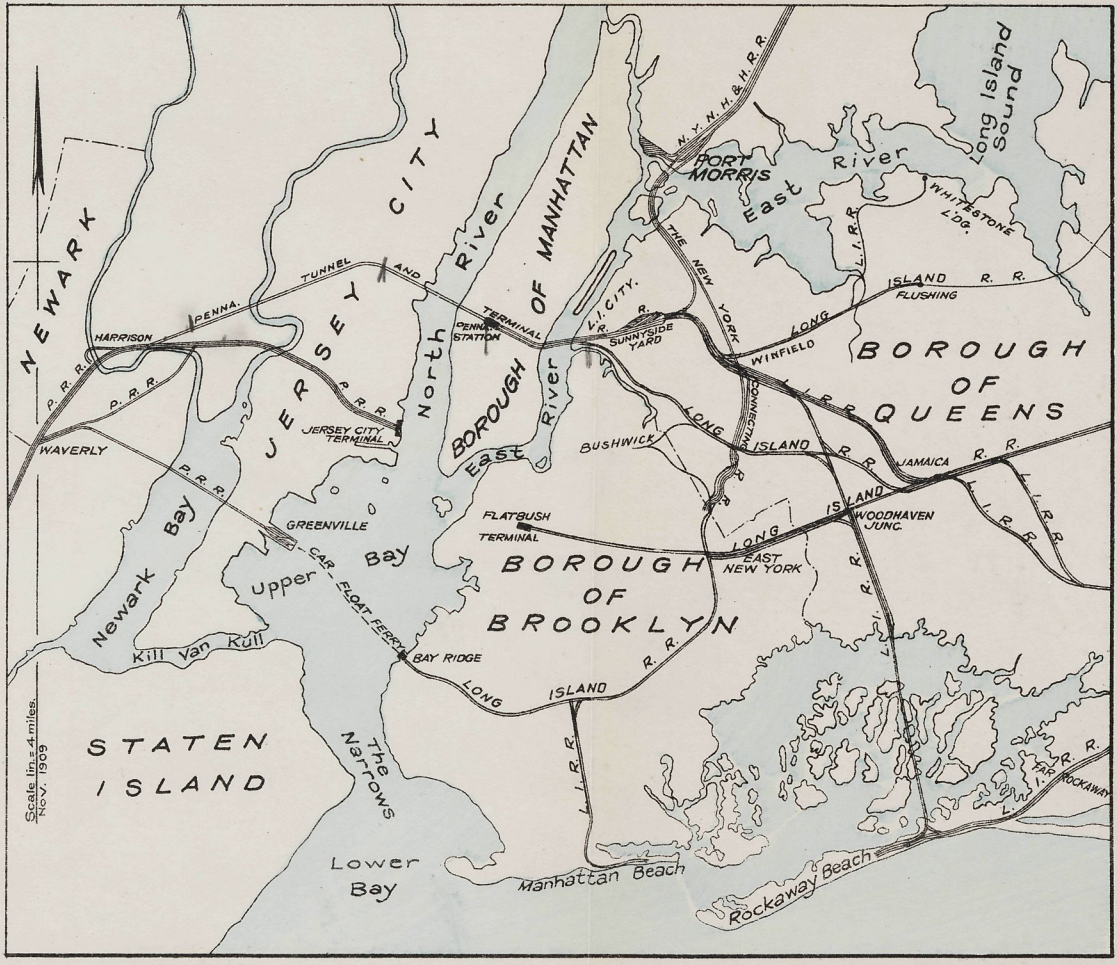
W. J. Richter

Pennsylvania Tunnel and Terminal R. R.

New York,
November, 1910



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Gift of
W. J. Slichter
Evanston

Pennsylvania Tunnel & Terminal R. R.

STATISTICS

Extent of Line:

From junction with New York Division east of Newark, to connection with the Long Island R. R. near Woodside, Long Island.

Manhattan Transfer:

(**Formerly Harrison**)

For interchange of power between the New York Division and the P. T. & T. R. R.

For interchange of passengers between N. Y. Division, P. T. & T. R. R. and Hudson & Manhattan R. R.

Extends from 5th St., Harrison, to bridge crossing the N. Y. Division and D. L. & W. R. R.

