possibly to defeat it altogether, is a direct injury to itself. We know of many cases where a town has actually prevented the introduction of rapid transit unwittingly by following the course of asking too much, even when its proposition has been accepted. For instance, suppose two or more petitions have been received for franchise rights, and, irrespective of the standing of the petitioners, the franchise has been awarded to the person or company offering nominally the greatest inducements. The lower bidder may have been entirely responsible, ready and willing to carry out the project, and demanding only a fair profit for his investment. The successful bidder, on the other hand, may have been, and very often is, a promoter, who sees in a franchise a possibility of securing a margin for himself by selling out to someone else after the franchise has been secured, and who, consequently, is willing to offer extraordinary inducements if his petition be favorably acted upon. After receiving the franchise he hawks it around New York, Boston or Chicago, and from one banker's office to another, to be sold at the best terms. Nothing kills an electric railway proposition more quickly than the knowledge that it has been offered in this way to a number of financial houses. As a result, the franchise is often not sold at all, until it finally lapses, and rapid transit in the city in question is postponed for two or more years. By this we do not mean that the community serves its own interests best in demanding a short time for the commencement of construction or for the completion of the road. The organization and financing of a company necessarily take time from even a bona-fide bidder, and no responsible person is willing to run the risk of losing the money which he himself has put into the preliminaries of a road through unavoidable or intentional delays on the part of his contractor or banker. The most important requisite of a petitioner, from the standpoint of the town granting the franchise, is the character of the person making the application, more important by a great deal than the comparative amount of the returns offered. If the lower bidder is known to be a hustler, a man who goes into things with the intention of carrying them out, is of standing in the community, and has a reputation to lose if he goes into an undertaking and does not complete it, his bid is a much better one to accept than one which is higher from a person who does not have these qualifications.

The few isolated cases which have arisen in this country of alleged damage to water pipes through electrolysis from railway circuits are estimated at their true worth by the well informed. They are hardly ever or never considered by investors as constituting any danger to the single trolley system, and any possibility of a change to any other system is rightly looked upon as absurd. The experience of twelve years or more of electric railway construction has shown that the possibility of trouble from this source can be avoided by the exercise of reasonable precautions in the installation, in which the co-operation of the water companies is desirable. It is somewhat surprising and amusing to the average American, therefore, to read in some of the European publications the alarming predictions of the damage to water pipes which will ensue if the single trolley system is used. These predictions are usually accompanied by distorted statements of the true sentiments and conditions in this country. To such as believe them we can only say that trouble from this cause is a no greater disturbing factor in the mind of the American street railway manager, and not so great, as the early difficulties from induction with the telephone, which long ago disappeared with the application to this subject of intelligent engineering principles. As the question may arise, however, in some cities, we can do no better than to reiterate the general rule, that the easiest way to secure entire immunity from this trouble is by friendly co-operation between the water and railroad companies. It is, of course, perfectly feasible in most cases, by adding plenty of copper to the rail return, for the railway company to accomplish the result sought, which is the removal of all current from adjoining water pipe lines. But a much less expensive way of reaching the desired result, and one which will usually be much more satisfactory to both railway and water companies, is to take the problem up together, and by the introduction at points of insulating joints in the water pipe to accomplish better results than could be done by confining the changes entirely to the railway system. The very fact that a water pipe system acts as a return conductor in any case indicates that it will be particularly vulnerable to natural earth currents, which often cause trouble independent of any artificial electrical circuit. These currents are frequently of considerable magnitude, as we stated last month in a discussion on the reliability of millivoltmeter readings, and protection against this danger, as well as that of any possibility of trouble from artificial currents, can be secured by the same step. Our American readers are familiar with the fact that most American water companies showed, during the early days when the electrolysis trouble was considered more serious than it is now known to be, a readiness to co-operate in ways to prevent this trouble; and we can only refer to the successful results which have been secured by this practice to our foreign friends and others to whom this incident still possesses some elements of anxiety.

The Cost of Power

We earnestly wish that the large operating companies would take up for their individual and mutual good the actual production costs of power in electric railway stations of various sizes. There has been in years past a vast deal of discussion on the subject, and many figures have been brought forward giving the cost of power as a function of the station capacity and load factor. The figures have stood the test of experience fairly well, but they have reference mainly to stations of what we now regard as small output, a few hundred or a thousand kilowatts. The modern electric railway uses electrical energy upon a scale that puts all the older estimates to the blush, and the whole question needs very thorough revision in the light of modern experience and apparatus. The pertinent questions to-day deal with the relative costs of power in stations of a few and of many thousand kilowatts capacity, with the gain in passing from a 2000-hp to a 5000-hp engine and the like, and up to the present accurate data are almost or quite wanting. The earlier investigations tend to show that the curve expressing variation of cost with output becomes so nearly asymptotic at an output of a few thousand kilowatts that there is little economy in further increase of output. But that was before the day of 5000-hp units. Modern capacities and costs make an important variation in some of the constants assumed, and should have a place in the problem.

This topic bears directly upon one of the most important problems in electric railway engineering—the question of transmission to urban sub-stations, as against the operation of separate generating stations. Recent practice, based upon local investigation of the conditions, has tended largely in the direction of power transmission upon an enormous scale, and the wholesale use of rotary converters, even in the face of the obviously large losses in the transmission and conversion, and the large extra amount of apparatus involved. Such is the practice followed in nearly all the cases around the metropolis. On the other hand, some high authorities have grave doubts of the economy of this procedure, and at least one very important and well-engineered system has, without hesitation, taken the other horn of the dilemma and has built a splendid system of auxiliary generating stations. Of course local conditions have a very important bearing on the result, but, speaking broadly, it either is or is not true that a 50,000-kw generating plant can produce power 25 per cent cheaper than five equally well-designed stations of 10,000-kw capacity each. We say 25 per cent because there must be a margin of this order of magnitude to compensate for the necessary plant. At the present time figures ought to be available from systems of both kinds upon the requisite scale to permit a sound basis of judgment. The question repeatedly arises, not only in our large cities themselves, but in the allied great suburban systems, and the answer to it has great economic significance.

For the purpose of this inquiry the actual costs of operation, should be taken as the basis of operations. But of even greater importance are the costs of operation, including all fixed charges and administrative expense connected with the production of power. These items are seldom connected with the ordinary operative expenses, but when such a problem as the present is up for consideration they belong there and nowhere else. The costs of motive power, as generally published, are extremely misleading, by reason of the omission of these important factors, which may easily amount to a third of the total cost. The item of depreciation, too, is one that belongs in this group and should be rigorously included. The general public has a most erroneous idea of the cost of motive power in electric railroading. It is popularly supposed to be a far larger proportion of the total cost than it really is, and when estimates based on mere operative expenses are published the idea is disseminated that electric railways make enormous profits because their power costs them only 0.75 cent per car mile, or something of the sort. Then the 3-cent fare proposition bobs up again. But for the purpose in hand we want the whole cost, to the last penny, from the two systems of electrical distribution concerned. The systems of working conductors are the same in each case, but in one instance we have, perhaps, a few more sub-stations than in the other. Of course, if the number were the same the feeding systems would also be essentially the same, but an increased number of sub-stations is a perfectly legitimate advantage of the transmission method. The comparative data would be tremendously interesting and valuable, and the real economics of the huge modern units would be brought out in clear relief. We earnestly hope that such an investigation will be set on foot, for the subject is of the utmost importance, and the facts are not yet known. We should expect rather startling results, but in which direction we should not *a priori* venture to hazard a guess. Quite possibly the event might show the wisdom of a combination system. Incidentally it would be pertinent to investigate the economic bearing of the storage battery when used under the conditions obtaining in an immense system.

There is often a certain reluctance about giving out figures of this kind, based in large part on the knowledge that certain local conditions make the total figures large, so that the station will not make as good a showing as some others. This is not a valid reason, however, because the main object sought by all interested is not to determine the most economical station in the country, but the cost under varying conditions of operation. For this object, all figures are valuable, and those from uneconomical plants may make clear certain facts which are now obscure, to say the least.

The Worcester Consolidated Street Railway Company

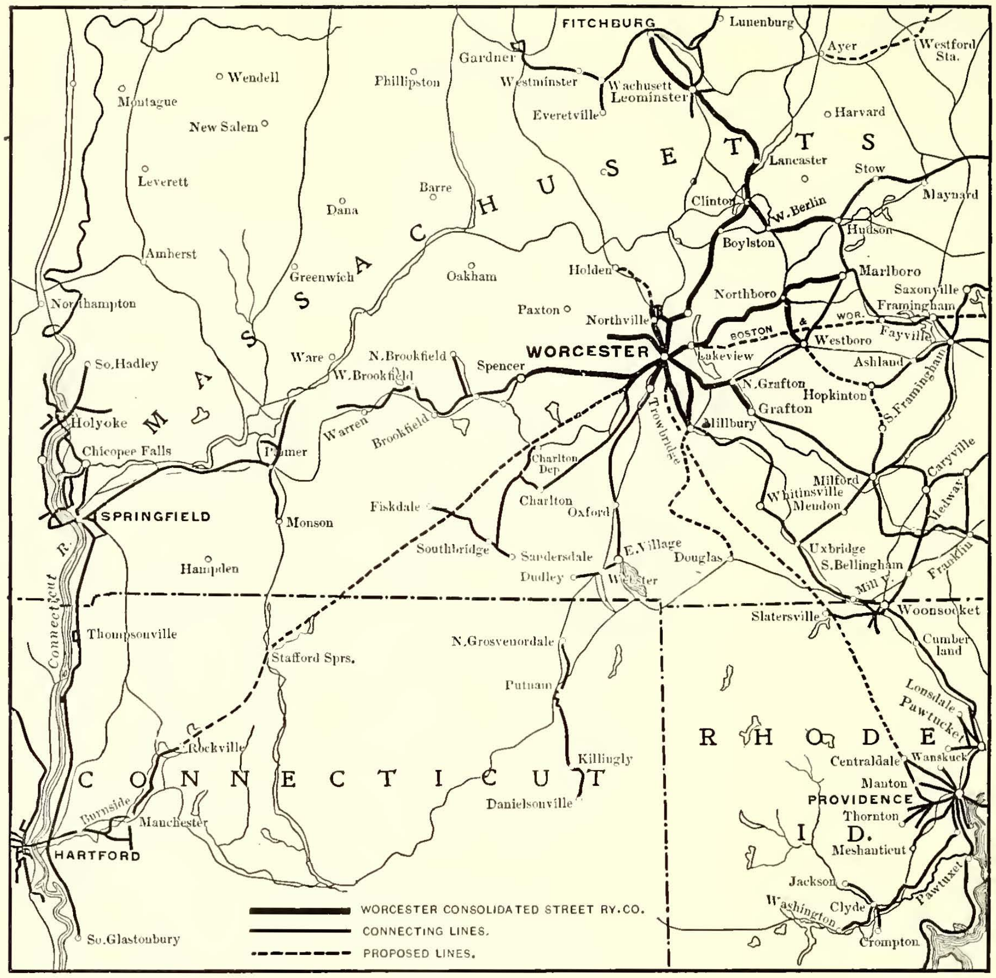
The city of Worcester, Mass., "the heart of the Commonwealth," has become the center of one of the most extensive interurban street railway systems in New England. Electric lines radiate to every point of the compass, as can be seen by the map on the next page; and of these numerous roads all but six are controlled and operated by the Consolidated Company, which has gradually absorbed the outlying systems and unified the city and suburban service. The six not included by the Worcester Company's organization are the Worcester & Webster, the Boston & Worcester, the Worcester & Providence, Worcester & Blackstone Valley, Westboro & Marlboro and the Hartford & Worcester, only the first of these being completed. The construction work of the Hartford & Worcester road is progressing rapidly, and it is expected to be running this summer, but the other two are as yet only on paper, although the rights of way have been practically all secured.

It is not the intention of this article to go outside the province of the Worcester Consolidated Street Railway Company. All other systems which now enter, or expect to enter, Worcester must do so over the Consolidated's tracks under special agreement with that company. The cars of the Worcester & Webster, which now operate into the center of the city, change conductors at the point of junction of the two systems, an employee of the Consolidated collecting fares until the car leaves the latter's territory. When the other lines are completed it is probable that a different scheme will be adopted with them, possibly the changing of both motorman and conductor at the boundary and the paying of rental for the use of the car. This combination of urban and interurban traffic gives the management of the railway a great variety of problems to solve, as practically every class of service is operated. One of the striking novelties on the road, the type of car adopted, is a result of using one style of rolling stock for both long and short distance riders.

A BUSY CORNER IN WORCESTER

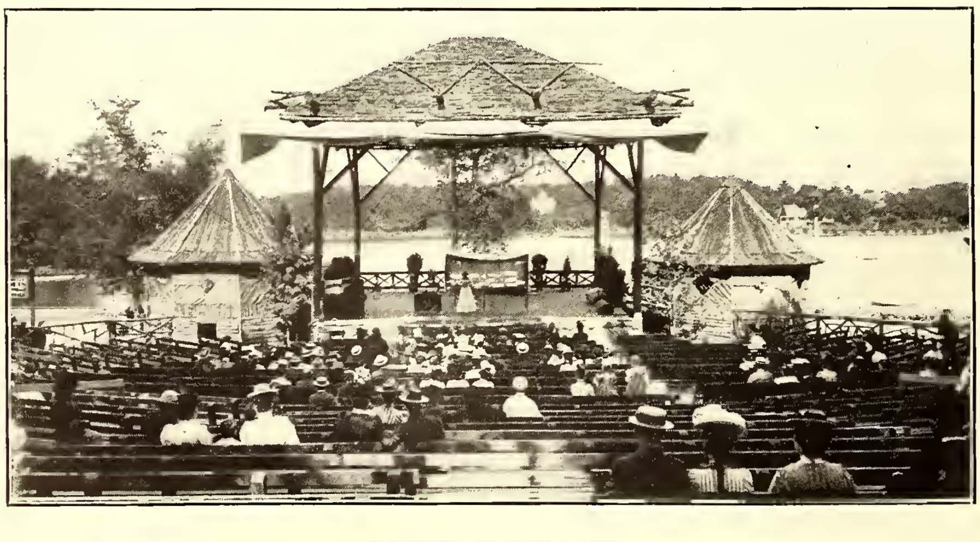
Worcester is built on a very hilly country, but the city has been laid out with more regard for this diversified and irregular surface than from the geometrical standpoint, so that the grades are not either numerous or severe. The principal pleasure resort is the park on Lake Quinsigamond, a beautiful body of water about six miles in length, to which the cars of the company run. An open-air theater has been built here, and during the season first-class performances are given. Another attraction controlled by the company is the "Oval," an athletic field, where accommodation for large crowds is provided, and the cars are called upon to furnish transportation facilities.

In the early part of 1901 R. T. Laffin was made general manager of the system. Mr. Laffin is a thoroughgoing railway man, having been for nearly twenty years in charge of one of the most important divisions of the Boston Elevated's lines, and his connection with the Worcester Company not only relieved President F. H. Dewey from much of the active management of the system which was demanding too much of the time he should have devoted to his other large financial interests, but enabled the road to carry out a great number of much-needed improvements in all departments which the increasing traffic made imperative. One of the first steps in this direction was the relief of the



MAP OF WORCESTER SYSTEM

congestion on Main Street, where the majority of the outlying lines concentrated their cars, and a movement was started to obtain permission to place a loop around the



THEATER AT THE LAKE

"Common" in the center of the city. The advantages of this improvement were immediately appreciated by the city authorities, and a double track has been laid around this square, which greatly facilitates the operation of the cars, not only by providing a place to load and unload passengers on the side street and rendering the stopping of the cars on Main Street much less frequent, but giving an opportunity for "magazining" so that cars can be held in reserve for the rush hours. Other constructions of a similar character have been made throughout the city, another notable example being at Salem Square. A large amount of special work has been needed, aggregating in value some $60,000, and it has all been furnished by William Wharton, Jr., & Company, Philadelphia. Besides this new work, over 11 miles of track made with T and light girder rails have been replaced by 95-lb. 9-in. grooved rail of the Pennsylvania Steel Company's section No. 222. The line to Fitchburg has been practically rebuilt for its entire length and the roadbed been ballasted with stone and gravel. Chestnut ties are used in all new construction 7 ft. x 6 ins. x 6 ins. placed 30 ins. apart, with the rails supported on tie-plates.

The electrical features of the line have received as careful consideration as the track work. Thousands of dollars' worth of copper for new feeders, bonding, etc., has been used in the reconstruction. Each joint of the rails has two Crown bonds made by the American Steel & Wire Company, and the four rails in double-track work are cross-bonded every 500 ft.

All new construction is in charge of the superintendent of line and track, but repairs and repaving of the various divisions are carried out, if not too extensive, by the division superintendents. The company keeps the pavement between and on each side of the tracks in condition, and within the city has laid down a large amount of granite blocks. Grade crossings of steam railroads have been avoided by the building of trestles. The company intends to further increase the safety of its patrons by the installation of a block signal system. After considerable investigation, the system made by the United States Signal Company, of Watertown, Mass., has been selected.

POWER STATIONS.

All the lines of the entire Consolidated system are operated by direct-current distribution, notwithstanding the fact that the location of the various sections would appear favorable to the adoption of the alternating current. In calculating the various costs of transforming from the direct-current systems, which were then supplying the various divisions of the separate roads, to a unified alternating-current system, taking into account the difference in cost of new machinery and the prices which could be obtained for the old machines now giving satisfactory service, a number of which are quite out of date, it was decided to be more economical, to rearrange the distribution of the stations so as to enable the shutting down of a few and the addition of storage batteries in certain localities where they at present seem to be needed. This plan has been followed out, and there is now being installed in the main power station at

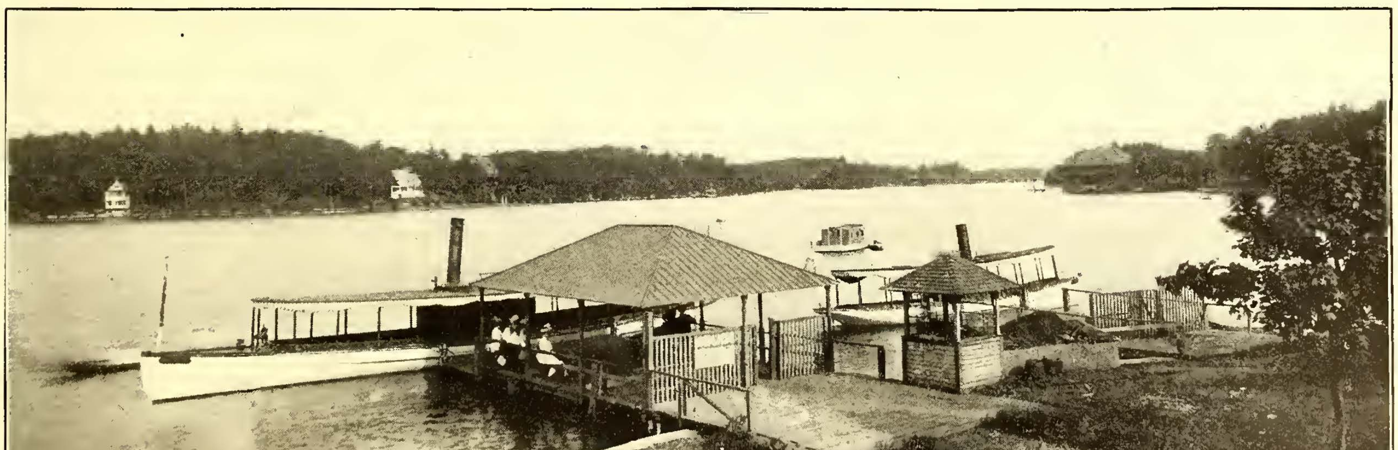
AN EXAMPLE OF THE NEW SPECIAL WORK

Worcester a 3000-hp generator to supplement the equipment already in operation. This large generator will supply the decrease made in the power capacity of the company's stations by the shutting down of stations at Fitchburg, Millbury and Leicester, a total capacity of about 1600 kw, of which nearly all the machines will be sold. This leaves a surplus of power of 1400 kw when the new

ATHLETIC FIELD AT THE OVAL

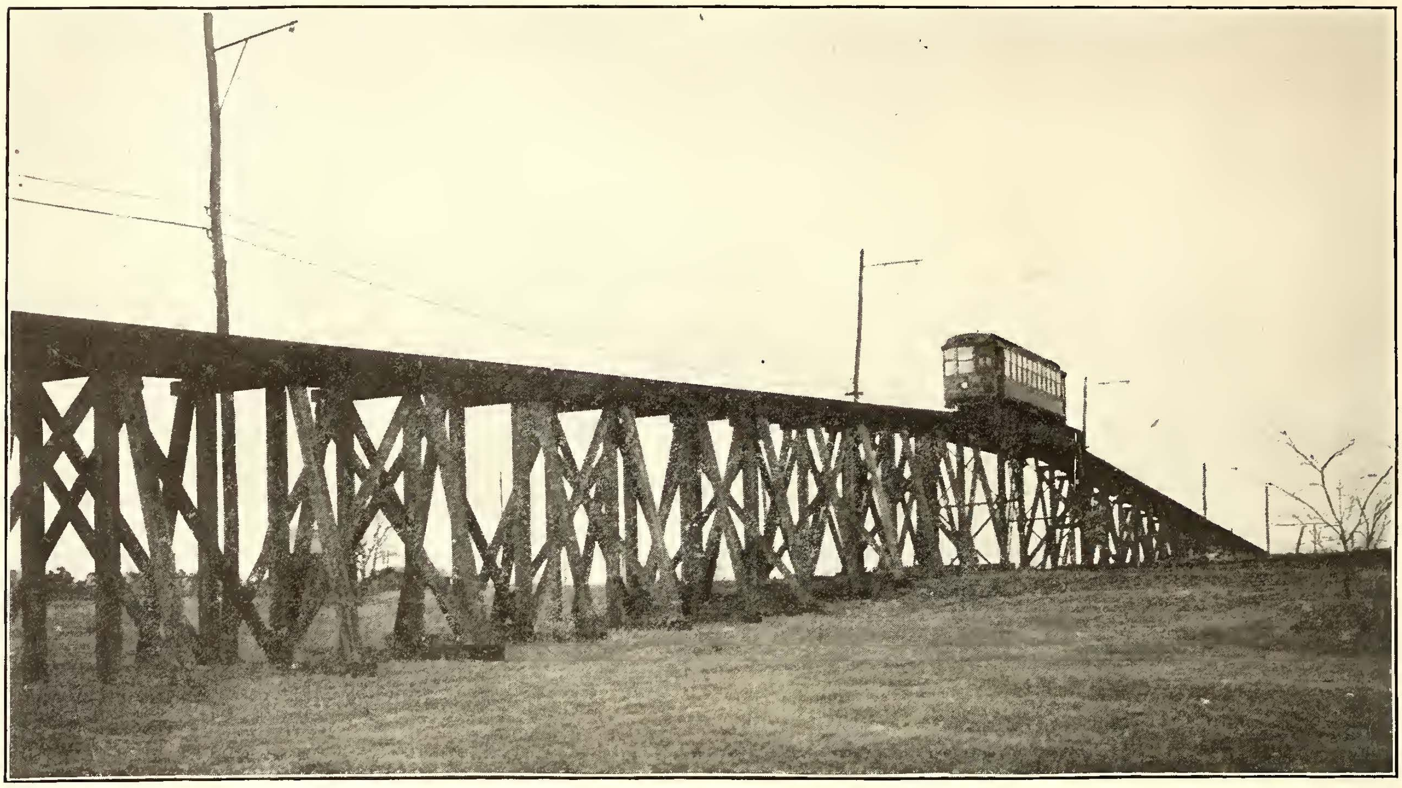
generator is completed. A 240-amp.-hour storage battery which was formerly used by the Worcester & Suburban Company in the city of Worcester has been moved to Fitchburg, near the terminal line at a 13 per cent grade. The shutting down of the Leicester station has not been complete, as there is still a contract between the lighting and the railway company for street and house lighting, and some provision has had to be made for this service. One of the old generators which is in this station has been belted to another and is operated as a motor for supplying this lighting service. There is a storage battery of 450-amp.-hour capacity in this station, which keeps the voltage on the motor practically constant, except at times of heavy loads. This regulation is further improved by a booster in the main power house. The stations mentioned have practically been abandoned; they are kept in readiness for emergency use pending the completion of the extensions being made to the equipment of the main power station. The new service includes, therefore, four power stations and two storage batteries, distributed as follows:

The main power station at Fremont Street, Worcester, of 3650-kw generator capacity and booster of 80-kw (200-amp.) capacity; the Northboro power station of 875-kw capacity, the West Berlin power station of 450-kw capacity and the Leominster Park power station of 500-kw capacity, with the 240-amp-hour storage battery at Fitchburg and the 450-amp.-hour storage battery at Leicester. A complete description of the generating and distribution

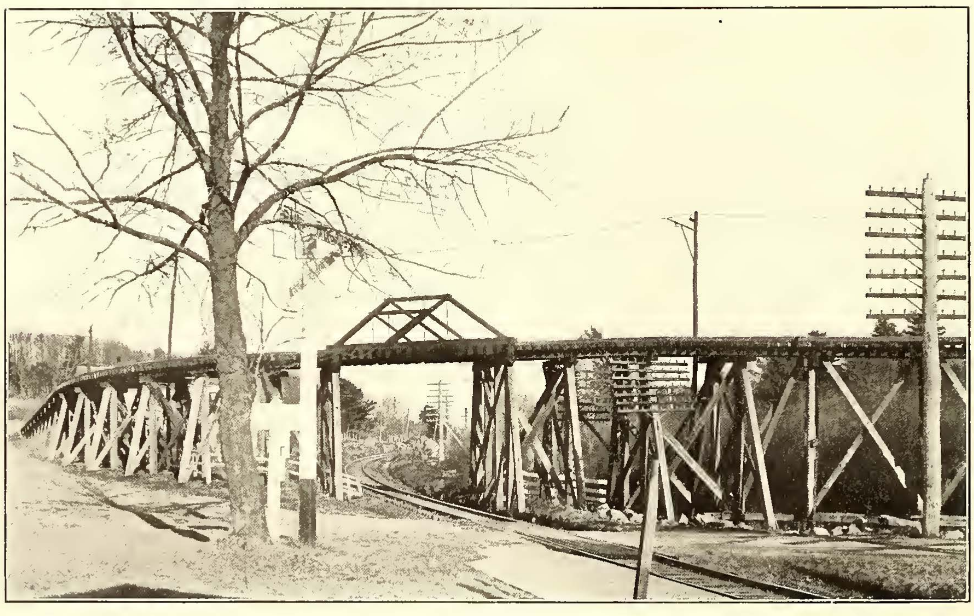


LAKE QUINSIGAMOND

system was given in the Street Railway Journal for September, 1900. Since then, however, the new 3000-hp unit mentioned above has been contracted for. This will be placed at the north end of the Fremont Street power station, where foundations have already been constructed. It will consist of a 3000-hp Reynolds-Corliss engine, made by the Allis-Chalmers Company, of Milwaukee, direct-connected to a General Electric 2000-kw generator. The engine is of the vertical compound type and runs at a speed of 75 r. p. m. This addition to the capacity of the plant will necessitate the installation of 1800-hp of new water-tube boilers made by the Aultman & Taylor Company and a 5000-hp twin vertical condenser made by the Blake Steam Pump Works.



CROSSING THE STEAM RAILROAD TRACKS AT GRAFTON



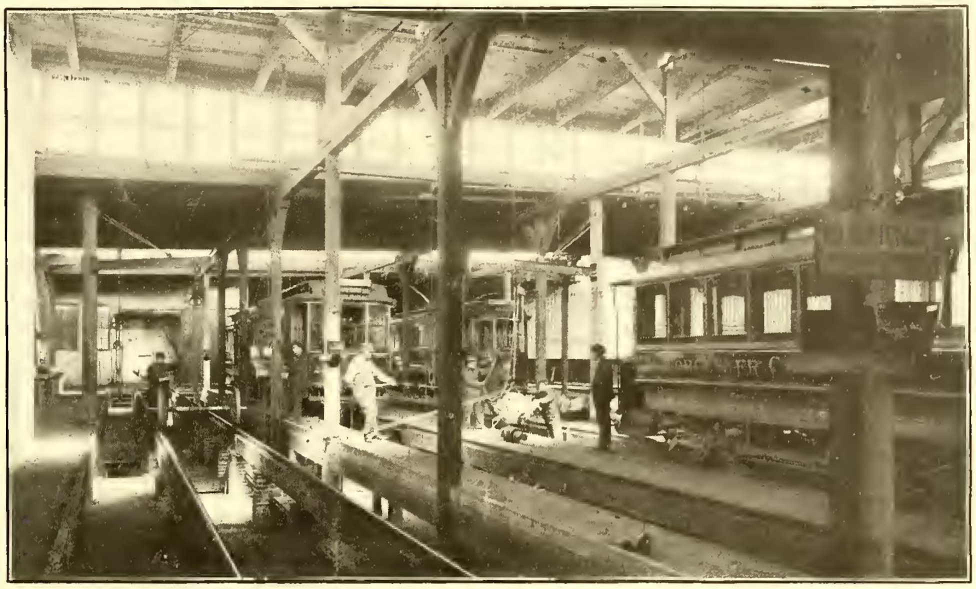
TRESTLE OVER RAILROAD TRACKS AT BERLIN

ROLLING STOCK

The consolidation of the number of small roads necessarily has given to the combined system a considerable diversity in the type of car employed. Under the single management, however, this equipment is being gradually standardized into a uniform type, and a number of minor changes are being made, which have already shown their effect on the power consumption of the various lines. The standard car which has been adopted is a double-truck four-motor car, about 35 ft. over all, and all new equipment will probably correspond therewith.

