Street Railway Journal

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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.

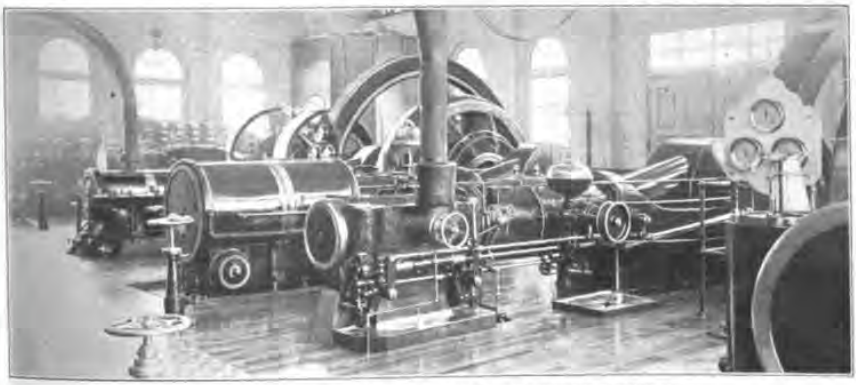
The southern portions of the cape are sparsely settled and in winter barren and bleak. Highland Light, Peaked Hill Bars and Chatham are yearly the scenes of furious storms, which line the coast with wrecks and necessitate the constant vigilance of the United States Life Saving Service. Electric railway 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 6½ 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 1½ 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 ¼ in. thick.

All floor timbers are of Southern pine. Each floor is laid with 4-in. plank and top board of ¾-in. birch or maple. The plank is spruce 7 ins. to 11 ins. wide, grooved ¾ in. square and furnished with hardwood splines. It was planed on one side to a uniform thickness of at least 3¾ 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 wane and knots. The planks

BURIAL HILL, PLYMOUTH

are grooved ⅝ 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

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 3½ lbs. per foot and is hipped to carry water by the ends of the monitor.

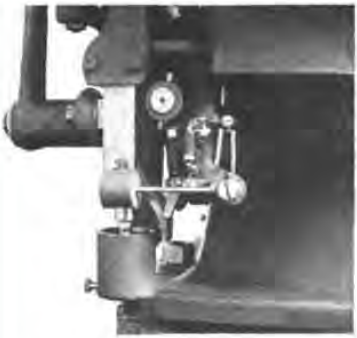
The power station is divided into two main parts, boiler room and engine room, separated by a wall. The engine room walls are painted with two coats of light drab above the window sills and with two coats of a darker color below. The boiler room walls are dark for 5 ft. from the floor and whitewashed 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 ⅞ 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 ½-in. holes aggregating the steam nozzle in area and drained by two ¼-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 2½ 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 ⅝-in. air spaces and ½-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 ⅝ 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 2½ 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 2½ 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 ¼ in. to 1½ ins. in diameter. Valves are provided throughout. The overflow from engine traps is carried into a main drip pipe 2½ 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 7½ 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 steam cylinder 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 1¼ ins. high and 1⅜ ins. low pressure. The clearance between the high-pressure cylinder head and piston 3-16 in., or 2 per cent, with ⅜ 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 3½ 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 5¼ 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

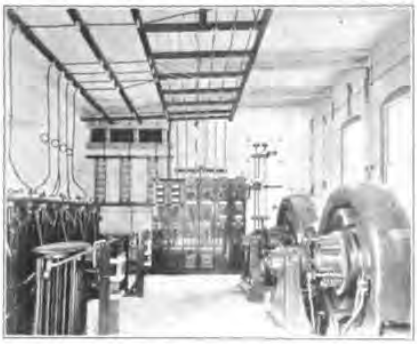
The speed changing, or synchronizing, device, which allows the speed of the engine to be varied some 10 r. p. m. while in operation, is controlled by a small switch placed on the switchboard, the operation of which is as follows: This switch controls a type C A 1-6-hp General Electric motor, mounted 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 31-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—1¾—1200, 509 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 3½ 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 5½ 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

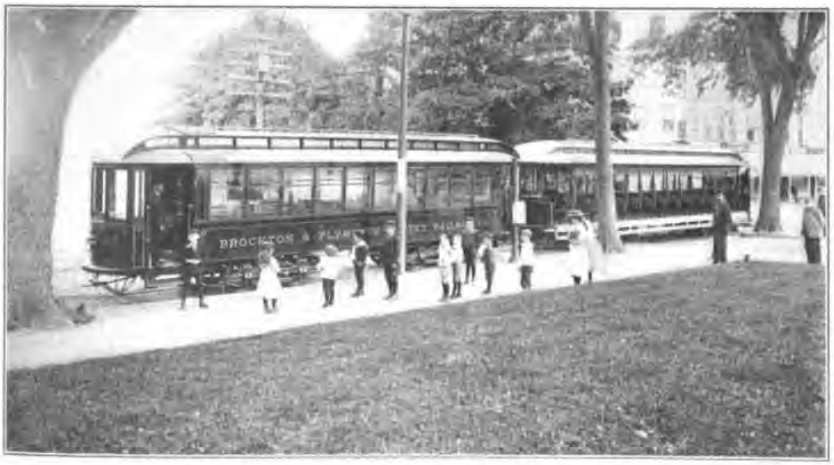
TRACK OPPOSITE MAYFLOWER GROVE

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 5½ 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 2½ 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 3¼ ins. x 4¼ 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 ⅝-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.

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, 4¾ ins. in diameter under head and 3¾ 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.



STANDARD OPEN AND CLOSED CARS

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. 8½ ins. over vestibules, seat forty passengers and have a 29-ft. 4½-in. body each. From center to center of seats is 32½ 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. 2½ 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 ⅝-in. round iron. Two trap doors are built over each driving axle and are corrugated ⅜ in. thick. Treads are 1 in. thick, body framing posts ash, the upper deck has 7-in. overhang and the brake-staff is 1¼ 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 bells 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, 3½ ins. x 5½ 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 4⅞ 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 3¼ 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. 4¾ 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. 8½ ins., and when worn out was 8 ft. 3¼ 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. 8½ ins. and 8 ft. 4¾ 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. 8½ 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.