Two passenger platforms, 28 x 1,100 ft. Capacity, four trains in each direction per platform.

Four main tracks and two inside shifting tracks.

At ends of platforms are located steam and electric locomotive storage tracks.

Capacity of storage tracks—10 steam, 20 electric locomotives.

The yard furnishes a loop for turning trains or locomotives; locomotive storage and rapid transit H. & M. storage yard—6 tracks—capacity, 112 cars.

Meadows:

From a junction with the N. Y. Division property to Hackensack portal.

Length, centre line.....25,174.0 ft.
Tangent ..... 18,895.0 ft.
One 30 min. curve.....2,065.0 ft.
One 30 min. curve.....1,240.0 ft.
One 1 deg. 54 min. curve.....2,974.0 ft.

Two tracks—13 ft. centre to centre.
Cubic yards of embankment on Meadows, 2,700,000.
Average depth of fill over Meadows, 28 ft.

North River Tunnels:

From Hackensack portal to 10th Ave,, N. Y., extending under Bergen Hill and North River, 13,380 ft.

Length of tangent, 13,242 ft.

Bergen Hill Tunnels:

Tangent, 5,980 ft.; grade minus 1.3%

Cross passages are located every 300 ft. in the Bergen Hill tunnels.

Bergen Hill tunnels are through trap rock.

Construction of tunnels—concrete and brick arch, concrete benches.

Concrete used, 95,000 cu. yds.

Distance between benches, 11 ft. 8 in.

Bergen Hill tunnels have two side drains at foot of benches, covered by flag-stones, open joints; drains discharge into sumps.

River Tunnels:

One 30 min. curve, length 176 ft., 3,000 ft. west of 10th Ave. portal.

One 2 deg. reverse curve at 11th Ave., necessary to keep within the lines of 32nd St.

Depth of tunnel invert below mean high water, 97 ft.

Maximum depth of water, 53 ft.

Air pressure used during construction, 15 to 37 lbs. per sq. in.

Formation of river bed passed through: gneiss, rock, silt, sand and gravel.

Grades—

Weehawken shaft to low point under North River, minus 1.19%, length 1,000 ft. and minus 1.4%, length 800 ft.

Lowest point under North River to pierhead line, plus 0.5%, length 1,900 ft. and plus 1.2%, length 500 ft.

Pierhead line to 11th Ave., plus 1.93%, length 1,780 ft.

11th Ave. to 10th Ave., plus 1.91%, length 1,000 ft.

Tunnel Construction—

Exterior diameter of tunnel, 23 ft.

Interior diameter of tunnel, 19 ft.

Ring, 11 segments and a key segment.

Segments—external circumferential length, 77½ in.

Width of segments, 2½ ft.

Flanges of segments, 11 in. deep.

Joint bolts, 1½ in. diam., weight, 6½ lbs.

Thickness of web, 2 in.

Tunnel lining, cast iron and steel, 66,960 tons.

Steel bolts, 2,606 tons.

Weight of iron lining, per lin. ft., without concrete, ballast or track, 9,495 to 12,128 lbs.

Material excavated from east side of 10th Ave. to Hackensack Meadows—300 ft. west of Hackensack Portal—490,000 cu. yds.

Dynamite used, 1,201,000 lbs..

Total yardage of concrete, 188,960 cu. yds., N. R. Division.

Barrels of cement, 1,315,507.

Weight of concrete in tunnel, 20,400 lbs., per lin. ft.

Weight completed tunnel, with track, 32,400 lbs., per lin. ft.

Weight of displaced silt, at 105 lbs. per cu. ft., 43,625 lbs., per lin. ft.

Ratio of weight of completed tunnels to displaced silt, .74.

Area tunnel, 23 ft. diam.—415.5 sq. ft.

Tunnels, 37 ft. centre to centre.

River Tunnel Benches—

Top of bench one ft. below axis of tunnel—18 in. above floor of cars.

Width of bench, 3 ft. 2 in.

Top rail to invert, 2 ft. 1 in.

Top rail to intrados of tunnel, 16 ft.

Pennsylvania Station Yard:

From 10th Ave. to 6th Ave.—length, 3,500 ft.

From 31st to 33rd Sts.—510 ft.

Area—

28 acres. Number of buildings removed, 500.