The company now has some 260 cars, divided about as follows: Fifty 20 ft. and under, fifty 25 ft., twenty 30 ft., the remainder being mostly between 20 ft. and 25 ft. long. There is a great diversity of electrical equipment, trucks, etc., including various types of both Westinghouse and General Electric motors and Brill, Peckham, Bemis, Laconia and Taylor trucks. The company is using four-motor equipments on nearly all of its double-truck cars, and has adopted the G. E.-67 motor as standard. A novel type of car, of which there are now fourteen in use, is illustrated herewith. These cars were made by the Osgood Bradley Car Works, Worcester, and are equipped with Laconia 8-B high-speed trucks, having a 4 ft. 4 in. wheel base. The cars have 30-ft. bodies and are 7 ft. 10 ins. wide at the side panels. The seating capacity is forty, the seats being arranged in the peculiar manner shown, with five cross seats and two longitudinal seats on each side. In this way an attempt has been made to meet the requirements of a combined urban and intcrurban traffic which has proved very successful. Two registers are used on all cars, one for cash fares and one for transfers. Those made by the International Register Company, Chicago, are used for cash and Lewis & Fowler registers are used for paper. The steps of the cars are being equipped with treads made by the Universal Safety Tread Company, New York.

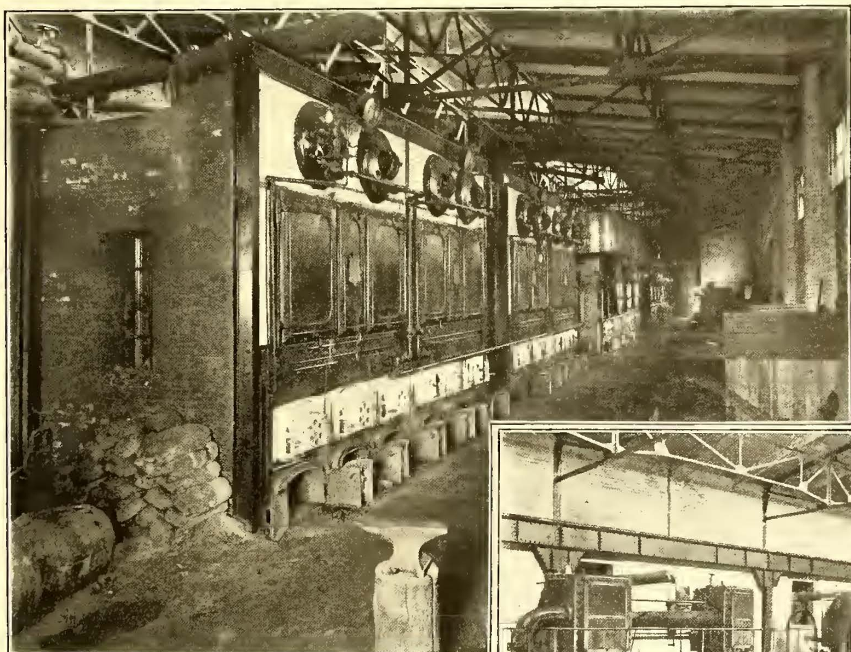
A number of G. E.-800 motors, which came to the Consolidated from the other roads, are having their armature windings changed from the ring to the drum type. All these motors which have so far been put back into service are found to work very well with their new windings. A special form has been made in the winding room, and by leaving an open coil an almost symmetrical winding has been obtained. This reconstruction of the old armatures not only considerably reduces the expense of winding, but will give them a longer life.

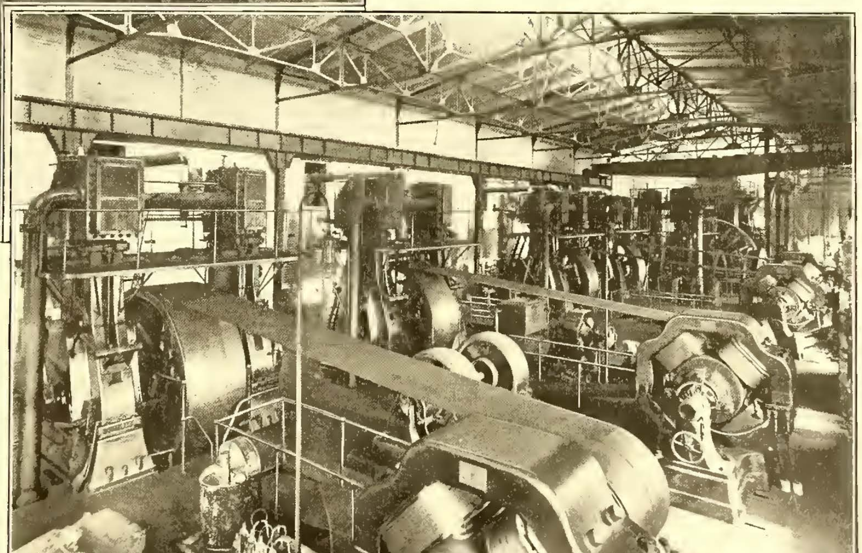


INSPECTION AND WORKING PITS IN GATES LANE CAR HOUSE

Considerable interest has been shown by both the railway officials and the citizens of Worcester this winter in the operation of a rotary snowplow which has been added to the equipment. Although the past year has not been one which would be remembered as extremely severe, there were several storms in which heavy snowdrifts occurred on the interurban lines, and the efficient action of the plow saved the road from being tied up in a number of instances.

A view is shown of this plow, which is of the well-known single Ruggles type, made by the Peckham Manufacturing Company, of New York, going through a drift. The speed of this plow is regulated in an ingenious manner. An ammeter is inserted in the circuit of the motor which operates the cutter and places it in such a position that it could be observed by the man driving the traction motors. In this way he could tell exactly when the cutter was doing too much work by the current consumption of the cutter's motor and could slack up the speed of the plow. The maximum speed which was allowable in carrying a car through a drift was at all times readily ascertained by the driver, and no trouble was experienced from the blowing-out of the breakers and consequent stalling of the apparatus. Other plows furnished by the Wason Manufacturing Co., Springfield, Mass.; Smith & Wallace, Woburn, Mass., and the Taunton Locomotive Manufacturing Co., Taunton, Mass., are also used.

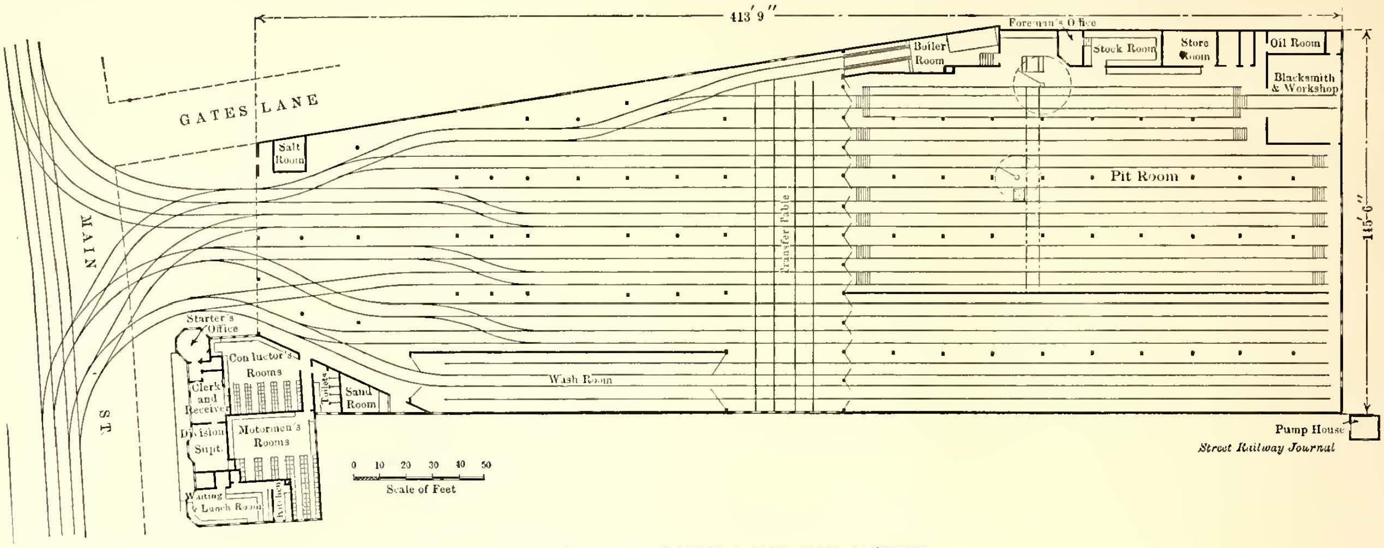




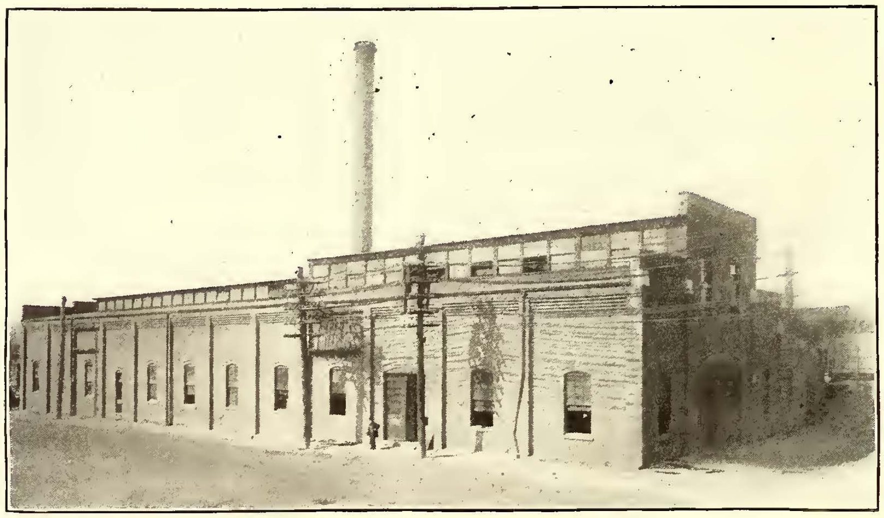
GENERAL VIEWS OF BOILER AND ENGINE ROOM, FREMONT STREET STATION

GATES LANE CAR HOUSE

The extension of the system has necessitated the building of a new car house, which is situated on Main Street at the corner of Gates Lane, about a mile from the center of Worcester. The capacity of this car house, which covers considerably over an acre itself, and is built on a plot of land layout is shown in the accompanying plan, which was made from the original drawings of the architect, F. F. Low, of



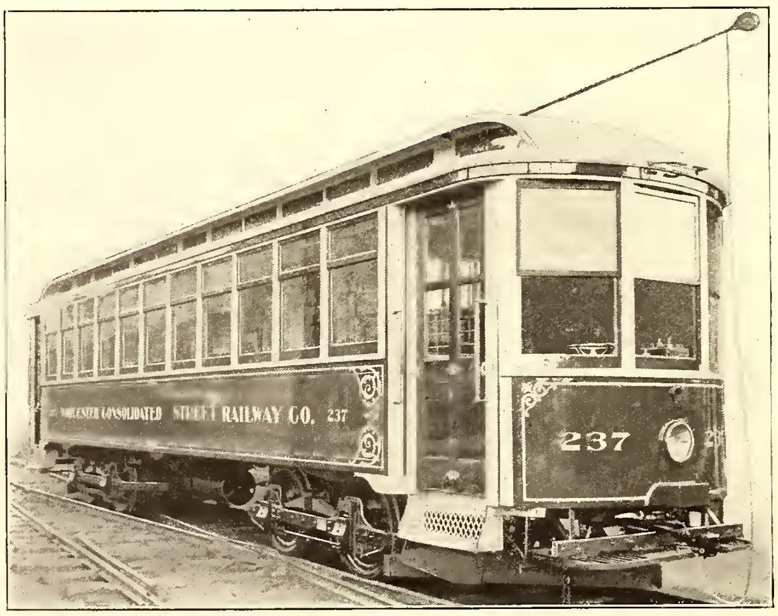
PLAN OF NEW GATES LANE CAR HOUSE

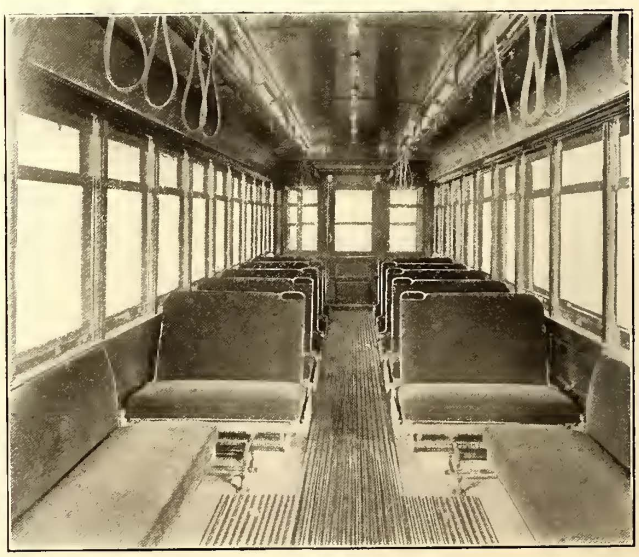


THE FREMONT STREET POWER STATION

Boston, and the half-tone illustrations show some of the special features of the interior as well as a general view of the Main Street front. Everything that has been shown by experience to be necessary to the equipment of an up-to-date car house has been incorporated in the design of the building, while a number of novel features have been added which are of exceptional interest. The layout of tracks, as shown by the plan, is somewhat peculiar and provides what is practically an individual entrance to each interior track. The Main Street double track has two tracks running into it in both directions, so that cars entering or leaving the house will not interfere with each other. The advantage of a system of this kind when all the cars are being run in the same direction, as in case of fire, is readily seen. The wash room is placed at one side of the car house, entirely out of the way of arriving and departing cars. While it has a single track running directly through it, there is

of much greater extent owned by the company, is approximately 110 cars, which, with the numerous other build-





EXTERIOR AND INTERIOR OF NOVEL WORCESTER CAR

ings in use for this purpose, it is thought will supply sufficient storage for a number of years to come. The general an extra rail laid to gage on each side of this track, so that it can be used either as a double-track or a single-track room.

When used as the former, the cars enter, of course, from the transfer table at the rear end. Directly in front of this room is placed a sand bin, which contains coils of pipe in the sand, for drying by steam heat. The entrance to the sand bin is at the side, so that a flat car containing a load of sand can be readily unloaded into the bin from the wash-room track. The sand then passes over the coils of hot pipe down a sloping floor to the center and is discharged at

WASH ROOM—GATES LANE CAR HOUSE

the bottom thoroughly dry and in a convenient situation for supplying the sand boxes.

At the center of the building tracks are laid upon which runs a transfer table made by the Taunton Locomotive Works, of Taunton, Mass. This table is of the well-known design which has been perfected by this company, having spring ways on each side which are forced down to the longitudinal tracks as a car runs up on the transfer table or is being removed from it. When a car is being transferred from one track to another on this table the springs hold these inclines in a horizontal position so that they clear perfectly all the other tracks and the rapid shifting of the cars is made possible. Immediately behind the transfer table is a line of fireproof doors separating the rear end of the car house from the front. This rear end is divided into two unequal parts, about one-third being used for storage and the remainder containing the pit rooms and the work and store rooms. The location of these rooms is such as to greatly facilitate the repair of the cars, everything being in the immediate vicinity of the work going on and so placed that repairs are made with the greatest rapidity. A blacksmith shop is provided at the rear of the first pit which has an equipment of tools sufficient for ordinary repairs on trucks, etc., including an electric motor for operating the machine tools and running a fan for the forge draft. Adjoining the blacksmith shop, and made throughout of the best fireproof construction, is an oil room. Along the side of the building are arranged small rooms containing

OPENING THE LINE AFTER A SNOW STORM

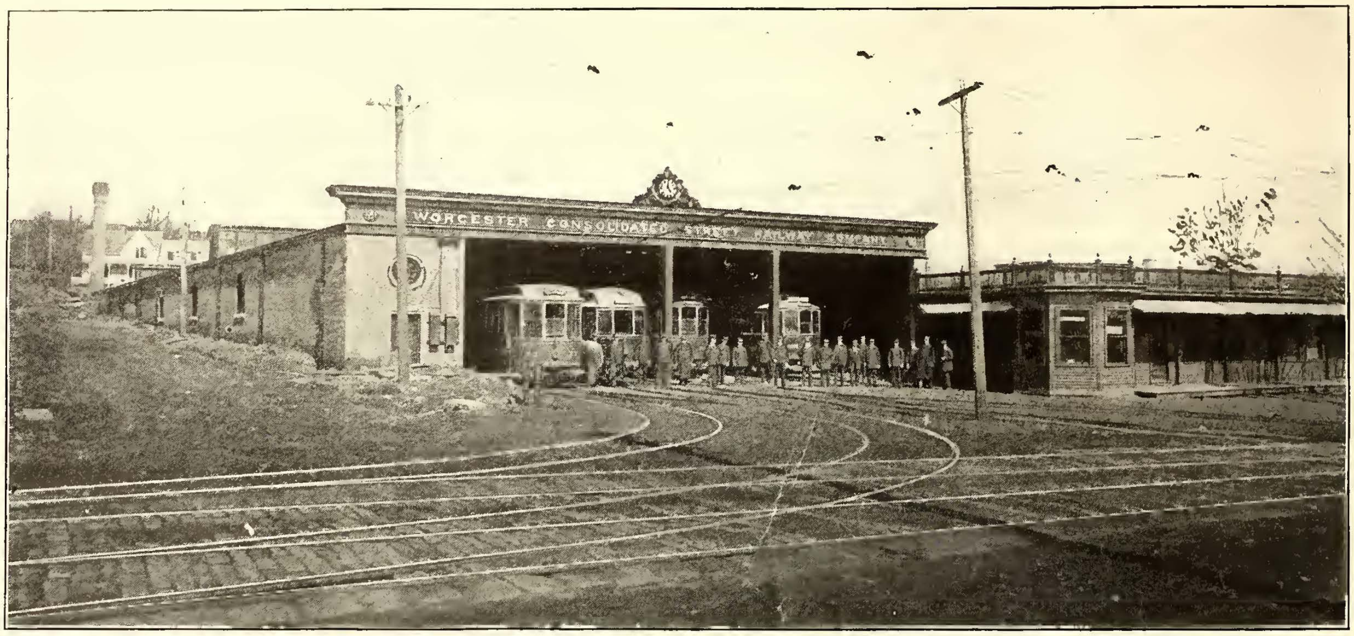
the various supplies immediately necessary in repairing cars, the pit foreman's office, lockers, etc. The boiler room which supplies the steam for heating the building, drying

1600-KW DIRECT-CONNECTED UNIT IN FREMONT STREET STATION

the sand, etc., is provided with a track running directly over the coal pocket, which is placed in front of the boiler. In this way the coal car can be run in and dumped with great ease.

The inspection pit at the side of the building, which is illustrated in one of the accompanying engravings, is of a rather peculiar construction. The floor on each side of the rails is lowered a foot or two so that work on the truck can be done in a more comfortable position than where the floor is level with the track. This pit greatly facilitates the rapid inspection of the cars, both by enabling the inspector to obtain more daylight around the trucks and to better get at the various parts without assuming a cramped position. Running under the pit tracks is a transfer truck for removing wheels. The wheels are removed in a manner somewhat out of the ordinary. The pair of wheels shown in the illustration of the pit room are placed over a removable section of the track. After a car has been run over this section it can be jacked up by the hoists at the side, and by removing these sections of rail a pair of wheels can be lowered to the transfer truck below without difficulty. A car body hoist at the rear allows a truck to be removed and run back into the blacksmith shop on the continuation of the pit tracks. Two jib cranes are provided for the handling of motors and other heavy parts in the pit room. With the exception of the inspection pits having the lower platforms running along the sides, the girder supporting the rail rests on wooden columns; in the inspection pits, as shown in the engraving, these are made of brick. The lighting of the pits internally is effected by incandescent lamps placed in a peculiar socket having an inverted cup-shaped tin sheath to protect the socket from moisture. A work bench is placed at the side of the room near the inspection pit, where small repairs can be made.

There is a small pond on the property of the company adjoining the car house, from which water is pumped to a 30,000-gallon tank on the roof by a motor-driven pump in the small pump house in the rear of the building. This supply of water will be used in general throughout the piping system of the building, but the town supply is constantly in readiness to be turned on in case of emergency. A number of fire hydrants are placed in convenient places about the premises, and a city fire-alarm box is located at the corner of Gates Lane and Main Street. All the rooms are provided with an automatic sprinkler system connected to both supplies of water. All the glazing of the monitors, etc., is made with wired glass. In the front corner of the structure a handsome office building has been placed containing the starter's office, clerk and receiver's office, division superintendent's office and locker rooms and lobbies for motormen and conductors. The lockers are made of expanded metal and arranged so that there is a large amount of free space where the motormen and conductors can assemble when off duty. At the corner of this building, in addition, is a waiting room for passengers containing a restaurant. This latter is of great convenience to the company, as it enables the employees to get their meals immediately at the car house when working on extra hours and at other times when it would otherwise be necessary



THE GATES LANE CAR HOUSE

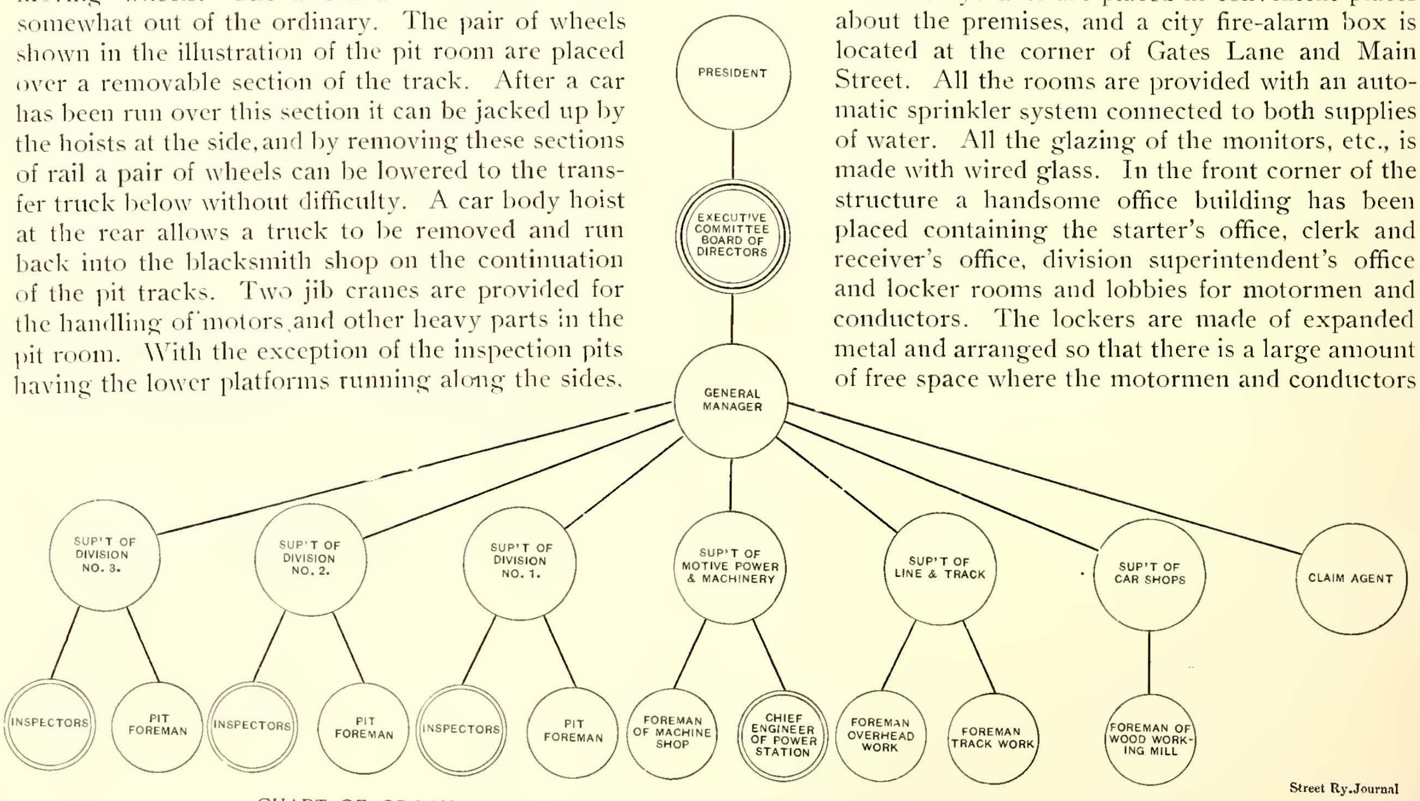


CHART OF ORGANIZATION, WORCESTER CONSOLIDATED STREET RAILWAY COMPANY for them to procure their meals outside. The entire car house is supplied with a system of watchman's clocks, and an efficient supervision is kept at all times. A master clock is placed in the starter's office, which is connected to several automatic electric clocks throughout the building. On the front of the building there is placed a large clock, also operated from the master clock in the starter's office, which will enable the conductors and motormen to set their watches without leaving the cars. This clock is 3 ft. 6 in. in diameter, and its face, which is of ground glass, is illuminated at night by five 16-cp incandescent lamps, there being two lamp circuits connected to a double throw switch, one being held in reserve for emergencies. The electrical circuit between the master clock and the others is operated by a battery current from two cells, the master clock closing a contact once every minute. The figures on the dial are Roman numerals, so as to be readily distinguishable as well as having a pleasing appearance. All of this time service has been supplied by Blodgett Bros. & Company, of Boston. At the entrance of the car house and directly in circuit with the main current supply is a circuit breaker and ammeter, and outside of the house in the same main is an auxiliary circuit breaker. The ammeter furnishes a ready method of showing at night whether the electric heaters, a few of which are used in the building, are turned on or not, as well as indicating how much power is being used by the machine tools, etc. The lighting circuit is also supplied with a circuit breaker.

All the floors in the pits are granolithic. The tracks, except over the pits, are laid on sleepers, with the ultimate intention of paving with common sidewalk brick. The total car house area per car is 552 sq. ft., assuming the exact capacity as being 109.53 ft. over all cars. The outside doors of the building were furnished by the Kinnear Manufacturing Company, Columbus, Ohio, and are of the steel-rolling type.

ORGANIZATION

The Worcester Railways & Investment Company, which was organized about a year ago to control the Worcester Consolidated Street Railway Company and its allied lines, has a similar financial scheme to that adopted by the Massachusetts Electric Company, and has proved very satisfactory to both the financial and engineering interests. The Worcester Consolidated Street Railway Company is the operating company of the system, and the relations which its officers hold to each other are shown in the accompanying chart of organization. The operating head of the system is the general manager, who reports directly to the executive committee of the board of directors, which includes, ex-officio, the president and vice-president of the company, and contains in all six members. The various heads of the departments, as shown in the chart, all report to the general manager. After the consolidation the system was divided into three divisions. The division superintendents are men who were connected with the roads entering into the consolidation, so that they retain practically the same positions that they held before consolidation. The motive power and electrical equipment have, however, been consolidated under one head, the superintendent of motive power and equipment, which greatly aids in the standardization of the rolling stock and enables the company to adjust its power distribution in the most advantageous manner. The superintendent of motive power and machinery, therefore, has two departments directly under him, as shown. The line work both for track and overhead material is also done in one department, which is subdivided into two divisions. The officers of the company are as follows: President, F. H. Dewey; vice-president, A. G. Bullock; secretary and treasurer, J. W. Lester; general manager, R. T. Laffin; superintendent of motive power and machinery, William Pestell; division superintendents, H. E. Bradford, J. B. Gorman and G. H. Burgess; superintendent of car shops, J. H. McMillin; superintendent of line and tracks, George B. Shepley. The offices of the company are in the handsome new building of the State Mutual Life Insurance Company, on Main Street, the square, white top of which is seen above the other buildings in the picture on the first page of this article.

Arrangements for the A. S. R. A. Convention at Detroit

The American Street Railway Association will hold its twenty-first annual convention at Detroit, Mich., on Wednesday, Thursday and Friday, Oct. 8, 9 and 10, 1902. The local committee at Detroit has arranged for the Light Guards Armory for both exhibits and convention sessions. The armory is within easy walking distance of all the leading hotels in the downtown district of Detroit, and but a few blocks from the Campus Martius, which is the street railway center of this city. The location of the armory is at the corner of Larned and Brush Streets. The exhibits will, of course, be on the main floor and galleries of the armory. The convention will be in one of the assembly rooms, and the accountants' convention in one of the parlors. The amount of exhibit floor space available, in galleries and on main floor, including aisles, will be between 18,000 and 19,000 sq. ft.