Excavation—

3,000,000 cu. yds. rock.

Retaining Walls—

Length of retaining walls, 7,800 lin. ft.

Concrete for retaining walls, sub-structures, foundations and street bridging, 171,549 cu. yds.

Storage Capacity of Yard—

222 cars.

Trucking Subways and Pipe Galleries—

Under yard and station, 65 ft. below street level, are located trucking subways and pipe galleries, total length, 5,200 ft.

Drains—

Terminal area is equipped with sewers, sumps and automatic drainage pumps which discharge into city sewers.

Fire Mains—

Ten inch and five inch fire mains through yard and Station, with hose connections at required intervals.

Pennsylvania Station:

One of the principal features of the Station is the separation of incoming and outgoing passengers.

The incoming passengers pass from train platforms via short stairways or elevators to the exit concourse, and thence to street exits.

The outgoing passengers enter the main concourse, and pass to platforms via train gates and stairways.

The entrances and exits at 34th St., 8th Ave., 31st St. and 33d St. are all arranged so that incoming and outgoing passengers are separated thus avoiding confusion.

Dimensions and Data—

Area of building, 7.74 acres.

Length, 784 ft.; width, 430 ft.

Building supported on 650 steel columns.

Greatest weight on one column, 1,658 tons.

Weight of building steel, 27,000 tons.

Average height above street, 70 ft.

Maximum height above street, 154 ft.

Wire glass used in roof construction, ⅜ in. thick, 220 tons.

Gross aggregate of concrete used in station, 962,833 cu. ft.

Waterproofing used, 1,797,964 sq. ft.

Exterior of building, Milford pink granite, 500,000 cu. ft.

Brick, 15,000,000.

Number of electric lights in station, in terms of 16 c.p. lamps, 30,000.

Arcade—

46 ft. wide, length 216 ft.

Dining Room—

56 ft. wide, length 112 ft.

Lunch Room—

56 ft. wide, length 112 ft.

Waiting Room—

Main waiting room, length 277 ft.; width 108 ft.; height 150 ft.

Two sub-waiting rooms, 56 ft. x 100 ft.

Engagement room, 18 ft. x 28 ft.

Hospital, 21 ft. 8 in. x 16 ft. 6 in.

Nursery, 27 ft. x 46 ft. 3 in.

Two private waiting rooms for funeral parties, one 16 ft. x 18 ft. 6 in., one 16 ft. 8 in. x 21 ft. 8 in., one equipped with elevator to train platform.

Concourse—

Length, 500 ft.; width, 124 ft.

Train gates, 36.

Exit Concourse—

18 ft. above tracks; width 60 ft.; length 1,088 ft.

Exits—

34th St., stairway and escalator, capacity 12,000 people per hour.

8th Ave., stairways.

31st St., stairway.

33rd St., stairway.

Tracks and Platforms—

Number of tracks in station, 25.

Passenger loading tracks, 21.

Mail tracks, 3.

Yard tracks, 33.

Number of passenger platforms, 11.

Mail platforms, 2. Express platforms, 2.

Length of platforms adjacent to passenger tracks, 21,500 ft.

Four platforms, average 21 ft. wide x 900 ft. long.

Four platforms, average 21 ft. wide x 1,050 ft. long.

Two platforms, average 16 ft. wide x 1,000 ft. long.

One platform, 47 ft. wide x 745 ft. long.

Two mail platforms, 375 ft. long.

Two express platforms, 450 ft. long.

Total concrete in platforms, 20,000 cu. yds.

Elevators, Hydraulic and Electric—

Eleven standard plunger hydraulic lifts, platform 5 x 10 ft. Capacity 5,500 lbs.

Twenty-one standard plunger hydraulic lifts, platform 7x15 ft. Capacity 7,500 lbs.

Eleven Otis electric elevators, passenger platforms 4 ft. 6 in. x 6 ft. and 5 ft. x 6 ft. Capacity 3,300 lbs.

Baggage Room—

Width 98 ft.; length 300 ft.

2 Driveways to Baggage Room and General Waiting Room—

Width 40 ft.; length 502 ft.; grade 5.0 ft. per 100.

Baggage Passageway under 7th Ave.—

Width 36 ft.; length 452 ft.

Baggage Passageway under 31st St. –

Width 31 ft.; length 751 ft.

Baggage Passageway under 8th Ave.—

Width 56 ft.; length 421 ft.

East River Tunnels:

From 6th Ave. to Sunnyside portals, Long Island, including crosstown tunnels, tunnels under East River and Long Island City.

Length: 13,775 ft. 6th Ave. portal to Sunnyside portal. Tangent, 8,750 ft.

Grades –

6th Ave. to 5th Ave., minus 0.9%, length 1,500 ft.

5th Ave. to Madison Ave., minus 0.3%, length 600 ft.

Madison Ave. to low point under East River, minus 1.5%, length 4,050 ft.

Low point under East River is 1,100 ft. east of 1st Ave. shaft.

Low point under East River to east side of river, plus 0.7%, length 2,400 ft.

East side of East River to 3d St., Long Island City, plus 1.22%, length 3,200 ft.

3d St., Long Island City, to portals, Sunnyside, plus 1.5%, length 1,600 ft.

Character of Tunnels:

Crosstown tunnels are concrete and brick ring construction, waterproofed, through rock entire length.

The East River tunnels are cast iron segmental rings, bolted, lined with concrete, grouted on outside, and generally similar to North River tunnels.

Total cement used on East River Div. 1,402,700 barrels.

River-Tunnel Benches:

Top of bench 1 ft. below axis of tunnel and 18 in. above floor of cars.

Width of bench, 3 ft. 2 in.

Distance between benches, 11 ft. 8 in.

Distance top of rail to invert, 2 ft. 1 in.

Top rail to intrados of tunnel, 16 ft. 2 in.

Cast Iron Lining:

Ring, 2 ft. 6 in. wide, 11 segments and one key segment in each ring. Weight of ring, 11½ tons.

Total cast iron lining used, 100,000 tons.

Bolts for connecting ring segments, 1,500,000.

Concrete lining, 20 in. to 24 in. thick.

Sunnyside Yard:

Length 5,500 ft., width 1,550 ft., area 153 acres.

Track miles, 53—Ultimate, 80 miles.

Yard excavation, 2,843,780 cu. yds.

Buildings—

Commissary, 258 x 67 ft.—2 story brick.

Storehouse, 162 x 67 ft.—2 story brick.

Battery house, 103 x 67 ft.—1 story brick.

Oil house, 67 x 51 ft.—1 story brick, basement P. R. R. and Pullman.

Wheel shop, 80 x 40 ft.—1 story, expanded metal and plaster.

Engine house, 160 x 82 ft.—steel frame, expanded metal and concrete.

Wheel shed, 100 x 50 ft.—open.

Carpet shed, 88 x 33 ft.—open.

Sand house, 32 x 25 ft.

Steel umbrella sheds, 20 ft. wide; aggregate length, 2,798 ft., built between tracks, adjacent to buildings.

Boiler House—115 ft. x 51 ft.

Equipment—

Three yard water supply pumps, capacity, 750 gals. per min.

Three 500 h.p. B. & W. boilers with chain grate stokers.

Space for three additional boilers.

Two boiler feed pumps, 150 gals. per min.

One feed water heater.

Coal and ash handling machinery, 20 tons per hour.

Brick lined steel stack, 200 ft. high, 12 ft. 8 in. bottom diameter; top diameter 9 ft. 10 in.

Ultimate Car Capacity of Yard is as follows—

North yard, 42 tracks, multiple-unit cars	526 cars
South yard, 45 tracks, Pullman cars and P. R. R. coaches	552 cars
South yard, future extension	800 cars
Total	1,878 cars

Loop Feature—

By use of the under-grade loop at the east end of the yard, trains are turned for return trip before being placed in yard for storage and cleaning.

Sewers—

The slope and character of the yard directed the drainage to the west, toward the tunnel portals, it was necessary to intercept this drainage with an adequate sewerage system.

All sewers reinforced concrete construction.

Large sewer, rectangular, 9 ft. 6 in. wide; 7 ft. high.

Circular sewers, 48 in. diam.

Segmental arch sewers, 12 ft. wide, 10 ft. high.

Pipe Tunnels and Trenches—

Pipe tunnels constructed across the yard 8 ft. wide, 6 ft. 6 in. high, 3 ft. 2 in. from top of rail to top of pipe tunnel.