J. H. Fry, assistant general passenger agent of the Detroit United Railway, is chairman of the local committee on exhibits. Applications for space should be made to Mr. Fry, whose office is at 12 Woodward Avenue, Detroit. In the announcement to possible exhibitors, which is being sent out by Secretary T. C. Penington, it is stated that space should be applied for by Aug. 1. As the space is so limited, compared with last year, it is not unlikely that the applications for space will exceed more than ever before the capacity of the hall, and the local committee will no doubt be obliged to reduce the space from that asked for by each exhibitor in many cases after taking into consideration the total amount applied for by all the various supply houses. In making applications, the amount of space and shape of space desired should be stated. It is earnestly requested that all exhibits be in place on the evening of Oct. 7, prior to the opening of the convention. All articles intended for exhibits must be delivered to the Light Guard armory by its agent or owner at his own expense, but the local committee has made arrangements with the Riverside Storage & Cartage Company to haul and deliver all shipments to and from the building, if desired, at low rates. All electrical connections for power and extra lights must be made at the expense of the exhibitor. The local committee on exhibits will make contracts with carpenters, electrical workers and laborers at the regular price, so that the exhibitors will not be overcharged for lumber, labor, etc. Thursday, Oct. 9, has been set apart by the executive committee for the examination of exhibits. No session of the association will be held on that day, and no entertainment of any kind will be given by the local committee, so that delegates will have ample time to look at the exhibits. The headquarters of the association will be at the Cadillac Hotel. Other first-class hotels are the Russell, Wayne, St. Clair, Normandie, Griswold and Metropole.

Detroit is noted as the convention city of America, and the local street railway people have had ample experience in handling many dozens of conventions of various kinds each summer, so that no fear need be entertained but that the local arrangements will be excellent for the coming street railway convention.

Acceleration and Movement of Heavy and High-Speed Electric Trains *

BY W. C. GOTSHALL

Somewhat over a year ago the New York & Port Chester Railroad Company commenced an investigation upon heavy and high-speed electric traction. In the pursuit of this investigation there have been prepared by the engineers of the New York & Port Chester Railroad, and directly under the supervision of and by C. O. Mailloux, my associate, and myself, several hundred "run sheets," the object of these investigations being, of course, to determine the economical and proper conditions of operation for the proposed service of the New York & Port Chester Railroad Company.

I received the advance copy of Dr. Hutchinson's paper a few days ago. After reading the paper, it was apparent to me that the results and conclusions arrived at by Dr. Hutchinson in this paper were diametrically opposite to those which we had obtained in the study of the technical details of electric train service proposed for the New York & Port Chester Railroad Company.

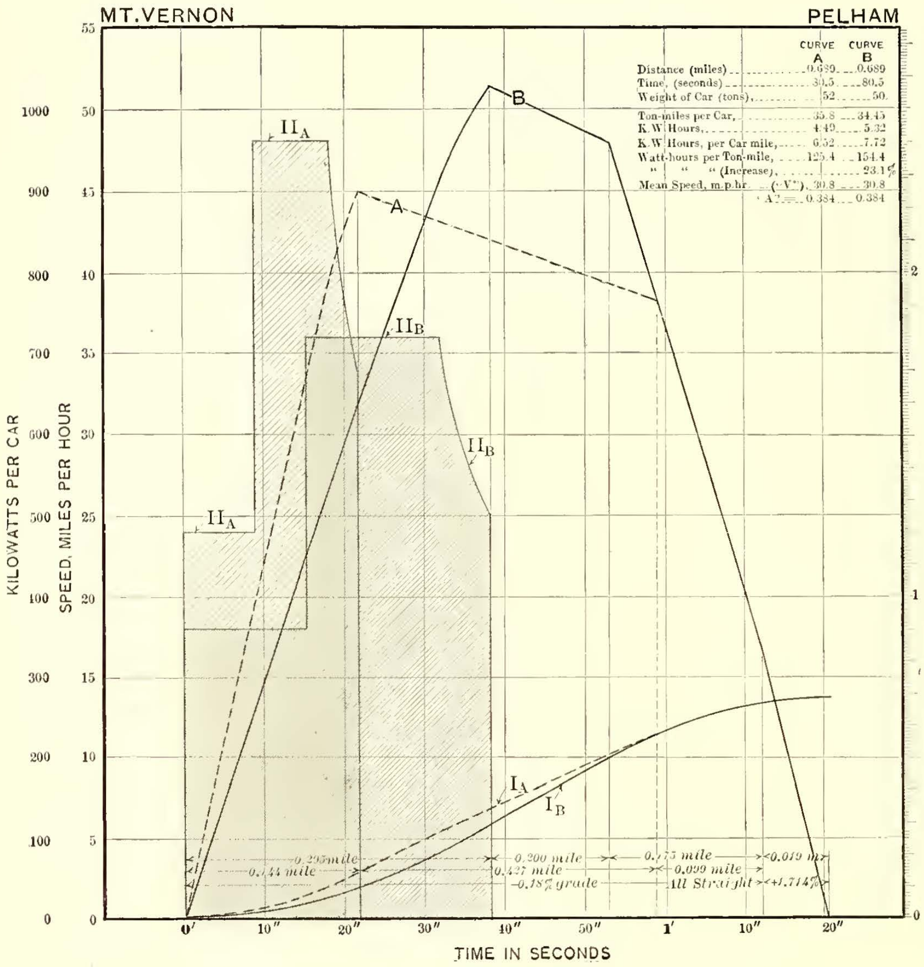


FIG. 1

On account of the difference between the results which we obtained and the conclusions of Dr. Hutchinson's paper, I will here call your attention to a few of the typical run sheets which have been worked out by us and which are now the property of the New York & Port Chester Railroad Company.

The paper which has been read purports to be, as stated in the first paragraph, a general solution covering all cases which can arise in ordinary practice of train movement. This statement is very broad—certainly broad enough to include, as a particular case, high-speed train movement such as would be required for rapid transit service. It is more particularly this aspect of the paper which I propose to discuss. It will be my purpose to confine this discussion to the fundamental points upon which the treatment of the paper rests, so far as I have been able to grasp them by examination of the curve sheets and by perusal of portions of the text. I may say that I am not quite prepared to look upon this solution as having a character and application quite as far-reaching as the author's statement would imply, for the reason that it fails to take into consideration some important points which generally involve and determine very important modifications in practical results. We all agree as to the desirability of finding and developing graphical methods for computing and analyzing the various factors and elements involved in the problem of train movement under certain given conditions. I am not prepared to believe, however, that it is wise to attempt a too broad or sweeping generalization by simplification at the expense of accuracy. The simplification is apparently obtained, in this case, by making many of the conditions a function of one principal, independent variable, which is called the "through acceleration" and designated by the letter A. Now, it is true that, in electric railroad work, as in other branches of our profession, in dealing with any problem we must always bear in mind the old adage that circumstances alter cases. These circumstances assume a difference in relative importance in many cases to such an extent that, while they may be of minor consideration in some cases, they become the primary consideration, or, literally, the independent variable, in other cases. Take, for instance, rapid transit work. In this case time is the paramount consideration; economy becomes a secondary one—contrary to the author's conclusion that economy of power is the sole governing consideration in the selection of an equipment. In high-speed work, the speed, in fact, is limited only by the absolute technical and commercial possibilities and impossibilities of the case.

If I interpret the author correctly, there are, at least, seven assumptions which he has made, apparently to simplify the mathematical treatment of the subject, which assumptions are apt to be fallacious in many cases and to require modification in almost all cases. These assumptions are the following:

First. That the line be absolutely straight.

Second. That it be absolutely level.

Third. That the train resistance is constant at all speeds.

Fourth. That all runs for the entire length will not differ materially from the average length of run.

Fifth. That the power will be applied during the first part of the run only; that is to say, only on the first part of the speed-time curve.

Sixth. That the general-type curve can be used with simple corrections for calculating the energy consumption under all conditions.

Seventh. That the rules and formulæ applying to tramcar practice will also apply to rapid transit practice.

I do not think that the conclusions of Dr. Hutchinson, or his method of arriving at those conclusions, are at all applicable to practical conditions. In this paper Dr. Hutchinson has used and applied the letter A as a symbol designating what he chooses to call "through acceleration," which is a purely abstract idea, the physical meaning of which is not easy to realize. For the purpose of ascertaining what range of value this term may have, I have taken a number of typical runs for the New York & Port Chester Railroad as they have been worked out and have determined the value for A for each of these runs. These determinations are shown in Table 1 in the column marked "A." The variations for the individual runs in the values of this quantity are very great, the difference being as much as 200 per cent. I believe that Dr. Hutchinson intends the value of "A" to be a sort of average acceleration factor. If such be the case, I call your attention to the fact that it would be impossible to arrive at any value of the average acceleration factor which could be used in practice from the results shown in Table 1. This is due to the material difference in the lengths of runs, as well as to the grades and curves which influence the maximum speed attained. In Table 1, under the column marked "angle," are shown the inclinations of the various acceleration lines. The column marked "coefficient" gives the numerical value of the "tangent" of the corresponding angle, which is equal to the corresponding rate of acceleration in m. p. h. per second. The variation in the value of these angles is, undoubtedly, of interest, but cannot be a matter of any great surprise. These variations might, indeed, have been expected, since any conditions of the line other than that of a level

* Paper contributed in discussion of Dr. Hutchinson's paper at meeting of the American Institute of Electrical Engineers, Jan. 24, 1902.

condition must of necessity produce a different inclination for the line of acceleration, and, consequently, must determine a different value for the angle.

It may be well here to give a summary of the principal data in regard to this project. The project contemplates a four-track line running from the Harlem River to the Connecticut State line at Port Chester. Two of the tracks are to be used for express train traffic and two for local traffic. The total length of the main line, according to the present surveys, is 20.9 miles. The express trains will serve a total of eleven stations, making ten stops—the longest run being 3.114 miles and the shortest run 0.689 mile, and the "average length" 1.9 miles. The local trains will serve a total of twenty-two stations, making twenty-one stops. The longest local run is 1.853 miles and the shortest run (No. 10) is 0.428 mile, the "average" being 0.95 mile. The two main diagrams (Figs. 1 and 2) show the speed-time curves for local train runs No. 11 (Fig. 1) and No. 20 (Fig. 2). Some of the curves in Fig. 2 are reproduced

different kinds of motor equipments giving different accelerations. These diagrams have been prepared with the greatest care, every precaution being taken to consider, and to make due allowance for, every factor entering into the case. The data from which these curves were made were collated with the greatest care, and may be said to be substantially free from any assumption or guesswork whatever.

The curves themselves were drawn on a relatively large scale, in order to enable them to be drawn more accurately and to insure greater precision in all computations made by reference to these curves. In the original diagrams the speed values (m. p. h.) are drawn to a scale of 10 millimeters per mile and the time values (seconds) to a scale of 5 millimeters per second. The total chart, showing the run diagrams for all the express runs, is nearly 10 meters long and is 0.7 of a meter wide.

The curves were prepared with a view to being made as nearly expert-proof as possible. These curves constitute a part of the tech-

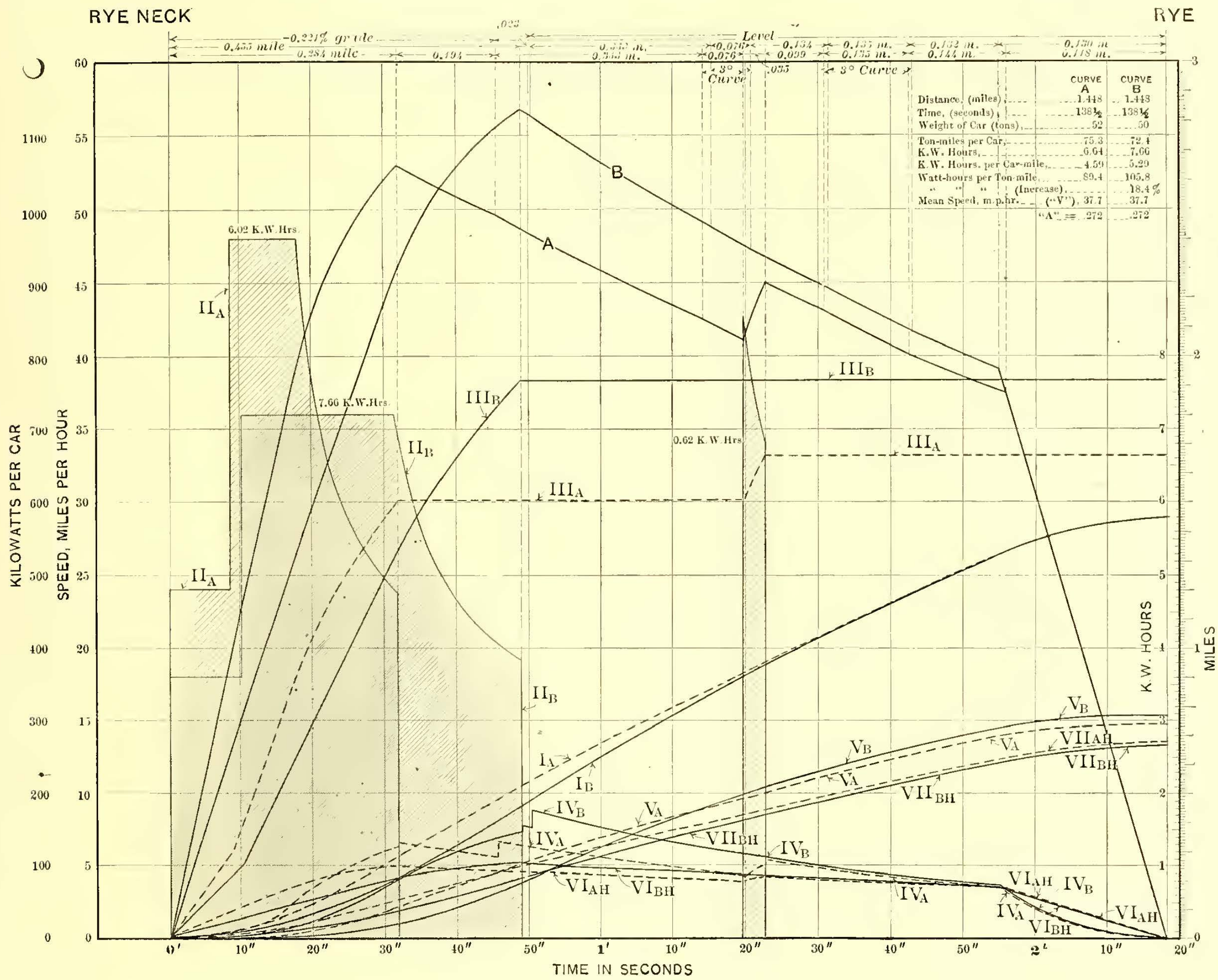


FIG. 2

separately in Figs. 2a and 2b. Table I gives various data in regard to the express runs. Table II. gives certain data showing the influence of grades on the initial acceleration.

The schedule time proposed is thirty-one minutes for express trains and forty-nine minutes for local trains. The schedule speed is, therefore, 40.58 m. p. h. for express trains and 25.6 m. p. h. for local trains. An allowance of fifteen seconds is made for stops. The mean speed (or average velocity) is, therefore, 44 m. p. h. for express trains and 28.9 m. p. h. for local trains.

Each car is to be equipped with four motors, one on each axle, thereby making the entire weight available for traction. The total weight of car for express service (fully loaded) is 52 tons, of which 17 tons (34,000 lbs.) is the weight of the complete motor equipment. For the local service, another car has been under consideration having an equipment of four smaller and lighter motors, making the total weight of car 50 tons (with full load.)

The diagrams in Figs. 1 and 2, already referred to, have been selected out of a large assortment of similar diagrams relating to various conditions of service and operation because they show a comparison of the energy required for a given run with the two

nical work recently submitted before the Railroad Commissioners, and the expert testimony corroborating them, as well as the manner in which they withstood the desperate attempts to discredit or criticise them on the part of the New York, New Haven & Hartford Railroad Company before the Railroad Commissioners, are, I think, a sufficient credential to entitle them to your consideration.

These diagrams and the tables will serve to make my meaning clear in regard to the various assumptions made in Dr. Hutchinson's paper to which I have previously called attention.

Let us briefly consider these various points. As to the first point, it is well known that no line is absolutely straight, and it is also well known that the curves increase the resistance to traction in a manner which varies with the sharpness, or the "degree," of the curve. The increased traction resistance due to curves tends to change the slope of the speed-time curve, and, consequently, affects the form of this curve the same as an up-grade; but its influence does not end here, however. The increased traction resistance is, indeed, but a secondary consideration, introduced by the railroad curve. The principal consideration is the limitation which it sets to the speed that can be safely maintained on those curves. This limitation does not operate so as to introduce any material modifications in ordinary tramcar practice, but it becomes a very serious and important consideration in rapid transit service. Unless the curve occurs at the beginning or at the end of the run, at which portions the speed is relatively low, it will be necessary to arrange matters in such a way that the speed will not exceed a certain limit at the time when the car reaches the points at which it enters the curve. This could be easily done by having a motor whose limiting speed would not exceed the safe speed for the curves; but it is unnecessary to state that this would be inadmissible, because the motor would be entirely too slow to make time on the straighter portions of the run. It is necessary, therefore, in such cases, for the car to accelerate to a relatively high speed, and for this speed to be

Table II.

Effect of Grades on Initial Acceleration.

GRADE Per Cent.		300 Ampere Motor				400 Ampere Motor			
		Speed	Acceleration			Speed	Acceleration		
		10 Seconds After Starting (M. P. H.)	Coeff. (V. T.)	Initial Angle		10 Seconds After Starting (M. P. H.)	Coeff. (V. T.)	Initial Angle	
				Deg.	Min.			Deg.	Min.
Up	+2 0	10.2	1.02	45	34	17.4	1.74	60	7
"	+1.5	11.3	1.13	48	30	18.4	1.84	61	29
"	+1.0	12.4	1.24	51	6	19.5	1.95	62	51
"	+0.5	13.5	1.35	53	29	20.6	2.06	64	7
Level	0.0	14.6	1.46	55	36	21.5	2.16	65	3
Down	−0 5	15.6	1.56	57	21	22.8	2 28	66	19
"	−1.0	16.7	1.67	59	6	23.8	2.38	67	13
"	−1.5	17.8	1.78	60	41	24.9	2.49	68	7
"	−2.0	18.9	1.89	62	7	25.9	2.59	68	53

then reduced, either by coasting or braking, or both, so as to bring it down to the proper limit at the time of entering the curve. It may be necessary to again turn on the current and again accelerate, after the curve is passed, in order to maintain the schedule speed. The presence of curves, therefore, introduces what are called "notches," or "humps," in the speed-time or curve run. These notches not only affect the form of the curve, but also have an important bearing on the energy consumption in watt-hours per ton mile. The paper of Dr. Hutchinson ignores them entirely.

One such "hump" is shown in Fig. 2, in the curve A, where the speed is reduced purposely before entering a curve (of 3 degs. radius), after passing over which the electric current is again turned on so as to accelerate the speed again for a short time before coming to the next curve (also 3 degs.), in anticipation of which the acceleration is curtailed, and some coasting is again allowed.

As for the second point, it is again well known that there is not a railway that is absolutely level from end to end, and it is also well known that grades materially affect the power required at different parts of the line. The principal point of interest in connection with the influence of grades in this case is the fact that a car accelerating on a grade will have its rate of acceleration modified by the grade—that is to say, the slope of the first part of the speed-time curve, or what my associate, Mr. Mailloux, designated in the Buffalo discussion as the "initial angle of acceleration," with a given equipment having a definite gearing ratio, depends upon the grade. Now, we all know that with the present resistance method of speed control the energy consumed in a given time at starting is constant, independently of the speed, up to the point at which the regulating or starting resistance is all cut out, at which point the acceleration begins to follow the so-called "motor curve." Yet, the rate of acceleration, that is to say, the initial angle of acceleration, and the distance covered up to the point at which the resistance is all cut out, may differ considerably, according to the grade. This means that the speed attained within a given time and with a given energy input will depend on the grade. I have tabulated (in Table 1) the values of the acceleration coefficient (see column headed "Coeff.), which is numerically equal to the tangent of the angle of acceleration for the eleven express runs of the proposed New York & Port Chester Railroad going in the direction of Port Chester. The highest value (2.36 per cent, corresponding to an angle of 67 degs. 2 min.) will be found in start No. 7, which, as shown in per cent grade column, is on a down grade of 0.9 per cent. The lowest value (corresponding to an angle of 61 degs. 1.8 min.) is obtained at start No. 6, which is on an up-grade of 1.714 per cent. In starts Nos. 1 and 2, which are on a level line, the value is 2.15 (angle equals 65 degs. 3 min.). Table II. gives the values of the acceleration angles and coefficients for two different kinds of motor equipments on up grades and down grades of, respectively, 0.5 per cent, 1.0 per cent, 1.5 per cent and 2 per cent.

It will be seen from this table that a 2 per cent grade, for instance, changes the acceleration coefficient materially. With the 300-amp. motor the accelerating rate (coeff.) of 1.46 on the level falls down to 1.02 on an "up" grade of 2 per cent and rises to 1.89 on a "down" grade of 2 per cent. With the 400-amp. motor, the accelerating coefficient which is 2.16 on the level is 1.74 on an upgrade and 2.59 on a down-grade of 2 per cent.

As to the third point, it may be said that while there is no material error in assuming constant train resistance for all cases where the speed does not exceed 25 m. p. h., yet above those speeds there is a possibility of error, which becomes a certainty when the speeds reach 40, 50 or 60 miles, the amount of error increasing with the speed. This matter is now so well understood that a mere mention is sufficient. Very little reasoning will show that the increase of train resistance as a function of the speed cannot be left out of consideration in any computations relating to high-speed service. It was shown by Mr. Armstrong, in his very able paper before this Institute in 1898, that for a given run the maximum speed reached during the run will increase as the angle of initial acceleration decreases. Now, as the train resistance is a function of the speed which is higher than the first power (usually comprised between the values of exponent = 1½ and exponent = 2) it would follow that the energy actually consumed in the movement of the train is greater with low accelerations according to resistance values, because the maximum speeds attained and maintained during the run are higher. This is shown graphically by special curves in Fig. 2, which, for the sake of clearness, are reproduced separately in Figs. 2a and 2b. In these diagrams, Figs. 1, 2, 2a, 2b and 2c, the letter A designates, in every case, curves having reference to a 52-ton motor car equipped with four motors and using 400 amps. in each motor in starting, while the letter B designates in every case curves having reference to a 50-ton motor car equipped with four motors, each using 300 amps. at starting. The curves "A" and "B" are the usual speed-time or run curves corresponding to these two kinds of equipment.

The curves 1-A and 1-B are the distance curves corresponding to these run curves—the ordinate value at any point on the distance curve, as read on the scale of miles at the right hand of the diagram, being equal to the distance traversed by the corresponding train at the corresponding time point.

The curves II.-A and II.-B are the power input curves, showing the electric power applied to each car at every instant of time during which current is used. It will be noticed that while in Fig. 1 the current is applied in each case only once, namely, at the beginning of the run, being shut off when the maximum speed has been reached, in Fig. 2 the current is again turned on for the run marked "A" corresponding to the 400-amp. motor equipment. The area of these power curves is, of course, equal to the energy consumption, usually expressed in kilowatt-hours.

Curves III.-A and III.-B are the energy, or kilowatt-hour curves, corresponding to the preceding curves and obtained by the integration of the same, the values being read by reference to the special

Table I

Concerning Express Runs of New York & Portchester Railroad

Run No.	From	To	Distance Miles	Time Seconds	Watt Hours per Ton Mile.	Speed			Per Cent. Grade at Starting	Acceleration				
						Highest	Lowest	At Braking		Coeff.	Angle		V	A
											Deg.	Min.		
1	Willis Avenue	149th Street	1.625	152½	160	57.5	25.0	59.7	.....	2.15	65	5	38.35	.264
2	149th Street	Bronx Park	2.751	204	141	60.5	40.0	62.7	.....	2.15	65	3	48.6	.238
3	Bronx Park	Bronx and Pelham Parkway	1.429	91½	169	60.4	60.4	60.4	+0.65	2.02	63	40	56.0	.614
4	Bronx and Pelham Parkway	Mount Vernon	3.104	218½	100	67.0	57.8	57.8	+0.163	2.12	64	45	51.2	.234
5	Mount Vernon	Pelham	0.689	72	172	53.3	50.0	50.0	−0.18	2.20	65	34	34.5	.479
6	Pelham	New Rochelle	1.843	166	142	54 5	38.4	50.3	+1.714	1.80	61	0	40.0	.241
7	New Rochelle	Larchmont	1.853	144	114	63.4	....	55.0	−0.90	2.36	67	2	46.35	.322
8	Larchmont	Mamaroneck	1.22	113½	158	57.6	42.7	55.0	+0.122	2.11	65	45	38.7	.341
9	Mamaroneck	Rye Neck	2.883	207½	111	62.7	41.7	55.4	−0.261	2.22	65	45	50.1	.2415
10	Rye Neck	Rye	1.45	105½	142	60.8	48.0	51.5	−0.22	2.21	65	39	49.5	.469
11	Rye	Portchester	2.09	127	159	58.8	36.0	52.2	+0.424	2.26	66	8	59.2	.467

scale (killowatt-hours) at the right-hand end of the diagram.

Curves IV.-A and IV.-B are special curves, to which we have given the name of intrinsic power curves. These curves show the power in this case being expressed n kilowatts. These curves are power in this case being expressed in killowatts. These curves are calculated by reference to a simple and well-known formula expressing the relation between the speed and the power required to keep the car moving at that speed. The curves show two notches, which are due to different causes. The first, or smaller notch, is due to the increase in train resistance caused by the addition of the motor and gearing friction, which are both excluded, being counted as part of the motor efficiency while the car is running. This notch occurs at the time-point when the current is shut off. The second notch corresponds to the point at which the motor leaves the down-grade on which the start was made. The moment that the car leaves the down-grade the energy required for traction of course instantly increases. In the case of an up-grade, the notch would have shown a downward slope instead of an upward slope at this point, the height of the notch being, of course, in proportion with the percentage of grade.

These curves are calculated by reference to formulæ, which include the variation of the train resistance as a function of the speed. This explains their convexity toward the time-axis at the beginning and at the end.

Curves Nos. V.-A and V.-B are the integral curves of the preceding curves, which, consequently, give at each time-point the energy consumed in train resistance up to that point. The ordinate values for the power curves are expressed in kilowatts, which may be read by the kilowatt scale at the left-hand end; the ordinate values of the energy curves V.-A and V.-B are expressed in kilowatt-hours and may be read by the energy scale at the right-hand end of the diagram.

Curves VI.-A H and VI.-B H are the corresponding intrinsic power curves, drawn according to the assumptions made in the paper of Dr. Hutchinson. These curves are calculated on the assumption that the line is level and that the train resistance is constant at 18.2 lbs. per ton, as stated in Dr. Hutchinson's paper.

Curves VII.-A H and VII.-B H are the corresponding intrinsic energy curves. These curves are reproduced separately, together with the corresponding run curves, which are exactly the same as in Fig. 2 (in Fig. 2b for the sake of greater clearness). The intrinsic power and energy curves, calculated by our own formula, are also separately reproduced in Fig. 2a. A simple glance suffices to show the radical difference between the curves shown in Fig. 2a and those shown in Fig. 2b. With the assumption of constant train resistance, the beginning and the end of the intrinsic power curves of Fig. 2b are very much higher than they should be, while they are very much lower at the middle points corresponding to the highest speeds attained during the run.

It will be observed that while the dotted line curve (V.-A) in Fig. 2a, corresponding to the intrinsic power of the train having higher acceleration, shows higher ordinate values than the solid line curve (V.-B) in the early parts of the run, yet it shows lower values at the end of the run, the two lines crossing at a time-point about midway in the run, as clearly shown on the diagram. The total intrinsic energy is slightly under 3 kw-hours for the higher acceleration and somewhat over 3 kw-hours for the lower acceleration. On the other hand, the corresponding energy curves in Fig. 2b retain throughout the entire run such relation that the dotted line curve (VII.-A H) always remains above the solid line curve VII.-B H) throughout the entire run. From the form of the energy curves in Fig. 2a, which show clearly that the energy actually consumed in maintaining the speed is less for a high acceleration than for a low acceleration, one would be led to look for greater economy with higher acceleration; whereas, from Fig. 2b, one would be led to expect the contrary result. These curves illustrate the manner in which an unwarranted assumption may lead to erroneous conclusions.

As to the fourth point, namely, the average length of run, in the case of the New York & Port Chester Railroad the average length of run is 1.9 miles (10,032 ft.) for the express train runs and 0.95 mile (5,020 ft.) for the local train runs. The longest express train run is 3.114 miles and the shortest 0.689 mile. The first column in the table gives the length of all the eleven (11) express runs in

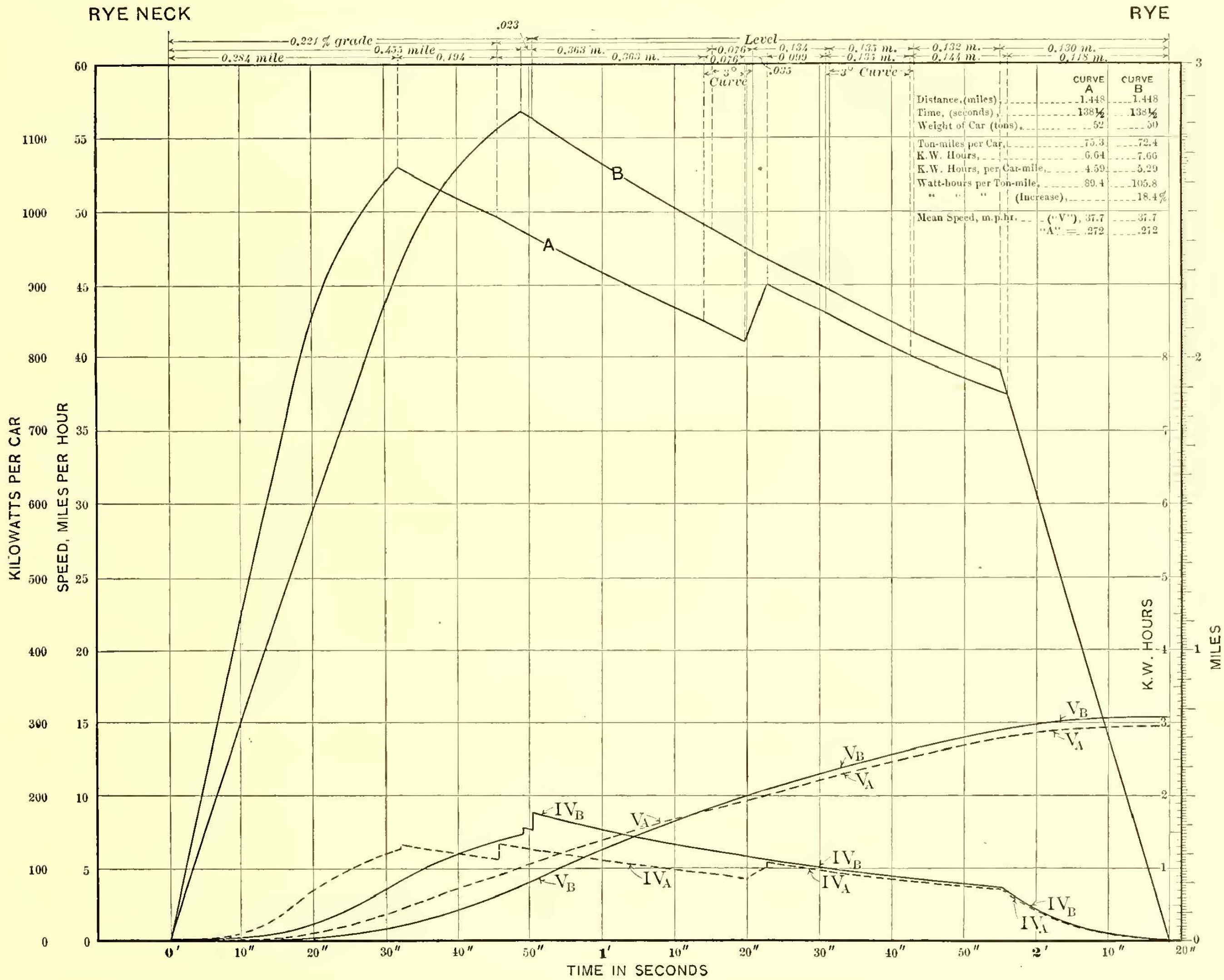


FIG. 2A

miles. It will be seen that the longest run (No. 4) is 3.114 miles and the shortest one (No. 5) is 0.689 mile. In the case of the local runs, the longest one is 1.853 miles and the shortest one is 0.428 mile. It will be seen that there are not two of the express runs which are of the same length and that the range of variation is great. The same statement applies to the local runs. Referring again to the values of the factor which Dr. Hutchinson designates by the letter "A" and to which he gives the term "through acceleration," it will be seen that this value also varies widely, its highest value (for run No. 3) being .614 and its lowest value (for run No. 4) being .234. The variations of this quantity "A" are such as to show clearly that it is not an independent variable, but that it is itself a function of other things, such as the length of the run, the maximum speed attained, or of some other quantity.

In regard to the fifth point, namely, the assumption that the power will be applied during the first part of the run only, it may son's paper, although they are evidently of too much importance to be thus slighted in any comprehensive solution such as this is asserted to be. The difficulty of dealing with them is increased by the fact that the percentage of energy due to these successive accelerations depends entirely upon the peculiar conditions of the case and cannot in the present state of the art be foreseen or predetermined in any other way than by actually constructing the speed-time curve under the exact conditions. It is of interest to note in this connection that in Fig. 2 in the run corresponding to the motor having higher acceleration the total energy consumption for the entire run is still lower than that required for the entire run with the equipment of the lower acceleration, notwithstanding the fact that, in the former case, a consequent acceleration occurs which involves an additional energy output of 0.62 kw-hours. I have also brought with me, and will add to the discussion, four additional run diagrams (Figs. 3, 4, 5 and 6)*, two of which (Figs. 3

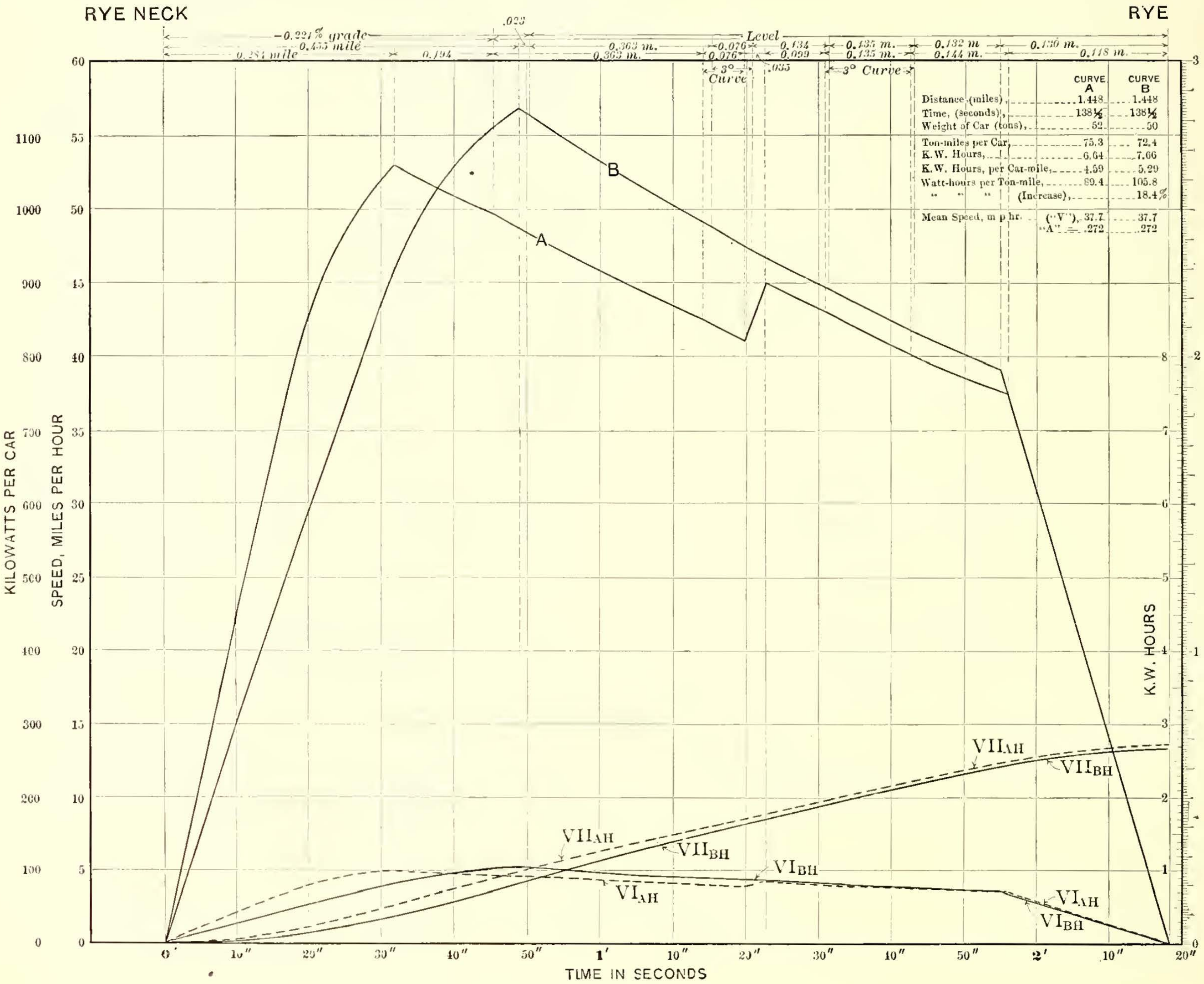


FIG. 2B

be said that this is somewhat related to the first, that is to say, it depends on the relative straightness of the line and has already been referred to in that connection. The necessity of reducing the speed either by coasting or braking so as to enter a sharp curve at or below a certain definite limited speed involves in most cases the necessity of again putting on the current and of again accelerating or raising the speed before coasting. An example of this is shown in Fig. 2 in the run in curve A already referred to, where the car, after attaining a speed of 53 m. p. h., is allowed to coast, so that by the time the car enters the curve the speed has fallen down to 42½ miles. The limiting speed for this curve (3 degs. of curvature) being 50 m. p. h., the car continues to coast until the speed has fallen down to 41.1 m. p. h., at which time the current is again turned on and the speed is accelerated to 45 m. p. h. The diagram shows that the energy input curve, corresponding to this second acceleration, requires an expenditure of 0.62 kw-hours, which, added to the energy consumed in the first acceleration (6.02 kw-hours), makes a total of 6.64 kw-hours as the energy required for the run. In some runs it may be necessary to have three, four, or more successive accelerations. These supplemental accelerations are left out of consideration entirely in Dr. Hutchin- and 4) show notches due to the necessity of reducing the speed on entering curves and requiring subsequent acceleration involving additional energy input. These curves give interesting information as to the expenditure of energy required for these successive accelerations. These curves and the other curves also show incidentally some interesting results of the influence which a small increase in the time of the run exerts on the energy required for this run. The table on each diagram gives the principal data and results in regard to each diagram.

As to the sixth point, namely, the use of a speed-time curve of general type for all cases and conditions, it is my opinion that such a curve, simplified as it must necessarily be, involves too many assumptions to be a safe and desirable expedient. Without analyzing very definitely the character of the correction to the type curve which the author suggests and proposes to apply, I will say that I am inclined to look upon this correction with suspicion, not only because it ignores the important points just discussed, but because of the possibility of error in the computation of the resulting energy

* The run diagrams presented were those shown by Figs. 1, 2, 3 and 4, on pages 46, 47, 48, 49 of the STREET RAILWAY JOURNAL for January, 1902.

input curve. The correction, as I understand it, consists in reducing the actual curve to an equivalent typical curve in which the entire acceleration is along a straight line, as shown by the dotted line M A A. It seems to me that this correction leaves room for doubt as to the form of the energy input curve, and, consequently, leaves room for more or less important error in the estimated energy consumption. I surmise that this is, in fact, another one of the weak points of Dr. Hutchinson's hypothesis.

The seventh point requires no special discussion, as the discussion of the preceding points has already made its fallacy sufficiently evident.

I now come to the feature of Dr. Hutchinson's paper, which is, perhaps, of the greatest practical interest, namely, the somewhat radical conclusion which he arrives at, to the effect that, contrary to what has been hitherto believed, the economy of high acceleration is of secondary importance, if not negligible. At the top of page 34 the author says: "I have made these calculations for a number of cases to correspond with practical conditions; the result is always that the energy used per mile is less for the lower accelerations." On this point I absolutely disagree with Dr. Hutchinson. The comparison already referred to between the curves in Fig. 2a and Fig. 2b is, as we have seen, opposed to this conclusion. The comparison of the energy curves on Figs. 1 and 2, in my opinion, contradicts Dr. Hutchinson's conclusion entirely. The two run curves in each diagram, it will be noticed, are curves of equal area as well as of equal time, that is to say, the acceleration and coasting are arranged in both cases in such a manner that the run is made in the same time.

The curves show readily the necessity for higher maximum speed when using the equipment consisting of smaller (300-amp.) motors, giving a lower acceleration; and the energy input curves (3a and 3b) show a material difference in the energy consumption per ton-mile during the run, which difference is all the more striking if we take into consideration the fact that the curves (B) corresponding to the smaller motor involve a total train weight and an intrinsic energy expenditure corresponding to only 50 tons total load, while the curves (A) corresponding to the equipment of larger (400-amp.) motor involve a total train weight of 52 tons. As would be expected, and as shown by the comparison between Figs. 1 and 2, the shorter the run (Fig. 1) the greater is the economy of high acceleration.

The energy required for the high-acceleration run in Fig. 1, as shown by the area of the large energy diagram furthest to the left, is 4.49. The energy required for making the same run under the conditions referred to in curve B is that shown by the energy diagram furthest to the right, and is equal to 5.32 kw-hours. The data for both sets of conditions are given in the upper right-hand corner of the diagram.

The figures for the energy input per car mile corresponding to curves A and B are, respectively, 6.52 and 7.72 kw-hours—the corresponding figures for the energy in watt-hours per ton-mile being, respectively, 125.4 and 154.4. The increase of energy required for the lower acceleration is, therefore, 23.1 per cent greater with the smaller equipment giving the lower acceleration. The same comparison in the case of Fig. 2 shows that the increase of energy in watt-hours per ton-mile in the case of curve B, as compared with curve A, is 18.4 per cent.

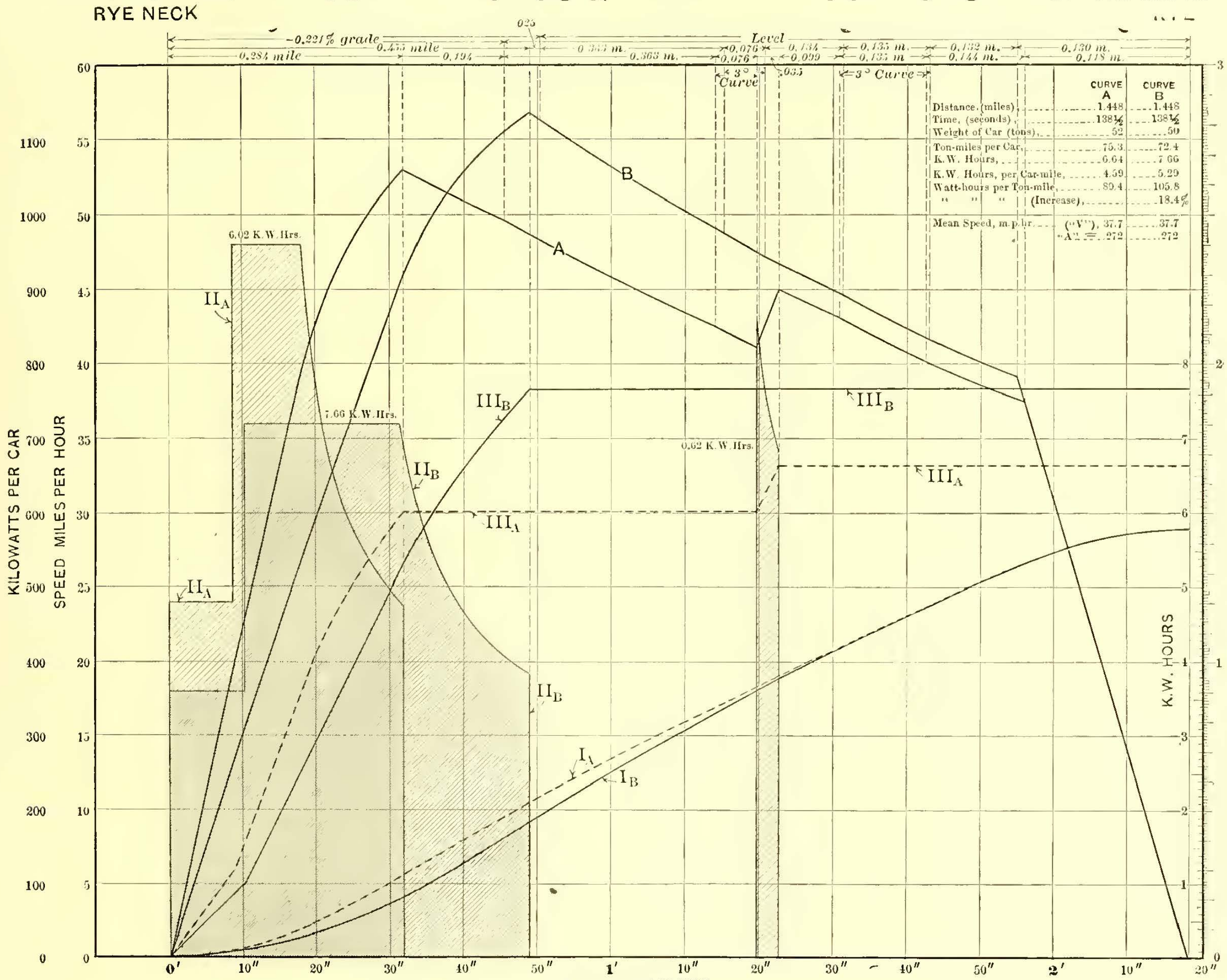


FIG. 2C

In discussing the New York Subway Rapid Transit Road the author concludes that the proposed schedule is impracticable, and he states that a motor capacity of 14.9 kw per ton is beyond the range of practical conditions. As the conditions in the case of the New York & Port Chester Railroad express service are, if anything, more severe, owing to the higher schedule speed, it would seem that the practicability of this project would also fail to meet the requirements of Dr. Hutchinson's formulæ. The 52-ton car has an equipment of four 400-amp. motors, operating at 600 volts, making an input of 960 kw, or about 18.5 kw per ton. If there should be a discrepancy between what we have found to be possible and what the hypothesis presented in this paper admits or limits, I for one think that the adjustment necessary to bring the two into harmony will have to come largely, in fact one might say wholly, from the side of theory.

The Manhattan Railway Company, of New York, finished the laying of thirteen three-phase submarine cables under the Harlem River to connect sub-stations in the Bronx with its main power station.

The Selection of Electric Motors for Railway Service*

BY W. B. POTTER

The excellent paper by Dr. Cary T. Hutchinson on the subject of energy and motor capacity for electric trains shows a careful study of the problem, considered from an average basis. In discussing that paper I shall endeavor to point out some variations from the average met with in the practical consideration of motor selection.

It may be stated as a general proposition that for a given schedule the lowest power consumption will be secured with the lowest speed gearing that will insure with reasonable margin the performance of the desired schedule. The torque per ampere is proportionately greater with the low speed gearing, and the maximum speed is also less; the first with respect to current fluctuations, due to improper handling of the controller, and the latter with respect to energy consumption, as influenced by the percentage of coasting, being less affected in their lower values by unskilled motormen.

Motormen will frequently keep the power on until they apply the brakes, regardless of the requirements of the schedule, and if gaining on the schedule will apply the brakes to slow down midway between stops instead of allowing the car to coast, as they should do before reaching maximum speed. It is a well-known and proven fact that different motormen, by reason of different percentages of coasting, may make a difference of at least 20 per cent in the energy required for the performance of a given schedule. The less frequent the number of stops the less will be the difference between different men. The difference may be taken approximately at 2 per cent for each stop per mile, and the more nearly the calculated requirements approach the theoretical or best possible economy the greater the allowance that should be made, as it is a fair assumption that none of the cars will be handled in a manner to secure the highest possible efficiency.

When a close calculation of the energy is desired, it is of advantage to use the actual characteristic of the motor under consideration rather than an average characteristic, not so much on account of the difference in power, due to the characteristic alone, as on account of the shape of the speed curve, which may differ widely at free running speed with different types of motors.

The free running speed assumed by Dr. Hutchinson as 130 per cent of the speed at which the external resistance is cut out would imply that power was cut off before the car had attained full acceleration, and it would depend entirely upon the service requirements whether such would be the case. Even 160 per cent is not sufficient for some motors. The free running speed will vary from 150 per cent to 200 per cent, the speed at which the resistance is cut out, that is, with motors of low saturation the car may double its speed on the motor curve.

The determination of motor capacity, that is, the motor heating in a given service, cannot with desired accuracy be obtained from the average of a number of motors. Dr. Hutchinson has assumed an average copper loss of 8.6 per cent of a rated input. This will vary from 5 per cent in the larger motors to 12 per cent in smaller motors, and different motors of the same commercial hp rating may vary 30 per cent to 40 per cent.

The average core loss has been assumed as 3.4 per cent of the rated input, and this percentage between different motors will be found to vary between 2 per cent and 5 per cent, and with motors having the same commercial hp-rating the core loss of some will be found to be double that of others. The following table will indicate some of the differences that actually exist between the motors of several different manufacturers.

PERCENTAGE LOSSES OF INPUT AT RATED CAPACITY

Commercial Rating	Field	Armature			Motor Total
	I^2R	I^2R	Core	Total	
38 hp.	4.70	4.00	2.37	6.37	11.07
38 "	4.60	3.80	4.92	8.72	13.32
50 "	4.2)	2.10	3.45	5.55	9.75
50 "	4.33	3.36	4.17	7.53	11.86
50 "	3 25	2.80	4.80	7.60	10.82
75 "	3.20	2.50	2.93	5.43	8.63
125 "	2.48	2.40	2.12	4.52	7.00

The average service losses in the motor as a whole have been assumed as an average of 9.4 per cent of the rated input, based on a maximum speed of 130 per cent. This average, both with respect to percentage and maximum speed, will vary materially with the character of the service; on frequent stops it may be a total of 9.6 per cent, with 3.2 per cent in the field and 6.4 per cent in the armature. With the same motor and infrequent stops the loss would be more nearly 3.4 per cent, with .6 per cent in the field and 2.8 per cent in the armature. As between different motors of the same rating for the same schedule, the total loss may be found to vary 30 per cent or more.

As between speed at rated capacity and free running speed, the core loss of some motors is constant within 5 per cent, while in other motors it may vary 100 per cent, being less at full speed.

The assumption that a motor will run one-quarter of the time at its commercially rated input for its rated temperature rise is a fair average, but actually the time will vary from 20 per cent to 50 per cent of the total time and depends on whether the motor is running closed or open, on the stand or under service conditions. In consideration of the variations that exist between different motors, it would seem a reasonable assumption that calculated temperatures based on the average of a number of motors would not give the actual loss in the fields within approximately 20 per cent, or the loss in the armature within approximately 40 per cent, and combining these variations with the difference in radiating capacity of different motors, the result based on averages might not give the actual temperature rise within 100 per cent.

The assumption that a motor as a whole will radiate continuously 3 per cent of its rated input is also a fair average, the variation being approximately 2.5 per cent to 3.5 per cent. This, however, does not give the distribution of losses in the field and armature, which is important as affecting temperature rise, and from the above table it will be noted that the distribution differs widely with different motors.

The commercial basis of rating a railway motor, i. e., "the hp-output giving 75 degs. C. rise for one hour's continuous run of 500 volts on a stand with covers off," was selected several years ago by the writer after a careful consideration of what the commercial rating of a railway motor could reasonably be expected to cover.

This method serves the commercial necessity of a relative measure of capacity between different motors, and the current required to give a temperature rise of 75 degs. C. in one hour insures a satisfactory test of commutation. It is further a desirably severe test of the mechanical and electrical design of the motor.

A criticism of this method of rating might be that the voltage should preferably be 550 instead of 500 volts, as 550 volts is now the more common voltage.

Seventy-five degs. C. rise was purposely taken at a higher temperature than railway motors should be operated in service, 65 degs. C. rise as a maximum and 55 degs. C. as an average being as high a temperature rise as is compatible with reasonable maintenance.

Before selecting this method the subject was carefully studied with reference to giving a significant rating applicable to service conditions, but the difficulty of doing this will be appreciated when it is understood that a tabulated statement of any one motor with different gear ratios, weight of cars and stops per mile includes 100 or more different schedules.

The use of motors too small for the service, with resultant burning out from overload, is inexcusable, for not only are they expensive to rewind, but the delays and annoyance to passengers incident to breakdown is above all things to be avoided. Reliability of service should be the primary consideration in every case.

The equivalent heating or reproduction of a given service by running the motor at the current giving an equivalent I^2R loss, and at the voltage giving the average core loss would be convenient and correct, providing the effective amperes of the given service are determined and applied at the proper voltage. The voltage at which such test should be made representing in effect the particular core loss for a given service will vary widely with motors of different capacities, and even between motors of the same capacity having different core losses.

Such a method assumes that for a common service there is a certain current and voltage common to all motors of the same capacity, which, if run on a stand with this current and voltage, will produce in the motors equivalent losses and in their proper distribution, and that the temperature rise of the armature and field so obtained will closely approximate the temperature rise in actual service.

The speed curves of railway motors materially differ; that is, they have different saturation curves, and, as before mentioned, the maximum free running speed in motors of the same rating may differ 50 per cent on the motor curve. Even assuming that the energy input in two cases is the same, the rate of input will not be the same, due to variations in the saturation curve; that is, the average current will be the same, but the current as effecting the heating, which is the square root of the mean square, will not

* Paper contributed in discussion of Dr. Hutchinson's paper at the meeting of the American Institute of Electrical Engineers, Jan. 24, 1902.

be the same, unless motors have the same saturation curve. These variations lead to the conclusion that a common current cannot be taken for various motors for a given service, as, regardless of the gear ratio, the speed, torque and ampere constants of each motor will not coincide, unless they have a speed curve of the same shape, which is seldom the case.

As before mentioned, the core losses of motors having the same commercial rating may vary as much as 100 per cent, some core loss curves being nearly constant in watt loss throughout the working range of the motor, while others at rated load may be double the watt loss at full speed.

The core losses are composed partly of eddy currents varying as a square of the speed or voltage and partly of hysterisis, varying directly as the speed or voltage, and the relative proportion of these two losses will vary greatly in different motors. It is not likely between different motors that the core loss of each will be composed of eddy currents and hysterisis in the same ratio; thus the speed or voltage that would give the service core loss would be quite different with different motors.

In order that the same current and voltage shall apply to several motors of different design or manufacture for a given service, it is necessary that the motors be geared exactly the same speed, that the motors shall have identically the same efficiency throughout, that the shape of the speed curve or saturation be identical, that the core loss curve be of the same shape and be composed of eddy and hysterisis losses in the same proportion.

It is needless to add that such uniformity does not exist, and it only remains to determine how far the difference between similar types of motors of different manufacturers differ from each other. This is shown by the following table of motors of different manufacture, with the current and voltage to give the losses and their proper distribution, the motors being geared to make the same schedule. The acceleration is taken at 1.5 miles per hour per second in every case.

Commercial rating	Amperes	Volts
Distance, 750 feet	Time, 54.4 seconds	
35 h.p.	35.9	310
35 "	33.6	344
38 "	32.4	372
38 "	33.4	351
Distance, 1 mile	Time, 227 seconds	
35 "	24 6	478
35 "	22.4	452
38 "	22.4	458
38 "	23.4	377

The above values for current and voltage would vary considerably with different percentages of coasting and different schedules.

Owing to the complex character of the core losses and speed curve a large number of calculations, of which the above are representative, indicate the futility of comparing or determining motors by assuming an arbitrary voltage. The current and voltage must be predetermined for each particular motor and service.

This method of rating further assumes that the temperature rise and the distribution of temperatures in a motor run on the stand will hold good under service conditions. Experience does not indicate this to be the case. A motor with a ventilated armature will give more nearly the service temperature rise on a stand than a motor with poorly ventilated armature. Furthermore, with a large number of starts per mile, the motor is run either at relatively slow speed or not running at all for a considerable portion of the time, while with few stops on high-speed suburban service the motor is relatively cooled by the long-continuous run, with the result that in the first instance the stand tests may give lower, and in the latter higher, temperatures, due to the relative difference in radiation of the motor frame.

For such determination of the motor capacity as is essential to the recommendation of motors suitable for a given service, experience has shown the desirability of determining the losses and consequent heating of the field and armature independently for each particular case.

From a speed curve based on the acceleration and maximum speed required for a given schedule the proper gearing, winding and commutation of a motor suitable for the service can be obtained. Owing to different lengths of runs, slow-downs at curves and the effect of grades, the speed curves of different runs over the line may, and usually do, differ materially. Having established the speed curves for a given service, the field and armature losses may be integrated by reference to the resistance and core loss curves of the motor under the varying conditions of control and running on the motor curve.

Having determined the average loss in the field and armature for a particular service, the next step is to determine the temperature rise of the field and armature under these conditions.

It is obvious that the most accurate means for determining the heating effect for different losses is to test the motors under service conditions at a known loss in the field and armature, and to measure the actual resultant heating.

To this end the motors should be mounted on a car and operated at various schedules and distances on a track, careful records being taken with recording instruments of the speed-time curves, amperes and voltage, the tests being continued until the motor temperature is constant. The temperature should be taken both by thermometer and by resistance, both with the motors closed and with the covers removed. From the known losses in the motor during these tests there may be determined the degrees rise per watt loss, both for the field and armature; the distribution of the losses in the two elements being represented by the watt loss in the armature divided by the watt loss in the field.

Having determined the ratio of losses for the particular service a reference to the temperature tests for the particular motor and ratio of losses enables one to determine the degrees rise per watt loss for the armature and field. It is then a simple matter of multiplication to determine closely the temperature rise of the armature and field for the proposed service.

Several years' experience with different methods of determining motor capacity have shown this to be the only rational and reasonably accurate method, as it takes into account all the variable factors.