This tunnel carries an 8 in. water main, 6 in. air main, 10 in. steam main, 14 in. suction pipe and 6 in. fire main, and space is provided for wire conduits.

Total cement used in yard construction work, 141,400 barrels.

At the east end of the yard is located a 100 ft. diam. electrically-operated turntable.

The whole yard is enclosed by an iron picket fence 7 ft. high, with 3 in. I-beam posts, set in concrete bases.

Shafts:

Ventilating fans are located at the bottom of the shafts in the North River Tunnels, and also in the building at Hackensack Portal.

The East River fans are installed in the buildings above the shafts.

These shafts promote ventilation, provide access and egress, permit electrical connections and provide space for sump pump discharge pipes.

North River—

Weehawken shaft, 75 ft. deep, 100 ft. x 103 ft.

Sump pumps and ventilating fan installation.

Concrete, 11,623 cu. yds.

Cast iron stairways, 31,000 lbs.

11th Avenue shaft, 65 ft. deep, 32 ft. x 32 ft.

Sump pumps and ventilating fan installation.

Hydrolithic waterproofing, 7,095 sq. ft.

Weight of ventilation nozzles, 2,824 lbs.

East River—

1st Avenue shaft, 80 ft. deep, 18 ft. diameter.

Long Island City shaft, 76 ft. deep, 18 ft. diameter.

Quantity of material used in permanent concrete lining of East River shafts:

Concrete, 12,500 cu. yds.

Felt and pitch waterproofing, 14,400 sq. ft.

Hydrolithic waterproofing, 5,000 sq. ft.

Reinforcing steel, 73,600 lbs.

Ventilation nozzles, 1,960 lbs.

Steel pipe, 26,400 lin. ft.

Vitrified electric conduits, 12,400 ft.

Cast iron spiral stairways, 13,240 lbs.

Wrought iron pipes, 3½ in. diam. for electric conduits, were imbedded in concrete of shaft lining.

Pockets were left in shaft lining for power cables.

Two in. diam. iron pipes were imbedded in concrete to serve as conduits for lighting and signal wires.

Cast iron discharge pipes are also placed in shaft lining. These pipes carry water from electrically-driven pumps in sumps to the city sewers.

Power House, L. I. City:

Main Power Station.

Dimensions—

200 x 262 ft.
Boiler room, 103 ft. wide x 262 ft. long.
Engine room, 66 ft. wide x 262 ft. long.
Electrical galleries, 25 ft. wide x 262 ft. long.
Four stacks, 275 ft. high, 16 ft. diameter.
Foundation piles, number, 9,115.
Concrete monolithic cap on piles, 18,000 cu. yds.
Coal pocket at top of building, capacity, 5,200 tons.

Coal Handling Plant—

Coal hoisting tower on the dock 500 ft. from power house, 170 ft. above dock level, coal hoisted in two-ton clam-shell buckets.

Hoisting Capacity—

100 tons bituminous coal per hour.

Boilers—

Thirty-two 564 h. p. water tube boilers. 200 lbs. working pressure.

125 deg. super heat. Space for 16 additional 564 h. p. boilers.

Equipped with type D Roney stokers, 150 in. wide, 12 grates deep.

Equipment—

Two 8,000 k. w. 11,000 volt, 3 phase, 25 cycle, turbo-generators. Space for one additional.

Three 6,000 k. w. 11,000 volt, 3 phase, 25 cycle, turbo-generators. Both the above for electric traction.

Two 3,000 k. w. 11,000 volt, 3 phase, 60 cycle, turbo-generators for lighting station, buildings, tunnels, etc., and ventilating fans, sump pump motors and signals.

One 200 k. w. motor-driven exciter.
One 50 k. w. motor-driven exciter.
Two 200 k. w. turbine-driven exciters.
One 600 ampere-hour storage battery—110 cells.
One Tirrill regulator for 25 cycle generators.
One Tirrill regulator for 60 cycle generators.
Three 175 k. w. oil-cooled transformers.
Eleven 1,200 ampere, 11,000 volt, type C oil circuit breakers.
Twenty-six 600 ampere, 11,000 volt, type C oil circuit breakers.