The following table has been calculated directly from results determined under service conditions as described above, and shows in tabulated form the capacity for a safe temperature of a 38-hp motor with different stops per mile, gear ratios and tons per motor:

List of Schedule Speeds for 38-HP. Motor

500 Volts. 33-in. Wheels. Straight and Level Track. 10 per cent. Margin Allowed in Schedule.

Stops per Mile	Gear Ratio	Tons Per Motor									
		4	4.5	5	5.5	6	6.5	7	8	9	1
¼	4.60	22.3	21.7	21.2	20.9	20.5	20.2	19.8	19.3	18.8	18.5
¼	3.94	23.3	22.9	22.4	22.0	21.7	21.3	21.0	20.4	19.9	---
¼	3.42	25.0	24.6	24.2	23.7	23.2	22.8	22.4	---	---	---
¼	2.82	27.6	27.0	26.5	26.0	---	---	---	---	---	---
½	4.60	20.9	20.5	20.2	19.8	19.5	19.3	18.7	18.2	17.6	17.3
½	3.94	22.0	21 6	21.2	20.9	20.5	20.2	19.8	19.2	18 5	---
½	3.42	23.5	23.0	22.6	22.2	21 8	21.3	21.0	---	---	---
½	2.82	25.6	25.0	24.6	24.0	---	---	---	---	---	---
1	4.60	19.4	19.0	18.6	18.3	18.0	17.7	17.5	16.8	16.4	15.7
1	3.94	20.3	19.9	19.6	19.3	18.9	18.5	18.2	17.5	16.8	---
1	3.42	21.6	21.2	20.7	20.3	20 0	19.6	19.3	---	---	---
1	2.82	23.0	22.6	22.1	21.6	---	---	---	---	---	---
2	4.60	15.8	15.5	15.3	15.1	14.9	14.7	14.6	14.2	13.9	13.5
2	3.94	16.6	16.4	16.1	15.9	15.7	15.5	15.2	14 8	---	---
2	3.42	17.6	17.2	16.9	16.7	16 3	16.0	---	---	---	---
2	2.82	18.1	17.8	17.6	---	---	---	---	---	---	---
3	4.60	13.7	13.5	13.3	13 1	13 0	12.9	12.8	12.5	12.2	12.0
3	3.94	14.3	14.8	13.9	13.8	13.7	13.5	13 3	12.9	---	---
3	3.42	14.9	14.1	14.6	14.3	14.0	---	---	---	---	---
3	2.82	15.4	15.2	---	---	---	---	---	---	---	---
4	4.60	12.2	12 1	12.0	11.8	11.6	11.5	11.3	11.2	11.0	10.8
4	3.94	12.6	12.4	12.3	12.2	12.1	12.0	11.8	11.4	---	---
4	3.42	13 0	12.8	12.7	12.5	12.3	---	---	---	---	---
4	2.82	13.3	13.1	---	---	---	---	---	---	---	---
5	4.60	11.1	11.0	10.9	10.8	10.7	10.6	10.4	10.3	10.1	---
5	3.94	11.4	11.3	11.2	11 1	11.0	10.9	10.7	10.4	---	---
5	3.42	11 8	11.6	11.5	11.3	---	---	---	---	---	---
5	2.82	11.9	---	---	---	---	---	---	---	---	---
6	4.60	10.1	10.0	9.9	9.8	9.8	9.7	9.6	9.5	9.2	---
6	3.94	10.4	10.3	10.2	10.1	10.0	9.8	9.7	---	---	---
6	3.42	10.6	10.5	10.4	10.3	---	---	---	---	---	---
6	2.82	---	---	---	---	---	---	---	---	---	---
7	4.60	9.4	9.3	9.2	9.1	9.1	9.0	8.9	8.8	8.5	---
7	3.94	9.6	9.5	9.5	9.4	9.4	9.2	9.1	---	---	---
7	3.42	9.7	9.6	9.5	---	---	---	---	---	---	---
7	2.82	---	---	---	---	---	---	---	---	---	---
8	4 60	8.8	8.7	8.6	8.5	8.5	8.4	8 4	8.3	8.2	---
8	3.94	9.0	8.9	8 8	8.8	8.7	8 6	8.5	---	---	---
8	3.42	9.0	8.9	8.9	---	---	---	---	---	---	---
8	2.82	---	---	---	---	---	---	---	---	---	---
Max.	4.60	27.3		26.0		25.0			23.5		22.7
Speed	3.94	29.0		27.5		26.5			25.0		24.0
*Double	3.42	31.0		29.6		28.5			26.9		25.9
Equip.	2.82	35.0		33.5		32.3			30.6		29.5

* Speed of 4-motor equipment 5 to 10 per cent faster for same tons per motor.

Such a method serves as a rapid, convenient and reasonably accurate method of selecting a motor within the variations covered.

This practical determination of the heating factors has led to marked improvements in the electrical design of motors, and the value and utility of these tests under service conditions can hardly be overestimated in their application to practical conditions.

In closing, I wish to express my thanks to Messrs. E. D. Priest and E. H. Anderson for their assistance in the calculations incident to the preparation of this paper.

A Consideration of the Inertia of the Rotating Parts of a Train *

BY NORMAN WILSON STORER

The problem of calculating the motor capacity and the amount of power necessary to maintain a certain train service involves a consideration of where all the power which is developed by the motors is expended; of just how much is used in overcoming train resistance; how much in overcoming the force of gravity, and how much in overcoming the inertia. The train resistance is a variable quantity depending on the track, bearings, wind and speed. A considerable number of formulæ have been produced to assist in calculating the train resistance under different speeds, but at the best the amount to allow for train resistance is only approximate. The energy required to overcome the force of gravity and the inertia of the train, however, is susceptible of the most exact calculation, but the latter part is seldom estimated correctly. There is one element in the inertia factor which has been almost entirely neglected, either because it has not been recognized at all or because its importance has not been appreciated. This feature is the inertia of the rotating parts of the train.

It has been generally understood that armatures of small diameter and light weight are desirable because their small fly-wheel capacity makes easier braking, but it has seldom been considered that this means also less power developed by the motor. A recent investigation of this subject has led to some very interesting results. It is found that the wheels with their low speed and the armatures, which usually revolve at a much higher rate than the wheels, together constitute an important element in the determination of the power required for operating the train. A specific instance will show this most clearly. Take the case of a double-truck car weighing 30 tons loaded. It has eight 33-in. wheels weighing about 700 lbs. each, and two motors rated, we will say, at 150 hp each. The radius of gyration of the wheels is about 77 per cent of the radius of the wheel. The center gyration of the wheel, therefore, moves at a rate 77 per cent of that of the train. The fly-wheel effect of each wheel then is equal to a weight of $\frac{700}{.77^2} = 415$ lbs. when reduced to the speed of the car. Eight wheels will therefore add 3320 lbs. to the inertia weight of the car.

The armatures have each a fly-wheel effect of 1400 lbs. at a radius of 6 inches. With a gear ratio of 18 : 53 the center of gyration of the armature will move a distance of 9.25 ft. for every revolution of the axle, or for a corresponding movement of the car of 8.6 ft. Its relative speed is, therefore, $\frac{9.25}{8.6} = 1.08$ times the car speed, and the fly-wheel effect is therefore $1400 \times 1.08^2 = 1640$ lbs. reduced to the car speed. The two armatures thus add an equivalent weight of 3280 lbs. to the inertia weight of the car.

The wheels and armatures together add an equivalent of $3320 + 3280 = 6600$ lbs., or about 11 per cent to the inertia weight of the car.

The following paragraph will show the effect of a change in the gear ratios:

With a gear ratio of 20 : 51 the fly-wheel effect of the armatures would be equivalent to the addition of 2400 lbs. to the inertia weight of the car. This together with that of the wheels adds a total of 5720 lbs. or about 9.5 per cent to the inertia weight of the car.

From a considerable number of instances that have been taken the fly-wheel effect of the rotating part of an electric car is found to average about 10 per cent of the inertia of the entire weight of the train. This means that 10 per cent more energy is stored in every train than is accounted for by the dead weight, 10 per cent more power is required for accelerating, 10 per cent more energy is lost in braking, and the train resistance measured by the retardation in coasting is 10 per cent below the true resistance.

The actual increase in energy supplied to a train on account of the fly-wheel effect of the rotating parts is the energy in these parts which is lost in braking. The relation this bears to the total power developed by the motors is dependent on the number of stops, the speed at the time the brakes are applied and on the energy absorbed by the train resistance. Where the stops are frequent, the energy lost in brakes may be from 50 per cent to 75 per cent of the entire power developed by the motors, in which case the energy required by the rotating parts will be from 5 to 7½ per cent of the total.

There are two simple methods for including this item in the calculations. The first is by basing the calculations on a weight of car 10 per cent heavier than the actual in determining the acceleration and drifting. The second is by assuming that the force required to produce a certain rate of acceleration is 10 per cent higher than would be necessary if it were simply a dead weight. This is probably the simpler method, as it gives round numbers for calculations, as 10 per cent added to 91.3 gives practically 100 lbs. per ton as the force required for accelerating at the rate of 1 mile per hour per second. All that is necessary then in correcting calculations for accelerations is to use this figure of 100 lbs. per ton instead of 91.3. It will give a good average correction, although if great accuracy is desired it will be preferable to calculate the fly-wheel effect of each of the rotating parts of the train separately. It will usually be found that for slower speed service, where the gear reduction is considerable, that more than 10 per cent will be required, while for high-speed interurban work, where it would really amount to very little anyway on account of the small number of accelerations, the amount to be added for the correction will be less than 10 per cent.

As will be readily recognized this factor will also enter into the determination of the train resistance from the coasting line. Just how much of a correction will have to be made on this account depends somewhat on what is considered to be the train resistance. If this includes the friction in the motor then the train resistance obtained from the coasting line will be 10 per cent lower than the actual train resistance. On this assumption if the retardation in coasting is .2 miles per hour per second, the train resistance will be 20 lbs. per ton instead of .182 as calculated by the ordinary method. If, however, the train resistance does not include the friction of the motor the correction necessary to be made for inertia of rotating parts will be small, because it will be nearly balanced by the motor friction. When the train is coasting, the inertia of the rotating part is added to the inertia of the dead weight of the train in tending to keep up the speed, while the friction of the motor is tending to reduce the speed. When the train is accelerating, or moving with power on the motors, the motor friction is taken into account in the efficiency curve of the motor so that the train resistance to be used in calculating the acceleration should properly not include the motor friction. It will thus be seen that the error due to motor friction and the inertia of the rotating parts will tend to counterbalance each other in the determination of the train resistance from the coasting line. For accurate determinations, however, the train resistance should include a consideration of both the inertia of the rotating parts and the motor friction. The most accurate way to obtain this is to plot the friction curve of the motor and to obtain the inertia of the armature and wheels either from tests or from calculations based on the drawings.

It may be considered that this is an undue refinement, but if the matter is carefully investigated it will be found that the motor friction is quite a considerable portion of the total train resistance, in the same way as the inertia of the rotating parts is a considerable portion of the inertia of the train.

It is understood that general solutions for the railway problem may be offered which will give fair approximation of the motor capacity and the amount of power required. It is understood than any good engineer with a fair amount of experience can give a pretty good estimate of the power required for a given service, even when considering the capacity of the motor according to the old horse-power rating. But where accuracy is required, every known element should be considered at its proper value and there will still be at best enough variable quantities in the railway problem. The most reliable estimate for train resistance should be used; the inertia of the rotating parts should be obtained and considered; the weight of the entire train should be known; the acceleration and power curves should be carefully plotted and the average heating effect in the motors should be accurately determined before any large equipment is finally decided upon.

* Paper contributed in discussion of Dr. Hutchinson's paper at meeting of American Institute of Electrical Engineers Jan. 24, 1902.

The National Conduit & Cable Company, Times Building, Park Row, New York, has secured a contract valued at nearly $100,000 for trolley wire to be used in the construction of the Sydney City & Suburban electric traction system, Australia. The contract was obtained through R. W. Cameron & Co., of 23 South William Street, New York. As already mentioned in these columns, the initial equipment for the Sydney power station, representing an expenditure of some $800,000, was allotted to the General Electric Company, and it is proposed to extend the station shortly at an estimated cost, with equipment, of about $500,000. It may be well to state that the tenders now being invited by the municipal council of Sydney for the equipment, etc., of electricity supply works have no reference to further contracts for the Sydney electric traction system which is being built by the New South Wales Government Railway & Tramway Commissioners and not by the municipality of that Australian city.

The Relation of Energy and Motor Capacity to Schedule Speed in the Moving of Trains by Electricity *

BY CARY T. HUTCHINSON, Ph. D.

This discussion shows such serious misunderstanding of the paper that I will state its scope before referring to the remarks in detail. One of the most important factors in considering train movement is the initial acceleration. My purpose is to show the effect on the energy and motor capacity of using different initial accelerations. To this end it is necessary to keep all other conditions constant, otherwise the result is due to a change in more than one condition and cannot be estimated accurately.

I have therefore elaborated a method that gives the effect of varying the initial acceleration on the energy and motor capacity required for any fixed schedule speed over any distance. That is, I discuss the results of making, e. g., a schedule speed of 15 m. p. h. for a distance of 2000 feet, with any assumed initial acceleration. I do not discuss the differences due to various schedule speeds, although this is a simple deduction from the data given. Nearly every participant in this discussion has missed this point, and has assumed that the discussion was on the relative value of high and low schedule speeds.

To bring out the effect of varying one quantity all others must be kept constant. It is therefore necessary to use a generalized motor curve applicable to all sizes of motor. The general curve that I give is the average from a number of tramway motors now made by the two chief companies.

The criticism that these curves are not applicable by reason of the varying values of the motor losses is clearly without foundation; different motor characteristics will effect similar changes for an initial acceleration: better absolute results will be had with a better motor, worse with a poorer, but the relative results will not be altered.

The paper is based on certain assumptions; one is that the motor carries only the "rated current" during the period of initial acceleration. I have deduced the curves on various other assumptions of load during the initial acceleration up to 50 per cent overload; the relative results are not changed materially thereby, although the motor capacity required is changed. These curve sheets were not published; they would have made the paper too voluminous.

Perhaps the best answer to the general criticism of the "theoretical" and "mathematical" nature of this paper is a comparison of the results given by these curves with results obtained independently.

In the issue of the *Electrical World* of Jan. 25, 1902, the following data are given of the equipment adopted by the engineers of the Manhattan Elevated after long investigation:

Schedule speed, 14.7 m. p. h.
Length of run, 1775 ft.
Station stop, 14 secs.
Running time, 68 secs.
Total time, 82 secs.
Initial acceleration, 1.5 m. p. h. per second.
Retardation after braking, 2 m. p. h. per second.
Energy used per ton mile, 77 watt-hours.
Train weight (equivalent), 174 tons.
Equipment adopted, 8 G. E.-66, 1000 rated hp.
Kilowatts per ton, 4.3.
Starting current per motor, 200 amps.
Load at starting, 100 per cent of rated capacity.

From these data the average velocity $V = 17.7$ m. p. h. and the through acceleration $A = .26$.

The rule given in the paper is: The best initial acceleration to adopt is that acceleration giving the minimum motor capacity. Since these motors are used at their rated capacity during initial acceleration, as is assumed in the paper, the curve sheets are applicable except in so far as they are modified by the fact that the braking retardation adopted is 2 m. p. h./sec. instead of 3, as used in the paper. This will make a very slight difference in the results.

Curve Sheet 14, for $A = .26$, gives for the initial acceleration for the minimum motor capacity 1.5 m. p. h./sec., agreeing exactly with the figures determined by the Manhattan's engineers.

Curve Sheet 13, at this initial acceleration, gives for the energy required 75 watt-hours per ton mile. The Manhattan's engineers find 77; the agreement is substantially perfect.

Again, from Curve Sheet 14, the motor capacity required is

$$.165 \times 1775^{1/2} = 6.8 \text{ kw per ton.}$$

The capacity adopted by the Manhattan's engineers is 4.3 kw per ton. This difference is material. An examination of the curve sheets of the motor adopted—the G. E.-66—shows at once the reason. In the paper it is assumed that the sum of the core and copper losses at rated load is 12 per cent of the rated capacity. Curve Sheet 14 is based on this assumption, which, as I have said before, is a fair assumption. It happens, however, that this particular motor has a very low heat loss, the sum of the copper and core losses being only 7.8 per cent at rated load. The motor capacity depends directly upon this loss. Reducing the capacity found from Curve Sheet 14 in the ratio of 7.8/12—that is, the ratio of the heat losses at rated load—gives a motor capacity of 4.42 kw per ton for a motor such as the G. E.-66. This figure is practically identical with the value adopted for the Manhattan equipment.

In other words, the engineers of the Manhattan Elevated have unconsciously followed the rule contained in this paper and have adopted, after laborious investigation, motors giving exactly the same initial acceleration and the same energy consumption as would have been determined in a few moments by the curve sheets of my paper had they been available; and when proper allowance is made for the difference in the heat losses, practically the same motor capacity per ton. The engineers of the Manhattan Company evidently do not believe in high initial accelerations.

There is little that requires a detailed reply in the discussion of the paper. Mr. Stott and Mr. Gerry both state that it is a "recognized fact" that maximum accelerations give maximum economy. This, of course, I dispute; and as they offer no testimony to support their position, it must be taken merely as a matter of opinion. Mr. Gerry and others confuse schedule speed with initial acceleration and seem to think that I am arguing for low-schedule speeds.

Mr. Potter's paper gives interesting data on the individual characteristics of different motors, but has no particular bearing on my paper. We all know that motors differ, and for this very reason it was necessary for me to assume an average motor. Mr. Potter has probably not attempted to test the application of these curves to practical conditions or he would not have stated his belief that they were not applicable.

Mr. Gotshall has presented a number of interesting curves showing the "runs" on his proposed New York & Port Chester road. These curves are merely paper estimates, made in the same general manner as some of my curves are made, but for specific motors. By adding a discussion of the effect of grades and curves (which I purposely omitted, since they are arbitrary), Mr. Gotshall attempts to show that the results of my paper are not applicable to practical conditions. He finds great difficulty in comprehending the meaning of the quantity "A," the "through acceleration"; in fact, I think that it would hardly be an exaggeration to say that he has not yet comprehended it. In the verbal discussion of the paper he announced his discovery that this quantity A, which he declared I had called *constant*, had very different values for the different "runs" of his road! After thinking the matter over he offers in the written discussion another interpretation in these words: "In his paper Dr. Hutchinson has used and applied the letter A as a symbol designating what he chooses to call 'through acceleration,' which is a purely abstract idea, the physical meaning of which is not easy to realize. * * * The variations for the individual runs in the values of this quantity are very great, the differences being as much as 200 per cent. I believe that Dr. Hutchinson intends the value of A to be a sort of average acceleration factor."

I think it is hardly necessary to comment upon these quotations.

Mr. Gotshall, again referring to my unfortunate quantity A, shows that he finds great difficulty in grasping the meaning of "independent variable." He says: "Referring again to the values of the factor which Dr. Hutchinson designates by the letter 'A,' and to which he gives the name 'through acceleration,' it will be seen that this value also varies widely, its highest value (for run No. 3) being .614 and its lowest value (for run No. 4) being .234. *The variations of this quantity A are such as to show clearly that it is not an independent variable, but that it is itself a function of other things, such as the length of run, the maximum speed attained, or of some other quantity.*" Possibly he means by "some other quantity" that it is a function of the understanding of the reader, or the want thereof.

Mr. Gotshall also seems to think that he can use such motor capacities as 18.5 kw per ton. Since the weight of motors, controllers, brakes and sundry electrical equipment is very approximately 70 lbs. per kw, this means that 1300 lbs. will be required for these parts alone. It is difficult to see how the remaining 700 lbs. is sufficient for trucks, car body and passengers. That no such motor equipments will ever be used is a safe prediction.

Mr. Dodd, in his discussion, has taken the data and formulæ of my paper and by handling them in an incorrect manner has deduced certain results which are directly opposite to my results. He starts with equation (18) of the paper and makes it an arbitrary substitution of $100 = a\,x$; using the resulting equation, he calculates three

* Forming part of the discussion on Dr. Hutchinson's paper read before the American Institute of Electrical Engineers, Jan. 24, 1902, but contributed after adjournment.

tables. For each of these tables the initial acceleration, the brake power and the distance are constant. By assuming more or less use of the motor curve he gets several schedule speeds, and from them calculates the energy consumption. He then plots the schedule speeds so obtained in terms of energy consumption for the three different initial accelerations. This final curve sheet, which is the summation of his paper, offers no basis for comparing the same schedule speed with different initial accelerations. All that it does show is the difference in energy required for more or less use of the motor curve, with constant power, for the three particular initial accelerations assumed. In Table A, for instance, a schedule speed of 14.02 m. p. h. is obtained, with a velocity of 165 per cent of the rated velocity; whereas in Table B the schedule speed of 14 m. p. h. is obtained with a velocity of 112 per cent of the rated velocity. These two values are not comparable, as they are obtained under entirely different conditions.

In addition, Mr. Dodd uses the wrong equation to calculate the input. If any equation of this character is to be used, the equation (23) is the correct one and not (18).

The misunderstanding of the purport of the paper shown in the greater part of the discussion is in striking contrast to the clear view of its scope shown by our president. His statement of its bearing on the general question could not have been improved.

Dr. Hutchinson's Method of Determining Best Initial Acceleration *

BY LOUIS DUNCAN, PH. D.

Mr. Hutchinson's paper is valuable, as it brings out clearly the fact that a maximum train acceleration does not always mean an increased economy. The factors which he has taken into account have been neglected in the ordinary treatment of the subject. A high acceleration means an increased weight, and the added weight makes the energy per car mile for the same schedule about the same for all accelerations within the limits imposed. The tests which have been published, showing increased efficiency for high accelerations, have been made on trains with constant weights and with the same motors. They are not applicable to the practical case in which the motors must be designed to fit the acceleration.

It should be distinctly understood that in the paper the schedule is fixed, and the question discussed is the best acceleration to make this schedule. The motor curves are apparently taken from actual results obtained from machines now on the market and in operation, so there should be no question of their approximate accuracy.

The paper is important because it has lifted the question of train acceleration out of a rut and put it on a level of common-sense engineering.

Statistics of the Tramways in Great Britain and Ireland

The official report of the tramways of Great Britain and Ireland for the year ending June 30, 1901, and required by the House of Commons, has just been published. It contains the following among other interesting facts:

	England and Wales.	Scotland.	Ireland.	United Kingdom.
Capital authorized:	£	£	£	£
By shares	11 902,374	752,500	2,300,922	* 14,955,796
By loans and debentures	22,696,913	3,580,926	643.411	29,921,250
Total	34,599,287	4,333,426	2,944,333	44,877,046
Capital paid up:				
Shares	7,564,099	302,753	1,527,672	9,394,524
Loans and debentures	11,695,325	3,451,763	348,661	15,495,749
Total	19,259,424	3,754,516	1,876,333	24,890,273
Total capital expended	20,238,445	3,872,785	2,687,793	26,799,023
	Miles.	Miles.	Miles.	Miles.
Length of line	1,040	116	149	1,305
	Number.	Number.	Number.	Number.
Number of cars	5,051	1 204	555	7,184
Total No. of passengers carried	932,052.219	186,837,823	79,236,716	1,198,226,758
	£	£	£	£
Gross receipts	4,793,775	743,068	424,219	5,961,062
Operating expenses	3,652.047	569.056	304,076	4,525,179
Net receipts	1,141,728	174,012	120,143	1,435,883

* Forming part of the discussion on Dr. Hutchinson's paper read before the American Institute of Electrical Engineers Jan. 24, 1902, but contributed after adjou- ment.

A division is also made between those belonging to the local authorities and those not the property of the local authorities. This information is contained in the following table:

	Capital Expenditure on Lines and Works Open to Traffic.	Total Expenditure on Capital Account.	Length Open to Traffic. Double.	Length Open to Traffic. Single.	Length Open to Traffic. Total.	Number of Undertakings.
	£	£	Miles.	Miles.	Miles.	
Tramways belonging to local authorities	8,638,682	14,057,664	428	261	689	99
Tramways belonging to other than local authorities	10,261,517	12,741,359	257	358	615	114
Total United Kingdom	18,900,199	26,799,023	685	619	1,304	213

Tests on Power Consumption in Liverpool

In a recent paper before the British Electrical Engineers by J. Swinburne and W. R. Cooper particulars are given of some tests made on the Liverpool Elevated Railway with special motors designed to secure high acceleration. The total length of this line is 10.5 km (6½ miles), with seventeen stations. Up to the present this distance has been run in thirty-two minutes, or at the rate of about 20 km (12½ miles) per hour. Tests with new rolling stock have shown that this time can be reduced to 20.4 minutes, the time at stations remaining eleven seconds, as before. The total weight of the train, including passengers, during the trial run was 46.3 tons, the total carrying capacity of the train being 154 passengers. The energy required increased from 250 kj. per tonne km (110 watt-hours per ton mile to 310 kj. per tonne km (137 watt-hours per ton mile) or 6.35 units per train mile. The total cost of producing and transmitting this energy would be about 3d. per train mile. In the following table is given a summary of the results obtained:

	Old System	Accelerated Service
Mean speed	12½ miles (20 km.)	19½ miles (31 km.)
No. of stops	16	16
Mean time at stations	11 seconds	11 seconds
Mean distance between stations	729 yards (666 m.)	729 yards
Watt-hours per ton mile	110	137
Acceleration	1.6 feet (0.44 m.) per sec.^{2}	3 feet (0.91 m) per sec.^{2}
Retardation	3 feet (0.91 m.) per sec.^{2}	4.8 feet (1.26 m.) per sec.^{2}

Street Railway System in Plymouth, England

The extended description, published elsewhere, of the street railway system in Plymouth, Mass., makes a reference to the street railways of Plymouth, England, of interest. The transportation facilities of the city are really one with those of its neighbors, Stonehouse and Devonport, the three towns being indeed but one, and with their immediate suburbs comprising a population of about 250,000.

The London & South Western and the Great Western Railways conduct a special service of trains through the three towns. The bulk of the city traffic is, however, carried by the electric street lines. Of these there are three separate companies: The Plymouth Corporation Tramways Company, the Devonport & District Tramways Company and the London & Provincinal Tramways Company.

The Plymouth Tramways Company is a municipal corporation, and operates, at the present time, 12 miles of single track, runs thirty cars, and is now opening a new route of 2½ miles of track. The company carries, on an average, 660,000 passengers per month. This company is still extending its power house and opening new routes.

The Devonport & District Tramways Company is owned largely by American capitalists, and is managed by an American. The cars were purchased in Philadelphia. This company operates 15 miles of track and is about to commence work, if it has not already done so, on an additional 12 miles of track. The traffic on these lines, which pass through Devonport and suburbs and past the Royal Dockyard, is very heavy and constantly increasing. The company will shortly require several new cars, in fact plans are now being submitted to the manager. It is the purpose of this company to run out into the country, and, if possible, connect Devonport with Tavistock, about 14 miles distant.

The London & Provincinal Tramways Company leases from the Devonport Corporation the 2 miles of track connecting Plymouth with Devonport. These tracks run right through the heart of the three towns, and the traffic is very heavy. The whole equipment is the property of the Devonport Corporation, and the present company's lease is for twenty-one years.

An Analysis of Street Railway Operations in Germany

BY WILHELM MATTERSDORFF

The operating results of certain street railways in Germany, when analyzed and represented graphically, develop interesting curves which have been investigated by the writer and described in detail in the *Zeitschrift fur Kleinbahnen.* The following abstract of the more important principles brought out in the paper has been prepared, with the belief that the consideration of the subject from this standpoint will furnish material useful to the engineer as a basis for the preparation of his calculations, as well as of interest to the practical street railway operator.

The construction of the diagrams was passed upon two axes of reference, for which the work performed by the street railways in car kilometers per year was used as abscissas and the ratios of the most essential data relating to their operation as ordinates. It is to be noted that the data have not been used directly, but in a form that expresses the mutual relations of each, as given herewith:

(1) The relation of "density of car traffic" to number of "car kilometers run."

(2) The relation of "income per car kilometer" to "car kilometers run" or "traffic density."

(3) The relation of "expenses per car kilometer" to the above.

In accordance with this plan, eight large street railway systems, so far as their annual reports were available, have been investigated. The systems included are the following: Grosse Berliner Strassenbahn, Hamburger Strassenceisenbahn, Münchener Trambahn (Munich), Dresdener Strassenbahn, Deutsche Strassenbahn in Dresden, Breslau Strasseneisenbahn, Kölnische Strassenbahn (Cologne), and Wiener Tramway, of Vienna.

I. TRAFFIC DENSITY

Traffic density is construed as meaning the density of the car traffic, or the number of car kilometers made each year per meter of railway. The term *railway*, as here used, is taken in the sense defined by the *Verein deutscher Strassen- und Kleinbahn Verwaltungen*, as "length of streets along which tracks are laid and operated for public convenience according to established schedules." Tracks in switches, car houses, etc., are omitted in this figure. A kilometer of street containing a single or double track is reckoned

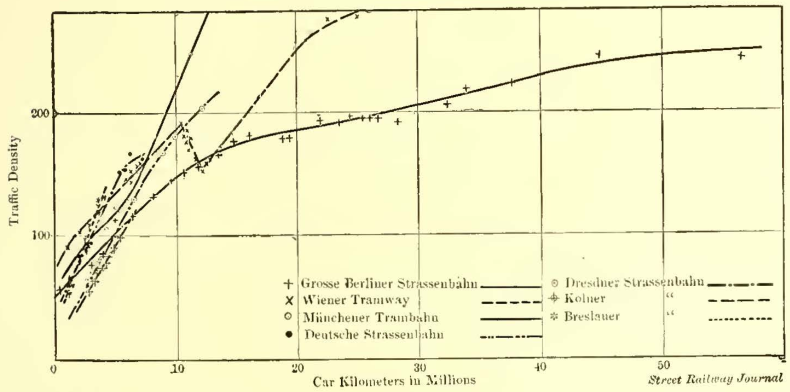


FIG. 1

as 1 km. Practically all of the trackage of the lines considered in the accompanying analysis is "double" track. The idea of traffic density, as applied to a large street railway with its branches, establishes a certain average value for the traveling population of the streets as well as for the transportation facilities of railway lines. This expression may be used also for the purpose of ascertaining the average interval between cars, which, of course, will be a fictitious quantity, but none the less characteristic for a railway system. To arrive at this result, the traffic density is divided by the average time of operation in a year expressed in minutes. The reciprocal of the quantity found will be the headway. For example, the average headway in the case of the Grosse Berliner Strassenbahn for the year 1900 with an 18-hour day, 56,000,000 car kilometers and 234 km of railway, is

$$\frac{234 \times 18 \times 365 \times 60}{56,000,000} = 1.65 \text{ minutes.}$$

It will often occur that rough approximations must be employed in calculations of this character owing to the fact that the reports of street railway companies are not sufficiently detailed to permit of the various data being arranged in their proper classes. For instance, the traffic density of the Grosse Berliner Strassenbahn in the period 1872-1889, for which there were no statistics available as to the length of *railway* operated, was taken as approximately one-half the total length of track.

In Fig. 1 curves are given showing the relation of traffic density to car kilometers run for various railways. From a study of these curves the following principle may be established:

Traffic density at first increases rapidly with the number of car kilometers run, then less rapidly, and finally reaches a limiting value beyond which there is no increase.

This principle applies, however, only when there is a uniform, progressive increase of car kilometers. If the development is not

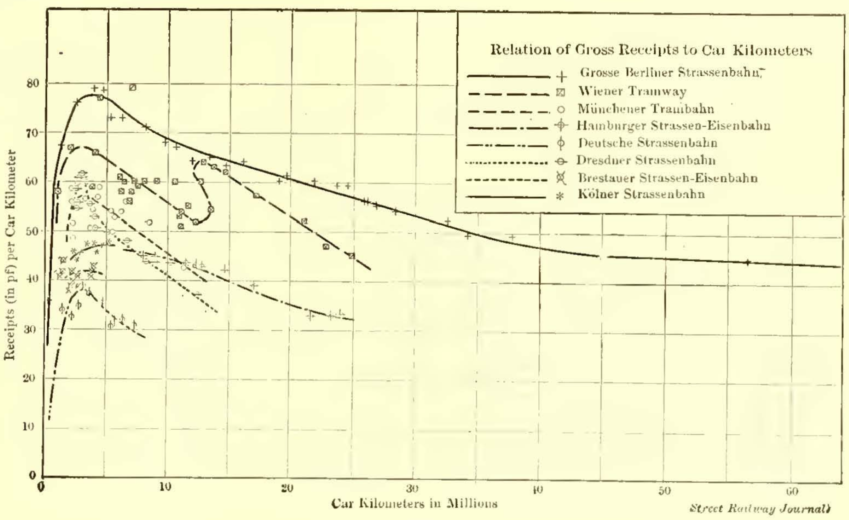


FIG. 2

uniform, as in case of a sudden extension of the railway mileage, with a decline, at the same time, in car kilometers, there will be a falling off in the traffic density until normal conditions are again reached.

Upon examining the individual curves, we find that of all the railways the Grosse Berliner Strassenbahn has reached a stage where the service approaches most closely to the limiting value. The traffic upon the busiest streets of Berlin can increase but very little in the future, and all additional traffic must be directed to other paths. The greater part of the increase in car kilometers during recent years has come from the extension of railway lines in the outer districts made possible by the introduction of electricity, but in the future there can be no such rapid growth in average traffic density. A similar condition of affairs exists with regard to the operations of the Deutsche Strassenbahn in Dresden, while the systems of Breslau and Cologne have not yet installed electric cars, and therefore show an undeveloped traffic density. The curve for the Dresdener Strassenbahn since the introduction of electricity begins to approach the horizontal at a rapid rate. The Munich railway is now increasing rapidly with respect to traffic density, owing to the small railway mileage combined with a rapid increase in car kilometers. The line representing the Vienna system exhibits special peculiarities that are noticeable. Although it shows rapid fluctuations as regards performance, yet all values for traffic density, with but four exceptions, lie on one curve. In its middle portion, covering the period 1884-1891, a depression is observed that is to be explained by a decline in traffic density and by the extension of railway mileage, but otherwise it ascends in an even manner to the end, where it approaches the limiting value as shown by the horizontal tendency.

A comparison of the absolute value of the traffic density in individual cases is also of considerable interest, even when only approximate accuracy can be secured. With the same number of car kilometers the traffic density is smallest in cities with large suburbs spread over extensive areas, while in cities with a complex railway system and large traffic it occupies a mean position. The largest traffic density is found in those cities having comparatively small suburbs and a railway system with few branch lines. In illustration of this, the following results are given for the railways under discussion, which are based upon 3,000,000 car kilometers: Cologne, 62 car kilometers per meter railway and 5½ minutes car headway; Dresdener Strassenbahn, 60 car kilometers and 5 minutes headway; Berlin, 78 car kilometers and 5 minutes headway; Munich, 100 car kilometers and 3.5 minutes headway; Deutsche Strassenbahn, 100 car kilometers and 3.5 minutes headway; Breslau, 108 car kilometers and 3.2 minutes headway; Vienna 113 car kilometers and 3.5 minutes headway. Of the above rail-

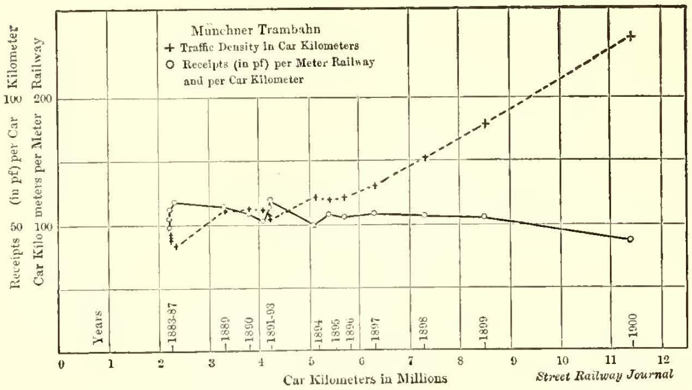


FIG. 3

way systems Cologne shows the least traffic density, which is to be ascribed to the extensive suburbs lying outside the city limits, that must be served by long lines. Next in order is the Dresdener Strassenbahn with its extensive suburban branches. Berlin in its interior has a complex system, while the surrounding parts are traversed by a large number of branch lines made necessary by the rapid growth of population in these directions. Greater traffic density is found in Munich, with its small suburbs, and also in Breslau, which has no suburban lines worthy of notice. The Vienna Tramway shows the greatest traffic density of all upon the basis of 3,000,000 car kilometers, and also the greatest density in an absolute sense, the value being 270 car kilometers per meter of railway, as compared with 240 for the Grosse Strassenbahn.

Again, if we inquire as to the number of car kilometers each railway must run to attain a common traffic density, we will find that, in accordance with the size of the system, the amount will be smallest for those railways having a large kilometer performance. Upon a basis of 200 car kilometers per meter railway, the number of car kilometers in Munich is about 9,400,000; in Dresden (Dresdener Strassenbahn), about 12,000,000; in Vienna, 16,000,000; in Berlin, 30,000,000, and the corresponding lengths of railway are, for Munich, 47 km; Dresden, 6 km; Vienna, 80 km, and Berlin, 150 km.

II. GROSS RECEIPTS

The relation of gross receipts and car kilometers has been discussed by the writer in an article appearing in the *Electrotechnische Zeitschrift.** It will suffice here to call attention to Fig.

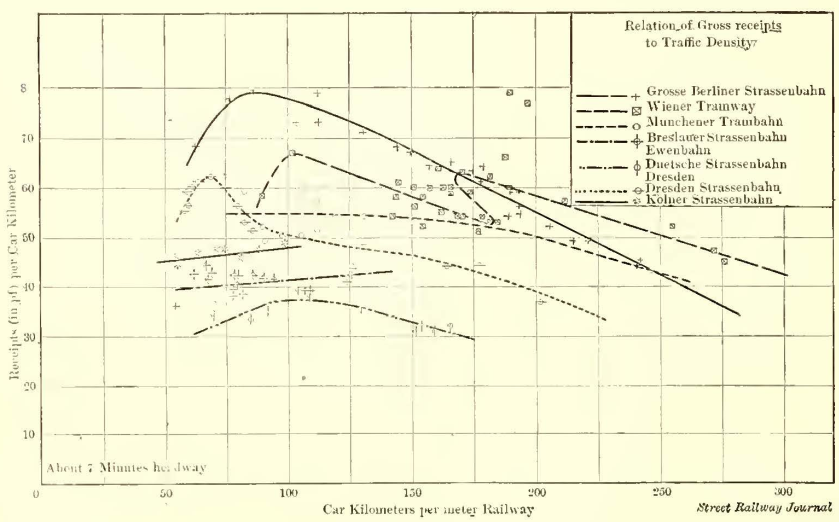


FIG. 4

2, and to state the result of this investigation, which may be expressed as follows:

The receipts per car kilometer increase rapidly at first with car kilometers run, but soon reach a maximum, after which, with an increased number of car kilometers, they decline, and the direction then is that of a curve asymptotic with a line running parallel to the abscissa.

The receipts per car kilometer may be raised artificially by limiting the car kilometers run, but it will fall again if the number be increased.

Fig. 3 gives both the traffic density and the receipts per car kilometer of the Munich tramway compared with car kilometers run, and shows very clearly the relations existing between traffic density and income. It will readily be observed that an increase in the value of the one is accompanied by a decrease of the other, but naturally the amount of fluctuation in receipts and traffic density are not always in the same ratio.

Fig. 4 shows the income of the various railway systems in relation to traffic density. When compared with Fig 2, it leads to the remarkable deduction that the maximum of receipts on all the lines under discussion lies between 3,000,000 and 4,000,000 car kilometers; this diagram establishes the following values for traffic density in times of maximum income: Dresden (Deutsche Strassenbahn), 195 car kilometers per meter railway and 3 minutes (Dresdener Strassenbahn), 70 car kilometers and 5 minutes head-Vienna, 100 car kilometers, and 4.5 minutes headway; Dresden (Dresdener Strassenbahn), 70 car kilometers and 5 minutes headway. In Breslau and Cologne the maximum may not have been reached; at any rate the conditions are difficult to interpret owing to the irregular development of the operations. The maximum

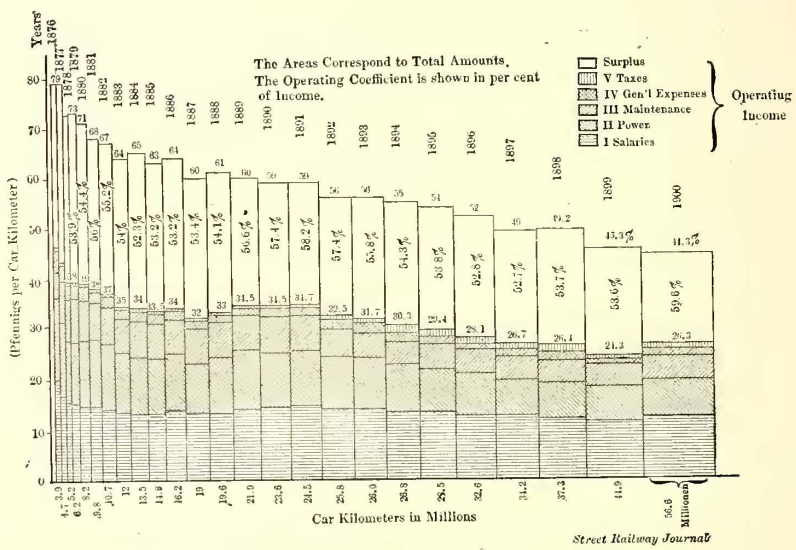


FIG. 5.—GROSSE BERLINER STRASSENBAHN

of income per car kilometer in these large cities is attained with an average car headway of about 5 minutes.

Fig. 4 records the fact that the lines entered upon their development with a traffic density of about 50 car kilometers per meter railway or with a car headway of from 7 to 8 minutes. The latter value corresponds to an actual average headway of 10 minutes after allowing for special trips.

A consideration of the absolute value of the receipts per car kilometer is also of interest. The receipts of the Grosse Berliner Strassenbahn exceeds those of the other railways, but show a more rapid decline than in Munich and Vienna; they fall below those of the last-mentioned city at about the density point of 200 car kilometers per meter railway, and below those of Munich at about 170 car kilometers.

The maximum income of the Dresdener Strassenbahn is 62 Pf. at 70 km per meter, while Berlin and Vienna receive the same income with 170 car kilometers per meter, or 2.5 times the former. If we assume the maximum income of Vienna corresponding to 67 Pf. and 102 car kilometers per meter as a basis, we will find that the traffic density of Berlin must be increased to 150 car kilometers, or by 50 per cent, to attain the same income.

The average receipts for the years under consideration are: Berlin, 61 Pf. per car kilometer; Vienna, 58 Pf. per car kilometer; Munich, 53 Pf. per car kilometer; Dresden (Dresdener Strassenbahn), 53 Pf. per car kilometer; Cologne, 46 Pf. per car kilometer; Breslau, 41 Pf. per car kilometer; Hamburg, 40 Pf. per car kilometer; Dresden (Deutsche Strassenbahn), 32 Pf. per car kilometer. Owing to the fact that in most cases the records

* 1899, Vol. II.

for the last decade only were available, the average value as here given may be too low, as, for example, that for Hamburg.

III. OPERATING EXPENSES.

It is very difficult to collect reliable and satisfactory statistics of

It should be mentioned that in Figs. 5-13 the number of car kilometers run per year is used as the abscissa; this differs from the method employed in Figs. 1 and 2, but has the advantage that the diagram of each fiscal year is a measure of the total operating expenses. By this method, also, the individual items of cost as

TABLE I.—TRACTION COSTS

YEARS	Münchener Trambahn (Pfennige per Car Kilometer. 1 Pf. = 0.238 Cents)											Hamburger Strassen-Eisenbahn (Pfennige per Car Kilometer)		
	Horse-Power			Steam-Power				Electric Power				Electric Power		
	Drivers	Stable Costs	Total	Engineers and Firemen	Materials	Engine Maintenance	Total	Motormen	Current Costs	Maintenance Power Station	Total	Current Costs	Maintenance Power Station	Total Power Costs
1890-91	4.5	15.0	19.5	2.4	7.0	3.8	13.2	----	----	----	----	----	----	----
1891-92	4.1	14.3	18.4	3.7	5.9	2.9	12.5	----	----	----	----	----	----	----
1892-93	3.8	14.0	17.8	4.0	6.2	2.5	12.7	----	----	----	----	----	----	----
1893-94	4.3	15.2	19.5	4.3	5.9	3.5	13.7	----	----	----	----	----	----	----
1894-95	4.4	13.4	17.8	4.4	5.8	3.9	14.1	----	----	----	----	7.7	1.6	9.3
1895-96	4.6	13.7	18.3	4.6	6.2	3.2	14.0	4.3	5.9	3.3	13.4	4.6	2.2	6.8
1896-97	4.7	14.9	19.6	4.4	6.7	3.1	14.2	4.0	5.8	3.6	12.4	4.7	2.4	7.1
1897-98	4.8	14.8	19.6	4.4	6.9	2.9	14.2	3.9	5.6	1.7	11.2	5.0	2.4	7.4
1898-99	4.9	14.7	19.6	4.1	6.9	2.2	13.2	3.7	5.0	1.6	10.3	5.1	2.1	7.2
1899-1900	5.3	15.0	20.3	5.0	9.5	2.6	17.1	3.8	4.8	2.4	11.0	----	----	----
1900-01	----	----	----	----	----	----	----	3.4	4.2	1.5	9.2	----	----	----
Average	4.5	14.5	19.0	4.1	6.7	3.1	13.9	3.9	5.2	2.2	11.3	5.4	2.1	7.5

operating expenses, as the methods of bookkeeping in use by street railway companies are extremely varied. However, the writer

TABLE II

Average Expenses and Coefficients of Operations (Pfennige per Car Kilometer. 1 Pf. = 0.238 cents)

	Salaries, Wages	Power	Maintenance, Repairs	General Expenses	Taxes, Rentals	Total Expenses	Coefficient of Operations Per Cent
Grosse Berliner Strassenbahn	14.0	11.0	6.0	2.0	0.7	34.0	54.0
Münchner Trambahn	13.0	8.0	6.0	3.0	0.9	32,0	59.0
Hamburger Strassen-Eisenbahn	8.0	11.0	5.0	1.0	0.4	29.0	71.0
Dresdner Strassenbahn	10.9	9.0	5.0	1.3	1.7	27.9	61.8
Deutsche Strassenbahn	9.5	8.8	5.0	1.3	0.3	24.5	72.0
Breslauer Strassenbahn	13.0	8.5	2.7	2.4	0.4	27.0	66.0
Wiener Tramway	17.3	10.4	7.2	3.7	4.8	43.5	80.6
Kölnische Strassenbahn	(6.9)	(15.8)	5.4	1.1	1.1	30.1	66.0
Average	12.2	9.5	5.3	2.0	1.7	31.0	66.3

has attempted to classify the available material according to a uniform system under the following heads:

I. Salaries—including all wages of conductors, inspectors, etc.

II. Power—including fuel, maintenance of power station and wages of motermen, or else fodder, hostlers and drivers.

III. Maintenance and repairs.

IV. General expenses.

V. Taxes and rentals.

Interest and sinking fund accounts are not included among expenses as here given.

Upon the basis of this classification, the evolution of expenses for the eight street railway systems is represented in Figs. 5-13.

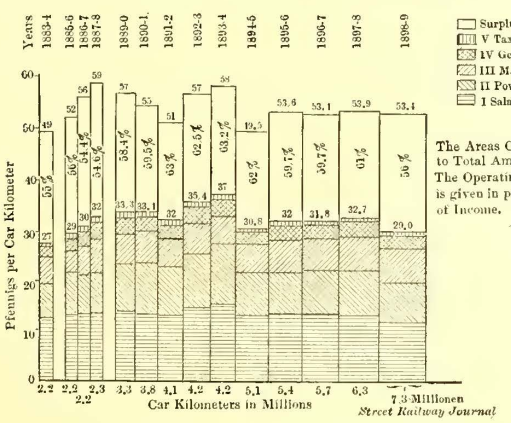


FIG. 6.—MUNCHENER STRASSENBAHN

In the case of the Cologne railway, the management and power costs could not be separated.

Table II. shows the average operating expenses of each railway as compared with the absolute figures, and Table I. the actual traction costs of the Munich railway subdivided according to horse, steam and electric power.

given in the various classes may be summed up without such confusion as might result if there were no common zero line for abscissa.

The evolution of expenses is subject to frequent fluctuations, although one might expect it would have a more regular course than that for incomes. Apparently the fluctuations in administrative economy have a more direct, more extensive and inevitable influence upon the expenses of street railways than upon the receipts, even when managers have direct oversight, so far as possible, of the financial side of the business. The general administrative conditions exercise a weighty influence upon almost all departments of the system; they stand in close relation to the rates

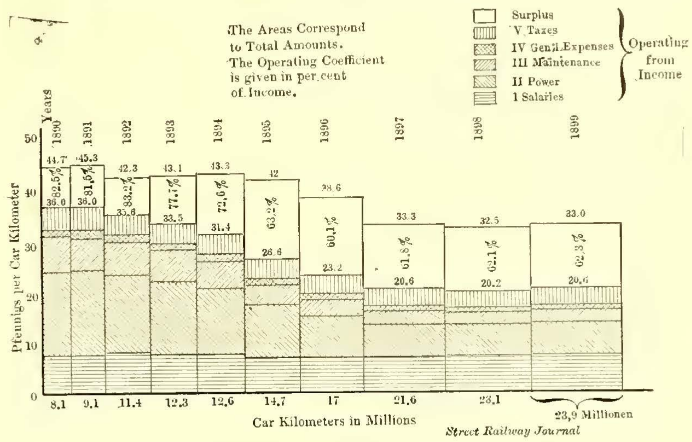


FIG 7.—HAMBURGER STRASSENBAHN

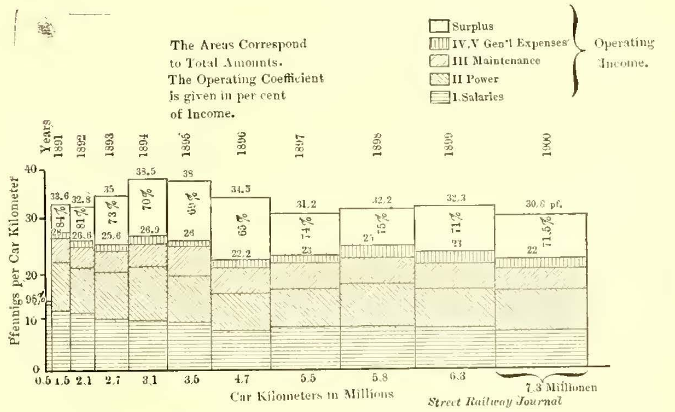


FIG. 8.—DEUTSCHE STRASSENBAHN, DRESDEN

of wages and to the costs of fodder, coal, electric current, materials, repairs, etc. There are also other causes which hinder the regular development of expenses that are outside the province of the manager. For instance, the Breslauer Strassen-Eisenbahn, in accordance with the terms of its agreement with the city, has undertaken the cleaning of the streets, thereby assuming an additional expense burden, the amount of which is largely dependent upon weather conditions. In this connection it may be noted that the weather has a direct effect upon current consumption. Such considerations as these show that, in order to derive a basic principle for the development of expenses, it is first necessary to form an average rate by disregarding all fluctuations that may lead to confusion and error.

The expenses per car kilometer varies in general with receipts. Expenses per car kilometer are subject, however, to frequent, sudden and temporary fluctuations; they decrease with a large increase in kilometers run, but with smaller increases they fluctuate and return to a general level.

Taking up the discussion of the individual railways, we find that the operations of the Grosse Berliner Strassenbahn (Fig. 5) shows

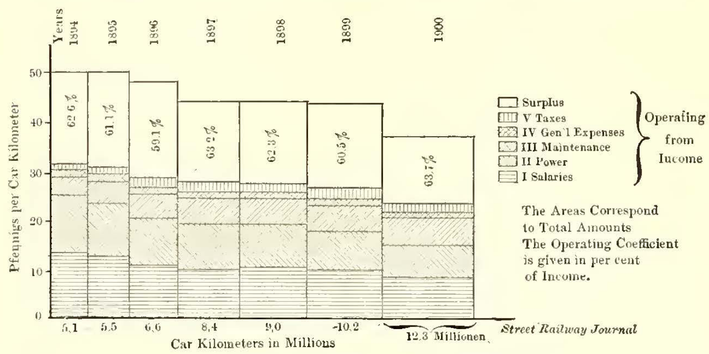


FIG. 9 —DRESDENER STRASSENBAHN

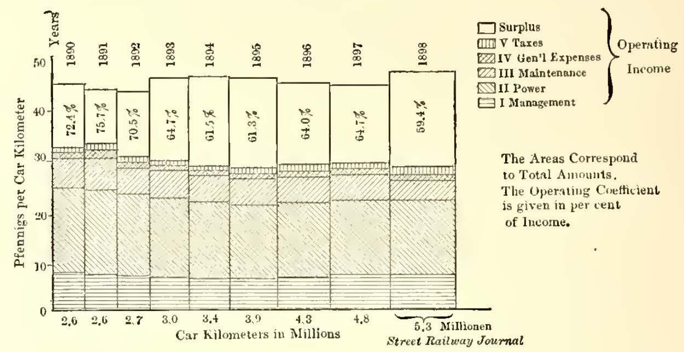


FIG. 11.—KOELNISCHE STRASSENBAHN

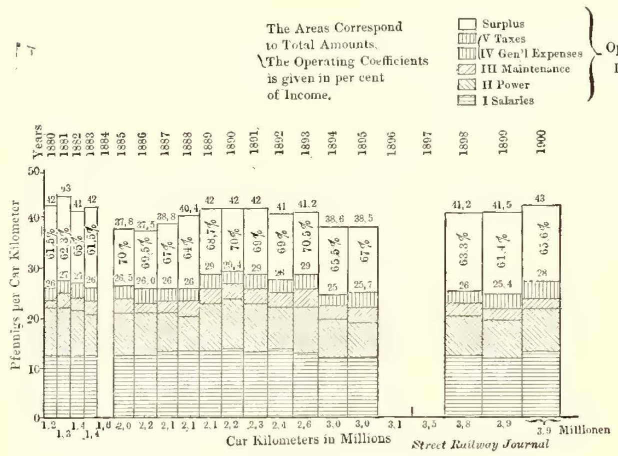


FIG. 10.—BRESLAUER STRASSEN EISENBAHN

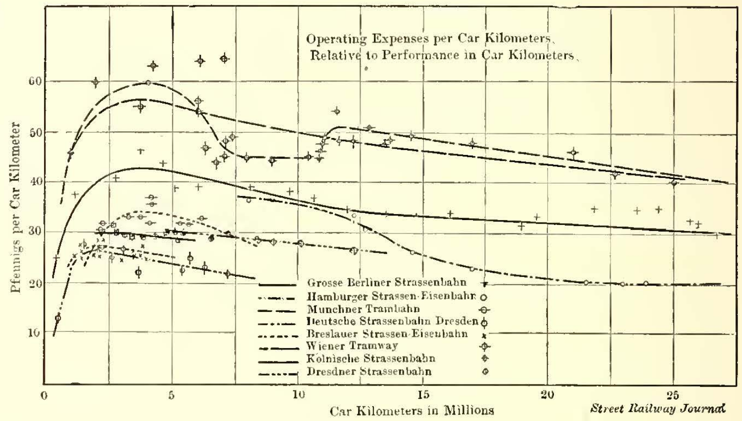


FIG. 13

way for the year 1900 were also abnormally high (the operating coefficient was 59.6 per cent against 53.6 per cent in the preceding year), although the greater part of the system had just been installed with electric power, thereby increasing the car kilometers run. The reason for this unusual condition is to be found in the difficulties that are always encountered when a large system tries to adapt new methods to its requirements, furthermore, in the use of both accumulators and overhead-trolley cars, in changes of traffic rates, and in the extension of the railway's zone of operations. In Hamburg, on the other hand, the expenses fell from 33.5 Pf. in 1893 to 20.3 Pf. in 1897, a result, undoubtedly, of the introduction of electric power, as the items of salaries and general expenses for this period showed a decline of only 9 per cent and 15 per cent, respectively, compared with 55 per cent for traction costs and 57 per cent for maintenance.

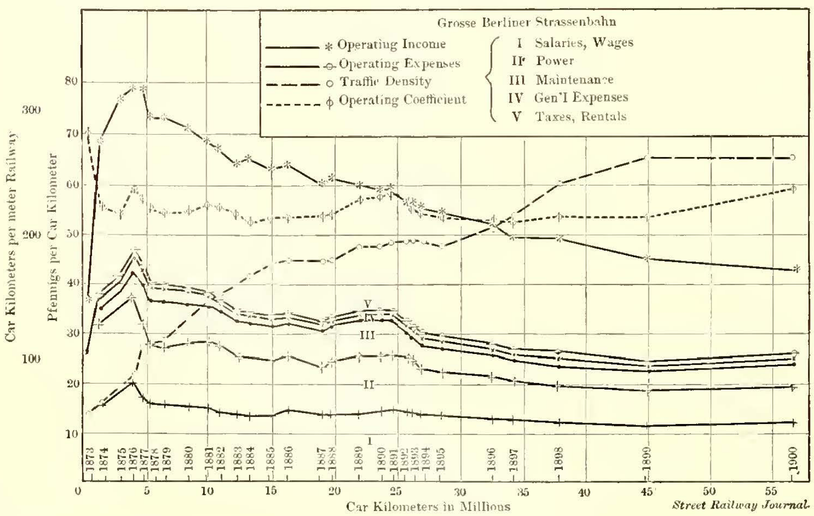


FIG. 14

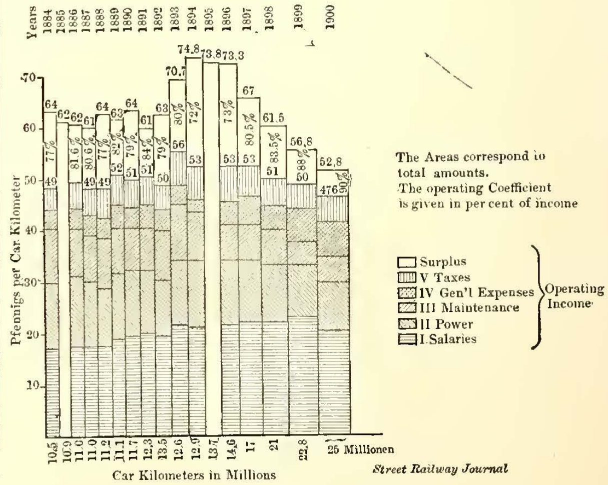


FIG. 12.—WIENER TRAMWAY

the most uniform development and the most striking similarity between the ratio of expenses per car kilometer and receipts. Munich, Hamburg, Dresden (Dresdener Strassenbahn) and Breslau also exhibit a similarity of conditions in this respect. Of course there are exceptions to this rule in periods of abnormal expenditure. Such a period is observed in the case of the Berlin railway from the years 1889-1891, as shown by Figs. 5 and 14; and like periods have been experienced in Munich (1892-93, 1893-94), in Breslau (1889-1893), and in Vienna (1893-96). Increased expenditure on account of salaries and wages appears to have brought about this unusual condition in Berlin, while in the other cities it is to be attributed chiefly to failure of the harvests and consequent higher costs of fodder. The expenses of the Berlin rail-

Table I. gives an interesting comparison of traction costs for the Munich railway under horse, steam and electric installation. The tabulation of the data was made under extremely favorably conditions by reason of the uniform system of accounting and identity of management. The average traction costs during a period of 10 years for horse-power were 19 Pf., for steam-power 14 Pf.; with electric power during a period of 6 years the costs were 11 Pf., or only 58 per cent of the costs for horse-power. The average cost of electric current was 5.2 Pf. and of maintenance of power station 2.2 Pf., making 7.4 Pf. altogether, as compared with 14.5 Pf. for stable, fodder and general supplies with horse-power. Such a comparison of data taken from actual practice goes to show that the introduction of electric power in a railway system should bring about great economies. Unfortunately, there have been many instances where the returns with electric power were not so satisfactory. The cause for such failures, if not traceable to errors in management, will be found in the assumption of abnormal financial burdens upon the part of the company as a result of a lowering of traffic rates, or an extension of the field of operations out of proportion to increment in earning power, or of increased taxes and rentals.

In Fig. 13 the total expenses in pfennigs per kilometer are given, from which a comparison may be made as to the absolute position of the various companies in this respect. It will be observed that Vienna stands first on the list, but some allowance must be made for the higher standard of valuations prevailing in that city as compared with German cities.

In Table II. the average operating costs of the eight different railways are given, itemized as follows: Salaries and wages, 12.2 Pf.; fodder and current, 9.5 Pf.; repairs, 5.3 Pf.; general expenses, 2.0 Pf.; taxes and rentals, 1.7 Pf. According to these figures, the item of salaries and wages composes 40 per cent of the total operating costs, power 31 per cent, maintenance 17 per cent, general expenses 6.5 per cent and taxes 5.5 per cent.

Finally, in Fig. 14, some of the statistical details in regard to the operations of the Grosse Berliner Strassenbahn are graphically represented, and a consideration of them will enable the reader to derive other relations not directly shown.

Notes on Massachusetts Railroad Commissioners' Bridge Specifications

The Massachusetts Railroad Commission has adopted a new set of specifications for bridges carrying electric railways. The specifications were drawn by Prof. George F. Swain, bridge engineer to the Commission, and contain many interesting features of design. Some of the more important details follow:

Yellow pine is recommended for all wooden bridges, and rolled medium or soft steel for all main parts of metal bridges. Piles may be oak, pine or chestnut.

Clearance shall be at least 6½ ft. on each side of the center of all straight track at a height of 10 ins. above the rail. Where tracks are curved the clearance is calculated on the basis of a 45-ft. car, width 8 ft. and distance between truck centers 20 ft. The lower edge of the running board must be at least 9 ins. inside of any girder and at least 6 ins. above it. All through bridges must have a head room above the rail top of at least 15 ft. for a width of 6 ft. over the railway track. The width between truss centers must not be less than 5 per cent of the span.

Ties are to be of hard pine, minimum dimensions, 5 ins. x 7 ins. x 10 ft. long for single track, maximum clear spacing 8 ins. Wooden guard timbers 6 ins. x 6 ins. must be bolted to every third tie by a ¾-in. bolt, to keep the ties in place.

To prevent a derailed truck from running far from the track, even if it is derailed before reaching the bridge, inside guard rails shall be provided, of the same form and height as the track rails, extending 50 ft. beyond the bridge and coming to a point in the track center. The guard rails must be extended around a curve if the approach is not of easy curvature or tangent. These rails shall be 8 ins. clear inside the track rails and spiked to every tie. Outer rail elevation must be provided on curves.

In the case of combined highway and electric railway bridges the ties must be 6 ins. x 6 ins. x 10 ins. spacing, 8 ft. long, with at least 2 ins. planking, minimum dimensions.

For single spans the following types of structure shall be adopted unless peculiar circumstances prevent, viz.:

Span Feet	Structure
Up to 20	Wooden stringers or rolled beams.
20— 30	Rolled beams or plate girders.
30— 70	Plate girders.
70—100	Plate girders or riveted trusses.
100—125	Riveted trusses.
125—200	Riveted or pin trusses.
Over 200	Pin trusses.

Pony trusses are to be avoided when possible. In special cases the board will allow them in 70-ft. to 90-ft. spans. Trestles may have bents of piles, framed timbers or steel with stringers, as per above table. Plans must show all details, dimensions figured, name of railway, location of structure, what it crosses and material used.

In calculating the structure weight, timber shall be taken as 4½ lbs. per foot board measure; rails, guard rails, spikes and bolts at not under 100 lbs. per linear foot of each track, and the total weight of floor above stringers at not less than 300 lbs. per running foot for each track. Stringer spans and floor systems of all trusses and girders must be proportioned to carry cars of either of the following types:

(a) A double-track car, loaded, weight 30 tons; total wheel base 17 ft.; each truck wheel base 4 ft.

(b) A double-truck car, loaded, weight 40 tons; total wheel base 25 ft.; wheel base, each truck, 5 ft.

In highway bridges the following additional loads shall be assumed on the highway floor:

City bridges. One hundred pounds per square foot of surface; roadway and sidewalks or a concentrated load of 20 tons on two axles 12 ft. apart. For trusses or girders, 100 lbs. per square foot floor surface for spans up to 100 ft.; 80 lbs. for spans over 200 ft., intermediate spans in proportion. The uniform load is to cover the floor within 2 ft. of the rails.

Suburban bridges. For floor and supports, 100 lbs. per square foot or concentrated load of 12 tons on two axles 8 ft. apart, as described under city bridges. For trusses or girders, 80 lbs. per square foot of floor surface for spans up to 100 ft., and 60 lbs. for spans of 200 ft. or over.

Light country highway bridges. Floor and supports, 80 lbs. per square foot. Trusses and girders, 80 lbs. per square foot spans up to 75 ft., and 50 lbs. for spans of 200 ft. or over.

All parts of a highway bridge floor must carry a 15-ton road roller having three wheels, with 6 tons, 4.5 tons and 4.5 tons on each roller. Width of front roller 4 ft., and each rear roller 20 ins., 5 ft. center to center and 11 ft. center to center front to rear roller.

The added percentage to allow for vibration of live loads is:

	Per Cent
Floor beams and stringers	25
Floor beam hangers	40
All counters	40
For other truss members and main girders:	
When loaded length is 20. ft or less	25
When loaded length is 200 ft. or more	10

Intermediate lengths are proportional.

A lateral force of 50 lbs. per square foot on unloaded, and 30 lbs. per square foot of loaded structure shall be provided. The pressure on a surface 10 ft. high and 40 ft. long is to be considered the moving load upon a car of type (b).

Centrifugal force on curves, 10 lbs. per running foot per degree acting 5 ft. above base of rail.

A longitudinal force of 15,000 lbs. applied at the top of the rail shall be considered as the force due to traction or application of brakes.

The maximum allowable stress in any piece from vertical loads and impact shall not exceed:

On timber:

Long-leaved yellow pine:	Pounds
Tension	1,500
Bending	1,200
Bending on ties	1,000
Shearing along grain	80
Compression along grain	400
Compression columns	$1{,}000 - \frac{10\,l}{d}$

where l = length of column in inches and d = least transverse diameter in inches.

For spruce or chestnut, two-thirds of the above figures.

For white oak, use the same as for yellow pine in tension, shearing and compression across grain, and two-thirds that for yellow pine in bending and on columns.

The stress on medium steel shall not exceed:

	Pounds
Tension, on net section	16,000
Shearing	12,000
Compression	$\dfrac{16{,}000}{1 + \dfrac{1}{20{,}000}\dfrac{l^2}{d^2}}$

where l = length of piece in inches from center to center of connection, r = radius of gyration in inches around axis of bending.

	Pounds
Bearing on pins, or on area equal to thickness of piece × pin diameter	22,000
Bending on pins, at centers of bearing surfaces	24,000
On rollers, per linear inch, d = diameter in inches of the roller	600d
Rollers on drawbridges, per linear inch	400d

Stresses on soft steel shall not exceed 9-10 of those on medium steel.

Stresses on rivet steel:

Shop rivets, power driven:	Pounds
Shearing	11,000
Bearing, when area is enclosed between other pieces	20,000
Bearing, when area is not enclosed	18,000

For field-driven rivets these stresses shall be reduced 25 per cent if hand-driven, and 10 per cent if power-driven.

Bed-plate pressure upon masonry, including impact, shall not exceed 400 lbs. per square inch. Dead load shall be increased 10 per cent on swing bridges.

Compression pieces of medium steel shall be figured upon the following basis:

$$t = \frac{P}{A}\left(1 + \frac{1}{15{,}000}\frac{l^2}{r^2}\right) \text{ where}$$

t = compression stress in pounds per square inch.
P = total compression.
A = gross area.

No material shall be less than 5-16 in. thick, except for fillers. Webs of channels may be ¼ in. In case of a bridge over a steam railroad, this limit shall be ⅜ in. for all material below the floor, including the lower chord. Minimum for gusset plates, ⅜ in. The minimum size of angles, except for fence rails, etc., shall be 2½ ins. x 2½ ins. x 5-16 in. No piece shall have a less area than ¾ sq. in. Three-quarter-in. or ⅞-in. rivets are recommended.

The length of a compression member between supports in any direction shall not exceed 100 times its radius of gyration about an axis perpendicular to that direction. Avoid adjustable members.

Single-lattice bars shall have a thickness of at least 2½ per cent and double bars connected by rivet at the intersection of at least 1 2-3 per cent of the distance between rivets connecting them to the member, in no case less than 5-16 in. Their width recommended is:

For 15-in. sections, or built sections with 3½-in. and 4-in. angles	2½ ins.
For 12-in., 10-in., 9-in., 8-in. and 7-in. channels, or built sections with 3-in. or 2½-in. angles	2¼ ins.

The pitch of rivets in the direction of the stress shall not exceed 6 ins. At the end of compression members the stress shall not exceed four rivet diameters for a length equal to twice the width of the member.

The distance from the edge of any piece must be not less than one and one-half times the rivet diameter, nor exceed eight times the plate thickness, and the distance between centers of rivet holes shall not be less than three rivet diameters. All lateral and sway bracing shall preferably be made in shapes which can resist both tension and compression. Hexagonal nuts are required.

Expansion and contraction corresponding to a variation of 150 degs. F. must be provided for. All bridges over 80 ft. long shall have hinge bolsters at both ends, and at one end rests of turned friction rollers, running between planed surfaces. Roller diameters must be at least 3 ins. For bridges under 80 ft. one end shall be free to move upon smooth surfaces.

In wooden structures, such as pile bridges, each bent must be braced laterally if the height from ground to rail base exceeds 10 ft., with longitudinal bracing if this height exceeds 15 ft. In pile and trestle bridges, if several stringers are used under each rail they must break-joint over the bents and be bolted together.

In proportioning roller-beam stringers the allowable stress shall be 16,000 lbs. only when the ratio of unsupported length to flange width does not exceed 20; if this ratio is 70, the allowable stress shall be 8000 lbs., intermediate values in proportion. The depth of a rolled beam shall be not less than 5 per cent of its span. Double beams shall be bolted together with cast-iron separators every 6 ft. Webs of rolled beams shall not be less than 5-16 in. thick.

In proportioning the flanges of plate girders one-eighth of the gross area of the web may be considered available in each flange. Plate girder webs must have a minimum thickness of 5-16 in.

Web stiffeners for plate girders must be at such distances apart that the total shearing stress per square inch on the gross area of the web, including impact, shall not exceed

$$\frac{12{,}000}{1 + \frac{1}{3000}\frac{d^2}{t^2}}$$

where t = thickness of web in inches.
d = clear distance between stiffeners.

The maximum clear distance between stiffeners shall not exceed 5 ft. The maximum pitch of rivets in stiffeners shall be 6 ins. The minimum dimensions of web stiffeners shall be 8-in. x 3-in. x 5-16-in. L's. In deck girders the load of an axle is considered distributed equally over three ties.

Web members of riveted trusses must be double and symmetrically connected at the chords. For upper chords and end-post connections a T-shape will not be allowed.

Members of pin trusses coming together at a pin shall be closely packed, and all vacant spaces filled with wrought-iron filling rings.

Steel trestle bents shall, if possible, be composed of two supporting columns united in pairs to form towers; each tower to be thoroughly braced, struts being between the column feet, the latter being anchored, and capable of resisting double the specified wind forces. Tower footings must be planed on all bearing surfaces and anchored to allow for expansion. Stringers and towers may be riveted together provided allowance is made at least every 100 ft. for expansion. All riveted work, except steel over 5-8 in. thick, shall be punched with holes 1-16 in. larger than the rivet size. Holes in the thicker steel are to be punched 1-16 in. smaller than the rivet, and drilled or reamed to a diameter ⅛ in. larger than the punched holes. No variation greater than 1-64 in. for every 20 ft. will be allowed in the length between centers of pin holes. Clearance between pins and holes shall be .02 in. for pins up to 3½ ins. diameter, and gradually increased to 1-32 in. for pins 6 ins. in diameter or over.

Although the board has no power to supervise manufacture, testing, erection or painting, its recommendations of steel are complete. The general characteristics are as follows:

Steel to be open-hearth process, with a maximum percentage of .06 sulphur, .9 manganese; in basic open-hearth steel, not over .05, nor in acid open-hearth more than .08 (.05 for rivets) per cent of phosphorus. Test pieces to be at least 10 ins. long and ½ sq in. in section. Rivet steel shall have an ultimate strength of 48,000-58,000 lbs. per square inch, an elastic limit not less than one-half the ultimate strength and 26 per cent elongation in 8 ins. A bar ¾ in. in diameter must bend 180 degs. cold, flat on itself without sign of fracture outside the bent portion. Soft steel: 52,000-62,000 lbs. tensile strength, 50 per cent elastic limit, elongation 25 per cent in 8 ins. and bending as in rivet steel. Medium steel: tensile strength 60,000-70,000 lbs. per square inch, and 22 per cent elongation in 8-in. piece. Bending as above.

Punched rivet holes pitched two diameters from a sheaved edge must stand drifting until the diameter is one-third larger than the original hole without cracking the metal. Steel eye-bars must show not less than 10 per cent elongation in the bar body, and must not break in the head. Pins up to 7 ins. diameter must be rolled, and if exceeding 7 ins. shall be forged under a steel hammer striking a blow of at least 5 tons.

Steel castings shall be made of open-hearth steel, containing from .25 per cent to .40 per cent carbon and not over .08 per cent phosphorus. Cast-iron test bars loaded in the middle between supports 12 ins. apart shall bear 2500 lbs. or over and deflect .15 in. before rupture when tested in the rough bar.

Instructions follow as to painting, inspection, erection and final test.

Rail-Bonds on the Baltimore & Ohio Belt Line

The Baltimore & Ohio Railroad has recently placed orders for plastic plug bonds, to be used on all rail-joints on its belt line. It is well known that this is the severest electric railway service in the world, as a large number of heavy trains, including freight trains, are hauled by electric locomotives every day through the tunnel, and the return current varies from 1200 amps. to 2400 amps. The track is new 100-lb T-rail, with heavy angle-plates. The plastic plug bonds, which when first applied had a conductivity equal to one-half that of the 100-lb. rail, still held about the same as when put in. This type of bond has consequently been adopted as a standard for this service, except that the bonds will be 1⅛ ins. in diameter, which will give practically the full conductivity of the rail. The experience in Baltimore, in the opinion of the engineers in charge there, indicates that the plastic bond is superior for that particular service to any other type of bond.

Power Brakes for Electric Cars

When electricity began to be used as a motive power for urban and interurban transportation the heavier cars and increased speeds that were adopted soon created a demand for a quicker and more reliable method of stopping than that provided by hand brakes. The steam roads had previously spent much time and vast sums of money in experimenting with various forms of power brakes and had universally adopted the air brake as the most successful for their purpose. Notwithstanding this fact, various forms of friction, hydraulic, electric and air brakes, many of which have been tried and discarded by the steam roads, were tried on electric cars. Few of these ever reached the stage of practical use, however. One after another has been eliminated, until to-day, just as in the case of the steam roads, the air brake is in use, with a very few exceptions, on the cars of all electric roads that have adopted power brakes of any kind.

A number of different forms of air brakes in which axle-driven compressors were used were brought out between 1889 and 1895, including the one invented and patented by N. A. Christensen. The Christensen equipments were installed and operated with entire satisfaction on cars of the Citizens' Railway Company, of Detroit, Mich., in the summer of 1893, and later on cars of numerous other roads. Mr. Christensen, however, saw the necessity of something better than axle-driven compressors, and in April, 1896, his first independent motor-driven air-compressor was put in operation on one of the cars of the Metropolitan West Side Elevated Railway Company in Chicago. An automatic governor was also supplied, which was arranged to open the circuit of the motor as soon as the pressure reached a predetermined maximum and to close it when the pressure was reduced to a predetermined minimum. This first equipment was a complete success, and other similar apparatus was soon installed in various parts of the country.

The Christensen Engineering Company was organized in the early part of 1897, and the company's manufacturing facilities were increased from time to time until, in 1899, land was purchased adjoining River Park, Milwaukee, and upon this ground a complete new plant has been erected. No expense has been spared in supplying the works with the most modern equipment obtainable. The site upon which the plant is located contains about 10 acres and is between the Milwaukee River and the tracks of the Chicago & Northwestern Railway, affording remarkably convenient facilties for shipping.

The rapidity with which the authorities of electric railways have recognized the value of the Christensen independent motor-driven compressor is indicated by the fact that over 95 per cent of all the

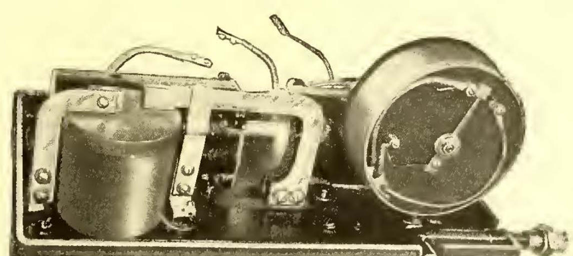


FIG. 2—AUTOMATIC GOVERNOR FOR CHRISTENSEN MOTOR-DRIVEN COMPRESSOR

electric roads that have adopted power brakes of any kind are equipped with the Christensen apparatus, and there are now over 5000 equipments in daily service.

The following detail description of the compressor used with these equipments will be of interest to many of our readers. The motor and compressor combined, as shown in Fig. 1, consist of a series-wound motor and a duplex, single-acting compressor provided with two pistons which are connected by wrist-pins to the connecting rods engaging with the crankshaft. This crankshaft is mounted in bearings provided in the case, the extended end of the crankshaft carrying a helical gear which engages with a helical pinion mounted on the extended end of the armature shaft of the motor. The latter is mounted directly above the compressor, the motor base forming a top cover for the compressor. This arrangement enables all the working parts to be run in oil. The suction and discharge valves are of seamless cold-drawn steel and are interchangeable one with the other and separately accessible. The armature bearing at the pinion end is so arranged that it is constantly lubricated by the oil within the casing of the compressor, and is provided with an automatic overflow arrangement. The brush holder of the motor is of the simplest possible construction and is provided with an instantaneous tension adjustment. The

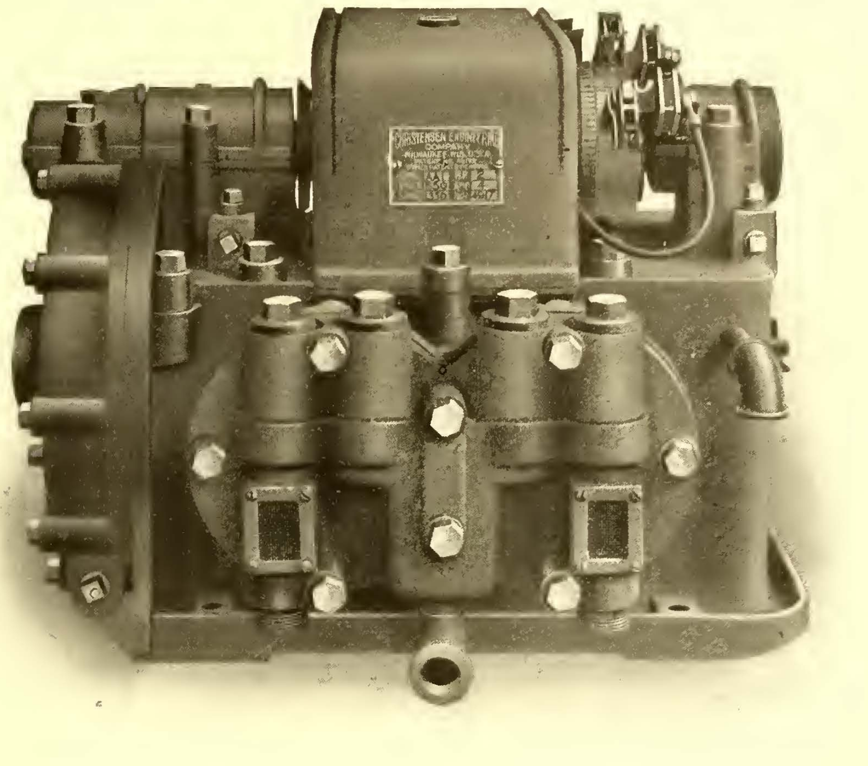


FIG. 1.—CHRISTENSEN MOTOR-DRIVEN COMPRESSOR

armature bearings are so designed that it is impossible for oil to get into the armature. The combined machine is of extreme simplicity, requiring a minimum amount of attention, as there are only two places for oiling, one being the main casing of the compressor and the other being the oil well on the armature bearing at the commutator end, both of which need replenishing only at long intervals. The helical form of gear is very much more durable than ordinary gears and practically eliminates noise.

The Christensen governor, shown in Fig. 2, consists of an ordinary Baurdon pressure gage mechanism with a special hand, which, upon coming in contact with a conducting stud at the position of minimum pressure, allows current to flow through a magnet coil which is provided with a plunger, to which the contact pieces for the motor circuit are attached, thereby starting up the motor. As soon as the hand strikes the maximum stud, current will pass through a second solenoid magnet, thereby pulling the magnet plunger in the opposite direction and opening the motor circuit. By this mechanism it is possible to get a close margin between maximum and minimum pressures. This margin is readily adjusted by moving the contact studs away from or toward each other.

The details of the accessory apparatus have been as carefully designed and accurately constructed as the compressor and governor.

Cars supplied with the Christensen air brake equipments are always under perfect control; quick stops can be made, accidents prevented and schedule speeds increased; flat wheels are prevented and life of cars and brake-shoes greatly increased.

The economy of air brakes was clearly shown recently by tests made upon two cars of equal weight and size, operating on the same road, at the same time under equal conditions, excepting that one was equipped with a Christensen motor-driven compressor air brake and the other with hand brakes only. The results showed that the former used from 10 per cent to 18 per cent less power than the latter. This was caused by the motorman of the hand brake car dragging his brake-shoes and was due to the almost universal practice of motormen holding their brake handles in such a position that they can quickly apply the brake when approaching curves or running through crowded streets.

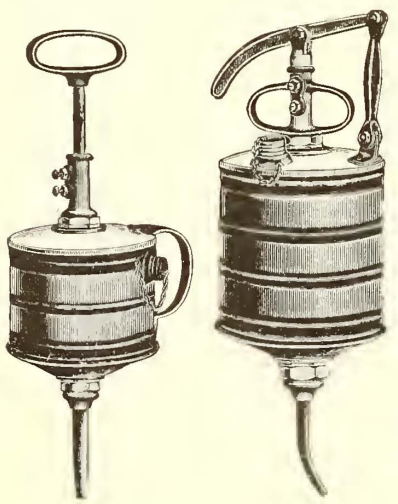
The policy of the Christensen Company from the start has been not to place any device upon the market until it has been perfected and proved reliable and durable in long, thorough and severe tests under the conditions it will meet in actual service; in other words, the company, and not the customer, pays for the experimental work.

That this policy is recognized and appreciated is indicated by the fact that orders approximating 1200 independent motor-driven Christensen equipments have been received since the first of the present year. These include several large foreign orders, among which is a second order from Sydney, Australia, for fifty equipments.

The Christensen equipments are now in use in England, Germany, Sweden, Norway, Russia, Australia, Africa, and, in fact, wherever electricity has been adopted as a motive power for cars.

An Oil Saver

The injudicious use of ordinary oil cans, as well as some special forms of automatic lubricators, provides no uncertain opportunities for great wastefulness of lubricating oils. The device herewith illustrated in two different forms for economically applying oil to working parts is reputed to have had its origin in an operating department of pronounced wastefulness, that of mine car wheels, but its advantages adapt it to all cases where lubricants are required. The oiler, which is the improved Tormay oiler, made by the Ironsides Company, of Columbus, consists of a central working barrel, containing a plunger and surrounded by an oil reservoir. Openings in the working barrel, sealed or unsealed, according to the position of plunger, communicate with the oil reservoir. The stroke of the plunger is adjustable, to govern the quantity of oil forced during each operation. When not in use its contents are not only preserved from leakage, but also protected from dust and other impurities.



NOVEL OIL CANS

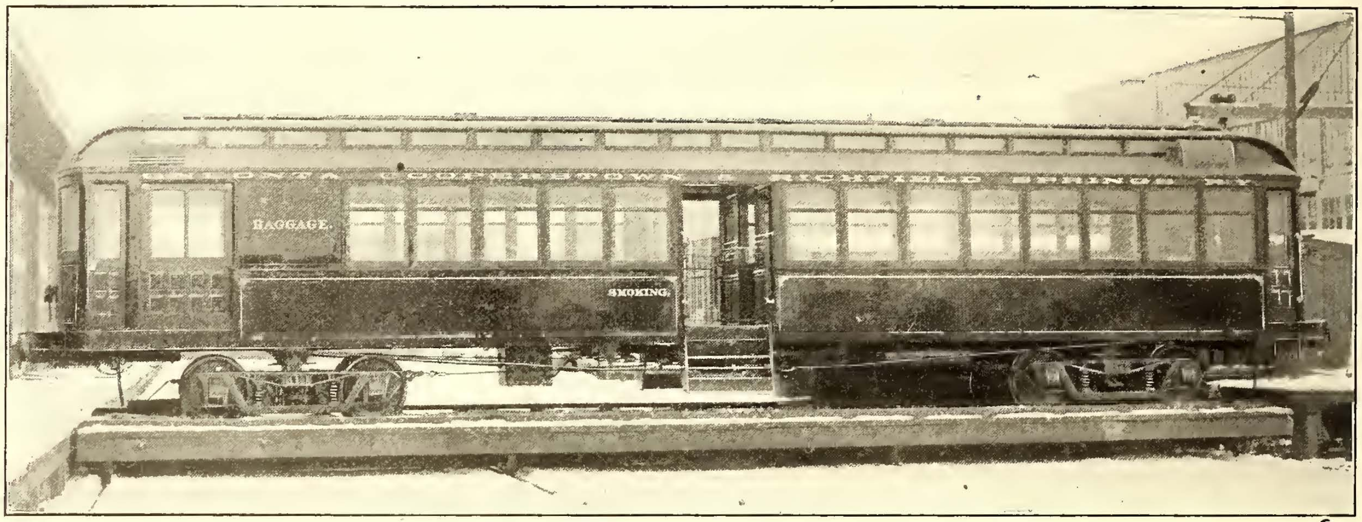
Overhead Line Material

The firm of C. J. Harrington, New York City, has recently purchased the entire insulating plant of a prominent manufacturer in New York State, which enables it to manufacture its own overhead material, which will consist, therefore, of the highest grade insulation and metal. The company will be prepared to furnish overhead material of any type, and will guarantee the insulating qualities to be equal to any now in the market. The factory contains the most improved machinery for this purpose, and a large stock will be kept on hand, so that quick deliveries can be made.

Interurban Cars with Side Entrances

The St. Louis Car Company, St. Louis, Mo., delivered recently to the Oneonta, Cooperstown & Richfield Springs Railway Company, Oneonta, New York, several interurban cars, somewhat different from those ordinarily used. By referring to the accompanying engraving it will be noticed that entrance for passengers is at the center of the car, on one side of which is the ladies' compartment, on the other is the smoking compartment, and also a compartment for baggage. The extreme length of car is 56 ft., the width 9 ft. The ladies' compartment is 20 ft. long, with the motorman's cab, 3 feet long, partitioned off. There are twelve seats in this compartment made by the St. Louis Car Company of Walk-Over pattern, covered with plush. It is also provided with water-cooler, toilet room and hot water heater.

The smoking compartment is 13 ft. in length and furnished with ten Walk-Over seats. The baggage compartment is separated from that of the smokers; it is 10 ft. in length and has sliding doors on both sides. The center platform is 4 ft. wide, with double steps on both sides; the passenger compartments open on this platform by single sliding doors. The interior finish is cherry, with solid bronze trimmings. The sash are in two sections; the upper stationary, while the lower drops to the arm rails, which are provided with a casing covering the sash pocket when the sash is lowered.



LONG COMBINATION CAR FOR INTERURBAN SERVICE

The car is mounted on double trucks, M. C. B. type, also made by the St. Louis Car Company. These trucks are equipped with double-plate wheels, made especially for heavy, high-speed work. All the cars have air brakes, made by the Christensen Engineering Company, Milwaukee, and every other accessory which is required by the ideal interurban car. Gates are placed on both sides of the central platform, so that passengers may pass from one compartment to the other with perfect safety. This is an ideal interurban equipment, and has proved very popular.

Brake-Shoe Company

The American Brake-Shoe & Foundry Company has been organized, with temporary offices at 26 Cortlandt Street, New York City, to take charge of the sales of the following well-known types of brake-shoes. The Sargent Skeleton Steel, the Diamond "S," the Skeleton Steel Insert, the Lappin Steel Back, the Streeter Steel Back, the Corning and the Ross-Mehan, as well as other types of brake-shoes for both steam and street railway service. The company announces that while hereafter the agents of the constituent companies manufacturing these shoes will represent the combined interests until further notice, purchasers are requested to send orders direct to the several companies as heretofore.

Time Table of Cleveland, Detroit and Toledo Lines

The officials of the roads in the three cities mentioned above, and of the railways connecting these cities, have started the publication of an official electric railway guide, covering that and contiguous territory. The guide has thirty-two pages, is of pocket size, and is very conveniently arranged.

The Manufacturing Plant of the John Stephenson Company

Under its new management the John Stephenson Company has become one of the largest car and truck manufacturers in the United States, and its plant has been greatly changed, both in appearance and capacity, since purchased by the new company. When the plant was first taken over, it covered but 96,837 sq. ft. of floor space; it now has 161,827 sq. ft. of floor space, the capacity having been more than doubled, as nearly all of the additional area has been actual working space. These extensions have been made to all the buildings, with the exception of the engine and boiler rooms and the drying kiln in the lumber yard. The tracks for cars erected are sufficiently long, so that the company is enabled to handle 100 50-ft. cars on the floor at one time.

In visiting the works of the Stephenson Company, one is immediately struck by the advantageous layout of the buildings, both from a manufacturing point of view and from their adaptability to enlargement. The main buildings, consisting of the woodworking mill, the erecting shop, the paint shop and the finishing shop, according to the most approved practice, are placed parallel to each other and about 80 ft. apart and are connected by electric transfer tables. This arrangement facilitates the better handling of work, reduces the insurance charges and enables the buildings to have the best of light and air. This latter consideration is of importance in the manufacture of cars, as light, air and a perfect heating system are necessary to obtain the best results in car construction. Under the pressure of business, which has rapidly developed in the new company, the arrangement of the establishment has been most efficient, as almost unlimited additions can be made without disturbing the system of construction or the progress of the material through the shops. The extensions can be carried out almost indefinitely to any desired degree, therefore, without changing the general plan. Such additions as have been already made have been equipped with hydrants, electric lights, hot water heaters and sprinklers, the same as the rest of the plant. The power house, which is of sufficient capacity to operate the many new machine tools which have been added in both the woodworking and ironworking departments, contains direct-connected units for supplying electric motors throughout the shops. From a mechanical point of view, the plant is, therefore, one of the most modern and up-to-date of its kind, and contains examples in every department of the very best practice in economical manufacturing.

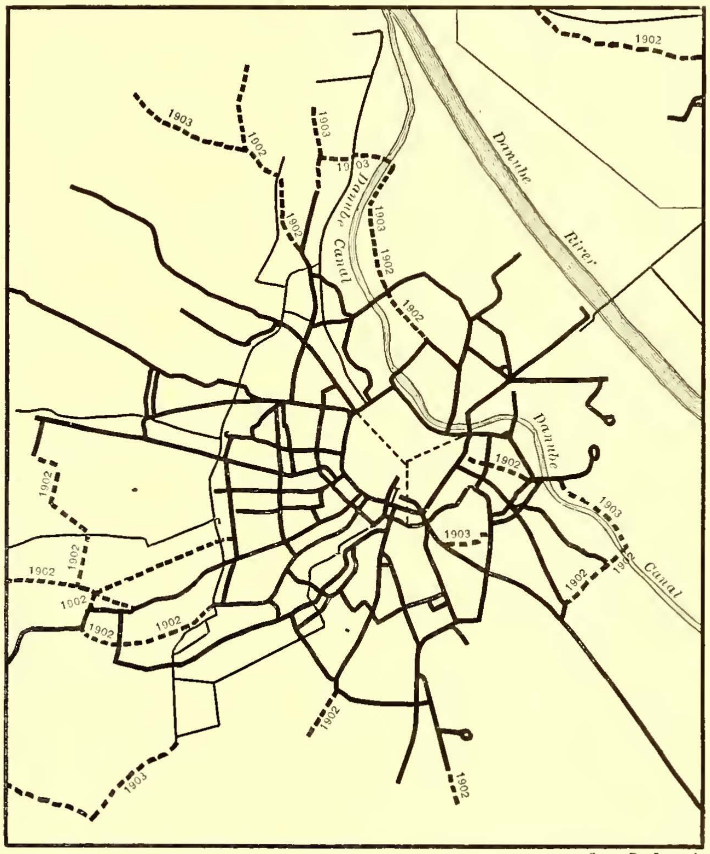
In addition to the buildings and machinery, several lines of railroad tracks have been laid to serve the extensive additions made to the lumber yard. The stock of lumber which is carried already contains between 4,000,000 ft. and 5,000,000 ft., and the company is constantly purchasing more. This department has been the subject of much thought, the management fully realizing that one of the most necessary features of a good car is the use of the best material in the body. The works have a network of private tracks which greatly facilitates the receiving of supplies and the shipping of the finished product. It owns its own switching engine, as well as an electric locomotive for handling material within the yards.

The location of the John Stephenson Company's plant is, without doubt, one of the most advantageous of its kind in the country for receiving and shipping goods. It is claimed that within 20 miles of the factory there are more cars used than within the same distance of any other three factories in the country. It is certainly true that the Stephenson Company selected a site which was in the center of electric car consumption. The shipping facilities are also of the very best. The company owns a railroad approach to the water front with riparian rights on nearly 1¾ acres of land thereon. It is thus peculiarly well situated for making shipments by steamer, as well as by rail, for both domestic and foreign consumption. Three railroads, the Baltimore & Ohio, Central Railroad of New Jersey and the Pennsylvania, by way of the Baltimore & Ohio, run directly to the plant. Within a dozen miles are four other lines, and it is thus in communication with all the leading trunk lines of the East. These shipping facilities, furthermore, enable the company to receive large consignments of lumber by water, thus greatly reducing the average charges. Being within 15 miles of New York City as well as possessing the shipping advantages detailed above, this location has already been appreciated by many other firms, and manufacturers are now seeking land in this locality for the building of new plants. The Milliken Brothers Steel Company has already under construction a new factory, the American Sanitary Company has decided to locate here, and several others have selected it for future sites. The Stephenson Company has also control of between 80 acres and 90 acres of land close to its works which it has not yet developed, but which are available for future extensions.

The practicability of adding to a plant while it is being worked at its greatest capacity has been well demonstrated during the last year at Elizabeth. The Stephenson Company has turned out, while the above-described extensions were being made, upward of 600 cars, and while the shops are being operated at present until 8 o'clock in the evening, work enough is on hand to keep the entire equipment busy for six months to come. It is interesting to note that the Brooklyn Heights Railroad Company secured 200 of these recently-built cars, both of the open and closed type.

Street Railways Owned by the City of Vienna

A recent issue of the Street Railway Journal contained a detailed description of the street railway system of the Bau- und Betriebsgesellschaft in Vienna, the ownership of which was acquired recently by the city. We are now able to supplement the description with a map showing the various railway lines included in the system and the extensions that are to be carried out in the future. The solid lines on the map indicate the electric railways in operation since Jan. 1, 1902, the dotted lines those that are to be built with electrical equipment during 1902 and 1903, while the light lines show the railways the city is planning to acquire in the future. Among the latter are the system of the Neuer Wiener Tramway Gesellschaft, equipped with both horse and steam traction cars and the electric Praterstern-Kagran railway. As the above map will show, the old system of street railways has grown into a vast network traversing the city in all directions. The extension of the system from time to time has necessitated, naturally, a corresponding increase in the number of signals used to indicate the route of the various cars. While formerly the traveling public was burdened with the identification of not more than a dozen such signals, at present there are no less than forty-seven of which the public must take cognizance.



PRESENT AND PROPOSED RAILWAYS IN VIENNA

The John Stephenson Company, of Elizabeth, N. J., received an order recently for sixty cars for the North Jersey Street Railway Company. These cars are to be standard 30-ft. cars of the same type now used on that road.

NEWS OF THE WEEK

St. Louis Transit Company's Provision for Old Employees

On Thursday, March 27, there was posted in the car houses and power houses of the St. Louis Transit Company, of St. Louis, Mo., the following self-explanatory notice to conductors and motormen in the employ of the company: "Motormen or conductors will not hereafter be discharged on account of old age, but will be given other places, such as 'watchmen,' 'switchmen,' 'trolley holders,' etc., and will be required, when on duty, to wear full uniform. The rate of pay will be the same as if they continued in service as motormen or conductors. (Signed) General Superintendent; approved, Second Vice-President."

Third Rail in Baltimore Tunnels

The Baltimore & Ohio Railroad Company has put into active service the third-rail system installed on the belt line between Camden station and Waverly through its tunnels under Baltimore. The engineers of the company regard the system as a complete success, and the entire overhead electric wires and supports will be torn down. The belt line has been fenced in for its entire length where the third rail is used, to keep persons from walking on the tracks. The equipment of the Baltimore tunnel with the third rail was described in detail in the STREET RAILWAY JOURNAL for Dec. 15, 1901.

New Jersey Street Railways' Showing

The State Board of Assessors, of New Jersey, has given its compilation of facts and figures of the business of the electric and street railway companies of New Jersey. The gross receipts of all the lines were $8,137,076, an increase of $398,688. The companies expended $4,464,513, which was a net increase of $84,288. The dividends paid last year were $486,640, a decrease of $131,300. The statement shows that the total mileage of these companies is 846. The capital stock issued was $81,607,189, and the capital stock of this authorization which has been paid in is $79,925,180. The total funded debt of these companies is $64,702,500, and the other debts amount to $3,079,597. The value of the roads is $152,401,800. There were eight companies that paid a dividend, the principal company being the Consolidated Traction, which is leased to the North Jersey Street Railway Company, of Jersey City. The aggregate of the dividends was $300,000. The other companies paying dividends were Asbury Park & Sea Girt, $6,000; Bridgeton & Millville, $4,000; Camden Horse, $50,000; New Jersey & Hudson, $22,500; Rapid Transit, of Newark, $59,220; Raritan Traction, $5,000, and Trenton Railway, $39,920.

Franchise Renewal Proposals in Chicago

The City Council of Chicago has passed a resolution to advertise the street railway franchises for sale if the street railway companies of that city fail to enter into negotiations with the city for the franchises before June 15 next. The resolution asserts that a large and important portion of the franchises expire within sixteen months; that the City Council has tentatively outlined its terms for the renewal of the franchise in the report of the committee on local transportation, and that negotiations between the city and the companies must be conducted in a thorough and systematic manner, and cover a considerable period of time. The resolution declares that up to the present time the companies have made no propositions to the city, and if an adjustment of terms is left until the last moment the city will be obliged to act hastily and, to some extent, under duress. For these reasons the resolution extends to the traction companies an invitation to enter into negotiations with the city for the renewal of the franchises, and concludes by declaring "that in the event of the failure or refusal of said companies to begin such negotiations, or to present reasonably satisfactory propositions by June 15, 1902, it is the sense of the Council that the city, through an appropriate committee, should take such steps as shall seem expedient, whether by advertising for bids, or otherwise, to call the attention of capital to the fact that the city has valuable transportation privileges to dispose of."

Extension of Time Under the New York Railroad Law

Governor Odell, of New York, has just signed the Bedell bill amending the railroad law in regard to the extension of time in the construction of street railways, which will be an important act for some roads and will rectify an injustice to which roads were liable. Under the old law, a railway company must commence the construction of its road or of any extension or branch for which it has received the necessary concession within a year of obtaining the final permission to build, and must build the road within three years from that time. If, however, the work has been hindered or delayed by legal proceedings in any court, the court could extend the time when the construction should be commenced and completed. The amendment amends the provision of the act so that if the construction is delayed or prevented by works of public importance, or from other causes not within the control of the corporation upon which such requirement is imposed, the time for the performance of the work by the company is extended for the period covered by such hindrance. The time for the compliance with the requirements of this act for companies which have received concessions has been extended until June 30, 1904.

The Turbine Equipment of the Metropolitan Railway

At a meeting held recently the directors of the Metropolitan Railway Company, of London, decided to award the contract for the machinery necessary for the electrical working of the line to the British Westinghouse Company. The following is a brief outline of the nature of the machinery which will be supplied: There are to be nine boilers, with a total normal continuous evaporating capacity of 160,000 lbs. of water per hour, with a temporarily much-increased power. The guaranteed thermal efficiency is 70 per cent. The pressure worked at will be 160 lbs. per square inch, and the steam will be superheated 180 degs. F. above the temperature of the steam at this point. There will be three combined steam turbines and three-phase alternators, the turbines being constructed by the Parsons Steam Turbine Company. The output of each combined set is to be 3500 kw as a normal load, and for short periods an output 50 per cent in excess of this figure. They will run at 750 r. p. m., and a 90 per cent vacuum is guaranteed. The efficiency of the combined sets is to be 17 lbs. of steam for each kilowatt delivered at full load and 20¼ lbs. of steam for each kilowatt delivered at half load, the power factor being .85. The alternators will deliver three-phase current at 11,000 volts and at 25 alternations per second. There will be three separate exciters driven by small ordinary steam engines. These will be capable of delivering either three-phase or direct current. Two of the three main sets only will be run at a time, the third being for spare, and the boiler power is only for driving two of the sets. It is understood that more boiler power over and above that in the contract will be provided.

Chicago Companies' Tax Injunction Refused

The injunction asked for by the Chicago Union Traction Company to prevent the collection of taxes under the assessment made this year by the State Board of Equalization has been refused by Judge Tuley. The main point in the contention of the traction companies was that the assessment was illegal because much other property in the State and city was not taxed proportionately, and that hence there was a discrimination against the street railways. Judge Tuley's decision was to the effect that laxity on the part of those who levy the taxes in failing to discover or properly assess all of the property in a city does not render illegal the collection of taxes from other property. The conclusion of the decision is as follows:

If these officials have failed in this duty—as they apparently have, but not with any fraudulent intent so far as shown—the remedy is not in a court of chancery. It is no part of the duty of a court of chancery to raise revenue, or defeat the raising of revenue. If there is any remedy for this state of affairs, it does not lie with the courts, but with the voters. It is for them to apply the remedy.

In conclusion, I can only say that from the evidence now before the court this bill to enjoin the payment of taxes assessed against the complainants' property is clearly not founded in good law nor in good morals.

Improvements in Kansas City, Kan.

Walton H. Holmes, president of the Metropolitan Street Railway Company, has unfolded to the committee considering the company's application for a renewal of franchises in Kansas City, Kan., plans for improvements that will call for the expenditure of several millions of dollars. The most extensive of the plans outlined by Mr. Holmes provides for the construction of a new line which, with those now existing, will make an electric belt line encircling the principal business section of the city, passing the Union Depot and the stock yards and connecting with all the company's lines except the Independence Electric Railway. It is probable that a short elevated line will be included in this plan. The Grand View line, extending from Riverview station to Eighteenth Street, is to be reconstructed at a cost of $107,000. The present wooden elevated, extending from the Central Avenue Bridge to Riverview station, is to be replaced with a steel structure to cost $122,000. The Fifth Street line, extending from the State line to Eighteenth and Minnesota Avenues, is to be rebuilt. The plan for rebuilding this line also calls for repaving between the tracks, and the estimated cost of these improvements is placed at $264,000. The Argentine line, extending from Packard Street, is to be reconstructed at a cost of $128,000. A new line on Tenth Street, extending south to Armourdale, is to be built at a cost of $202,000. The Chelsea Park branch, extending from Virginia Avenue to Eighteenth Street, is to be relaid with new rails. This work, together with the necessary bridging, will call for an expenditure of $242,000. Repaving between the tracks of all lines will cost $218,000. The elevated structure extending from the Central Avenue Bridge to the tunnel is to be rebuilt at a cost of $250,000, and the terminals for the "L" road at the Union Depot, new improvements, are to cost $55,000. Plans for new equipment for all lines call for an expenditure of $250,000. From the plans outlined by President Holmes it will be seen that over $2,000,000 are to be spent in improvements.

The Buffalo, Niagara Falls & Rochester Railway

The officers of the Buffalo, Niagara Falls & Rochester Railway Company have been busily engaged during the winter in perfecting plans for the construction of the new electric railway to connect Buffalo, Niagara Falls and Rochester, and the announcement is made that the work on the line will be begun in three different places, about May 1. Rochester, Lockport and Clarkson have been selected as the points at which operations will be begun. The general contract is held by Henry McTighe, of Brooklyn.

The company plans to erect its own power house, but as the road is expected to be in operation before the power house can be completed plans have been made to purchase power temporarily. The estimated cost of the power house has been placed at $300,000. The company will secure entrance to Rochester over the lines of the Rochester Railway Company, but it is proposed to erect a passenger station at the terminus of the Ridge Road, near Lake Avenue, Rochester.

Contracts for the ties, rails and other line materials have been placed for the entire line, but no effort will be made to build beyond Lockport this year.

The Everett-Moore Situation

Up to Monday, March 31, the Northern Ohio Traction Company has not been sold, but members of the bankers' committee feel confident that the matter will be closed up in the near future. The committee holds out for 37½ for the common stock and 87½ for the preferred. Two out-of-town syndicates are bidding on the property, but if deals are not closed with either of these it seems probable that local parties already interested in the company will buy the Everett-Moore interests. The committee has under its control about 6000 out of 10,000 shares of preferred stock and 14,000 out of 25,000 shares of common. The property is making remarkable gains in earnings. For twenty-six days in March the net increase was $6,695.54 over the same period last year.

It is now believed that the Toledo Railways & Light Company will not be sold. It is even said that there is an agreement among the majority stockholders not to sell the stock at less than $30 until next July.

Negotiations with a certain steam road for the purchase of the Detroit & Toledo Shore Line have fallen through, but other parties are considering its purchase.

Matters relative to the sale of the Detroit United are also being held in abeyance, as the bankers have not yet secured an agreement from a full majority of the stockholders to sell at $75.

No Strike at New Orleans

The employees of the New Orleans City Railroad Company, the New Orleans & Carrollton Railroad, Light & Power Company, the St. Charles Street Railroad Company and the Orleans Railroad Company, of New Orleans, La., in joint meeting, held on March 27, endorsed the proposition which provides for the renewal, for one year, of the agreement entered into with the companies in June, 1901, and there will be no strike. The original demands of the men called for the reduction of the workday from 10 hours to 9 hours, for the increase of wages from 18 cents to 20 cents per hour, and for the recognition of the union in all matters pertaining to the employing and discharging of men. The controversy finally resolved itself into the question regarding the recognition of the union, and realizing the weakness of this, the men, through the guiding influence of Representative McMahon, of the Amalgamated Association of Street Railway Employees, and Mayor Capdevielle, were led to see the folly of their ways. As an actual matter of fact, Mayor Capdevielle was the central figure of the entire transaction. He it was who arranged the agreement of June, 1901, and again, in an honest effort, and with the interest of both the men and the company at heart, he has succeeded in adjusting difficulties that threatened to plunge into disorder and possible riots the whole city of which he is Mayor. The citizens of New Orleans have in their Mayor a man of whom they have just reason to be proud. In all street railway strikes there is a third party, the public, which is sure to hold to strict accountability those who abrogate an agreement such as has been entered into at New Orleans.

The agreement that has just been ratified follows:

New Orleans, March 26, 1902.

COPY OF MEMORANDUM LEFT WITH THE MAYOR.

Should the present demands of the men be withdrawn or not insisted upon, we do not hesitate to give you our assurance that:

First—We are willing to sign with our employees a renewal of the agreement of last June for one year from date.

Second—We are willing to discuss with the pitmen, car helpers, etc., the question of their wages whenever they themselves approach us regarding same.

Third—If not already provided, we will provide sufficient and proper accommodations for the use of our men.

Fourth—We will so adjust matters as to allow our men sufficient stand time to make use of the accommodations provided in paragraph 3.

Fifth—The rules for missing to be: When a man misses his car, for the first offense he shall serve three days on the extra list; should he miss his car the second time in thirty days, he shall serve five days on the extra list, and for missing his car the third time inside of thirty days, he shall lose his run and be placed at the bottom of the extra list. Men missing their car shall report in time for the next relief. Should a man miss any relief while serving on the extra list, an additional day to be added for each miss.

NEW ORLEANS CITY R. R. CO.,
BY R. M. WALMSLEY, President.
N. O. & CARROLLTON R. R., L. & P. C.
BY J. K. NEWMAN, President.
ST. CHARLES STREET R. R. CO.,
BY ALBERT G. PHELPS, President.
THE ORLEANS R. R. CO.,
BY GEO. DENEGRE, Attorney.

The old agreement referred to in section 1 was as follows:

New Orleans, June 29, 1901.

To the Conductors and Motormen of the ——— Railroad Company:

Sirs—In answer to your communication of the 29th, and after consultation with his honor, Mayor Capdeviele, we reiterate the offer made by him that:

On and after July 1, 1901, the company will establish the following rate of pay for motormen and conductors:

A day's work shall constitute ten hours' platform service. All runs will be arranged, as near as possible, to ten hours. Dinner reliefs will continue as heretofore, but no pay will be allowed except for actual platform work. The price for such service shall be 18 cents per hour. Swing runs shall not cover a period of more than fourteen hours.

In regard to clauses 6 and 7, as mentioned by you, we firmly believe that our answer of the 27th fully covers all the points and removed any objections that might exist.

It will require until July 15 to arrange schedules to meet the change.

Respectfully, R. M. WALMSLEY, President.

Clause 6 refers to the freedom of employees to join organizations, which the companies state they had never restricted, and clause 7 refers to meeting committees of employees, which they also agreed to.

New York Franchise Tax Assessments

The State Board of Tax Commissioners of New York has made public the valuation for 1902 of the special franchises for the State. In some cases the assessment shows an increase, while in others a decrease is shown. Taken as a whole, the assessment of the franchises of the companies operating in New York City is about $10,000,000 more than last year, being $220,620,155, as against $210,306,931 in 1901.

The special franchise tax act was passed during Governor Roosevelt's term, and the first assessment under it was that of 1900. Certain of the New York corporations affected, in contesting both the constitutionality and the secret method of assessing the tax, made practically common cause against the act. In both the case of the Manhattan Railway Company, which instituted individual suit, and the companies that made common cause against the act counsel petitioned for a writ of certiorari to review the assessments for the year 1900. The petitions were granted, and the case of the Manhattan Railway was referred to Judge Charles Andrews, formerly chief judge of the Court of Appeals, and those of the other companies to Robert Earl as referee. The State Board of Tax Commissioners was instructed to report its proceedings and the methods it followed to the referees, but, so far as the documents made public showed, the information furnished was not particularly edifying. There were hearings before the referees from time to time last spring and fall, and they are still considering the contentions of the petitioners for review, to the effect that the assessments are unjustifiable, uneven and excessive. When they report, it will be to justices of the Supreme Court.

A special press despatch from Albany, dated April 1, said: "Justice Chester, of the Supreme Court, has decided that the franchise tax law is constitutional. The justice holds that neither the Constitution of New York nor of the United States is violated by its provisions. This decision is independent and in no way affects the proceedings now under consideration by ex-Judge Robert Earl, as referee, in which the constitutionality of the law is questioned by New York corporations."

PERSONAL MENTION

MR. THOMAS T. ROBINSON has been elected president of the South Middlesex Street Railway Company, of Framingham, Mass.

MR. GEO. J. KUHRTS is appointed chief engineer of the Los Angeles Railway Company, of Los Angeles, Cal., vice Mr. F. W. Skinner, deceased.

MR. F. C. GREEN, superintendent of the Consolidated Car Heating Company, of Albany, N. Y., has returned from an extended business trip to Europe.

MR. EDWARD B. JONES has been elected president of the Mount Holly Street Railway Company, of Mount Holly, N. J., succeeding Mr. Amos Gibbs, resigned.

MR. ROBERT HILL, formerly with the Hamilton Electric Railway Company, of Hamilton, Ont., has been appointed manager of the Woodstock-Ingersoll Electric Railway, of Woodstock, Ont.

MR. J. B. HICKS, who for several years has been connected with Robert Engham, Clark & Company, of London, Paris and Hamburg, is now manager of the street railway department of H. M. Shaw & Company.

MR. JAMES B. NEAL, of Boston, formerly superintendent of the Dorchester division of the Boston Elevated Railway, has been appointed superintendent of the Penobscot Central Railway, of Bangor, Me., succeeding Mr. Wilbur E. Pierce, resigned.

MR. A. W. McLIMONT, a well-known electrical engineer who has for some time past been interested in the construction and building of street railways in Mexico and the Southern States, has returned to New York. He is now with the Federal Electric Company.

MR. D. G. HAMILTON, president of the Chicago City Railway Company, spent a few days in New York last week. Although not on business, Mr. Hamilton visited the Manhattan Railway's new power station, the subway and other street railway features of the metropolis.

MR. J. ARTHUR AITON, of the well-known firm of Aiton & Company, Willesden Junction, London, is in this country on a short business trip. Mr. Aiton's firm makes a specialty of pipe work and has installed the piping systems in a large number of electrical stations in Great Britain. His mission in this country is to study the latest developments of the subject in America.

MR. JOHN S. HAMLIN, who, as has already been noted, has just been appointed manager of sales and construction for Chicago for the United States Steel Company, manager of the Neal duplex brake, has just received from the employees of the Union Traction Company, of Indiana, with which company he was connected as master mechanic, a handsome gold watch, a chain and a charm, in token of their appreciation and esteem.

MR. WALTER J. BRADY has been appointed superintendent of the Hudson County division of the North Jersey Street Railway Company, of Jersey City, N. J., succeeding the late Mr. William N. McCormack. Mr. Brady is about 40 years of age, and was born in Jersey City. He was first employed in a law office, but later entered railroading, becoming connected with the Jersey City & Bergen Railroad, now part of the system of the North Jersey Street Railway. Mr. Brady has been in the employ of the company about nineteen years.

MR. WILLIAM DULLES, JR., has just been elected president of the American Stoker Company, of New York, vice Mr. R. C. Peabody, resigned. Mr. Dulles has been connected with a number of very successful manufacturing enterprises, and besides the office which he holds with the American Stoker Company is president and director of the Appert Glass Company, vice-president and treasurer of the Mississippi Wire Glass Company, president and director of the Municipal Lighting Company, director and treasurer of the Holland Torpedo Boat Company and director in the Electric Boat Company, the Electric Launch Company and the Electro-Dynamic Company.

CONSTRUCTION NOTES

ANNISTON, ALA.—The Anniston Electric & Gas Company has recently awarded contracts for the construction of its proposed new lines in the southeastern part of the city. It is said that the company will build 10 miles of line in all.

BIRMINGHAM, ALA.—Surveyors are now laying out the route of the proposed line of the Birmingham & Steel City Railway & Power Company. The company's lines will radiate from Ensley, extending to Birmingham, Pratt City, Brookside, Wylam, Dolamite, Woodward and Bessemer.

HOT SPRINGS, ARK.—The Interurban Railway & Power Company has been incorporated, with a capital stock of $500,000, to build an electric railway between Hot Springs and adjacent cities and towns and to operate an electric railway in Hot Springs. The company will also generate power for lighting and power purposes. The officers of the company are: Charles B. Eames, of St. Louis, president; Hamp Williams, of Hot Springs, vice-president; Charles N. Rix, of Hot Springs, treasurer; Frederick D. Ward, of Hot Springs, secretary. These officers and A. C. Jones constitute the board of directors.

NEW HAVEN, CONN.—The Fair Haven & Westville Railway Company has begun work on the building of an extension to its Grand Avenue power plant. The present plant is 130 ft. x 80 ft., making the reconstructed structure 230 ft. x 80 ft.

WILLIMANTIC, CONN.—Charles O. Warren, S. A. Wheaton, Frank R. Jackson, of Eastford; W. H. Taylor, of Putnam, and George E. Hinman, of Willimantic, are reviving the project for the construction of an electric railway from Willimantic, extending through Choplin, Eastford, Ashford and Woodstock, to the Massachusetts State line, about 4 miles from Southbridge.

NEW HAVEN, CONN.—The Railroad Commissioners have approved the application of the Manufacturers' Railway Company to extend its lines through Ferry Street and Fairmount Avenue.

HARTFORD, CONN.—The Hartford Street Railway Company is having plans prepared for a new car house on Wethersfield Avenue to take the place of the old car house owned by the company on that thoroughfare. The new structure will be 470 ft. x 250 ft., and will have a capacity for storing 220 cars. It will be a brick structure.

SANFARD, FLA.—The Sanford, Orlando, Kissimmee & Southern Railroad & Steamship Company, recently organized, is promoting a plan for the construction of an electric railway to connect Sanford and Kissimmee, about 43 miles distant. The line would extend through a rich farming country, and the plan is to operate it in conjunction with the company's St. Johns River steamers. The officers of the company are: F. W. Bredow, of De Land, Fla., president; Charles Hobbs, secretary; Alexander Vaughan, treasurer.

VENICE, ILL.—The Granite City & St. Louis Railway Company, Venice, has filed articles of incorporation. The capital stock of the company is $500,000, and its purpose is to operate an electric railway, also light, heat and power plants.

MONTGOMERY, ALA.—Colonel Holt and his associates, who were recently granted a franchise for the construction of an electric railway here, have arranged to have J. G. White & Company, of New York, build the proposed lines here. Colonel Holt admits that negotiations for the purchase of the Montgomery Street Railway were begun, but is quoted as stating that the deal for the purchase was not consummated because the price asked by the owners of the Montgomery Street Railway was considered exorbitant.

NOBLESVILLE, IND.—The Union Traction Company, of Indiana, has purchased the franchises and grants of the Central Traction Company. These companies have long been fighting for rights between Kokomo and Indianapolis, and the deal that has just been negotiated settles the fact that only one line will be built.