Switchboard—

One bench board, 8 panels, for control of 25 cycle generators; and three panels for control of 60 cycle generators.
Six 25 cycle generator panels.
Two 60 cycle generator panels.
Two 25 cycle station panels.
One 60 cycle station panel.

One panel for Tirrill regulators for 25 and 60 cycle generators.
Three control panels for 25 cycle feeders.
Two control panels for 60 cycle feeders.
Two control panels for motor-driven exciters.
Two control panels for steam-driven exciters.
One d. c. motor panel.
One panel for storage battery.
One panel for exciter bus tie switch.
Three panels for station lighting and power.
Three panels for 25 cycle relays.
One panel for 60 cycle relays.
One panel for feeder wattmeters.
Power for signals is distributed from switch board in Service Plant.
The 25 cycle current is transmitted to four sub-stations on this Division and to twelve sub-stations of the Long Island Railroad.

Service Plant:

31st Street between 7th and 8th Avenues.
100 x 160 ft.
Structural steel in building, 2,437 tons.

Equipment—

Boilers. 5 B. & W. water tube boilers; 526 horse power each; ultimate 10 boilers; pressure, 200 lbs.

Ashes from pit discharged by gravity chute to narrow gauge cars, from these cars to ash storage bins, thence by gravity discharge to standard car on No. 1 track in the Station.

Two 1,000 k. w. 240 volt, 3 phase, 60 cycle, Westinghouse-Parsons steam-driven, direct connected turbo-generators. Space for one additional.

Two 2,000 cu. ft. per min. Nordberg cross-compound Corliss steam-driven air compressors, 100 lbs. pressure, for signals and ejectors.

Two 200 cu. ft. motor-driven air compressors, 120 lbs., pressure for brake testing.

One elevator pump, 1,500 gals. per min., 300 lbs. pressure, steam-driven, for baggage and passenger elevators.

One elevator pump, 500 gals. per min., 300 lbs. pressure, steam-driven, for baggage and passenger elevators—hydraulic.

One Corliss compound steam-driven pump, 1,500 gals. per min., for baggage and passenger elevators.

Two steam-driven Westinghouse air brake pumps for elevator system, for air cushion hydraulic elevator tanks.

Two duplex steam-driven underwriters' fire pumps. Capacity 1,500 gals. per min. each.

Two boiler feed pumps, duplex tandem, compound steam-driven.

One feed water heater (boiler), Wainwright. Capacity 6,500 gals. of water per hour from 70 deg. Fahr. to 200 deg. Fahr.

Three motor-driven automatic centrifugal pumps for circulating cold water and water for flushing purposes.

Four water storage tanks. Capacity 60,000 gals.

One garbage destroyer.

Three heaters for Station, indirect heating system. Capacity 85,000,000, B. T. U.

Three motor-driven centrifugal pumps for hot water circulation to Station, indirect heating system.

One refrigerating plant. Two 40 ton ammonia compressors.

Three brine pumps, motor-driven, centrifugal.

Two Green fuel economizers.

Two hot well pumps, motor-driven, centrifugal.

Two motor-driven centrifugal pumps, supplying drinking water.

Two single-acting, high speed steam engines, 50 h. p. each, for forced draught. Sirocco blast fans.

Four coal conveyors, 2 pairs. Capacity 120 tons per hour.

One coal skip hoist engine, 50 h. p.

One ash conveyor, 50 tons per hour, motor-driven belt.

Three Wainwright heaters, 315 gals. per hour.

Two Wainwright heaters, 635 gals. per hour, for hot water, toilets, kitchens and offices.

One Wainwright heater, 1,950 gals. per hour.

Thirty-eight Sturtevant multivane fans, motor-driven, for heating and ventilating system of Station building, as follows:

Type A, 58 in. diam. wheel. Type G, 40 to 46 in.

Type C, 69 in. diam. wheel. Type H, 57 in.

Type D. 86½ in. diam. wheel.

Three 750 k. w., single phase, 60 cycle, 11,000-420 volt air blast transformers.

Three 500 k. w., 60 cycle, 11,000-246 volt air blast transformers.

Two 150 k. w., 60 cycle, 11,000-2,200 volt O. I. S. C. transformers.

Two 100 k. w., 60 cycle, 11,000-220 volt O. I. S. C. transformers.

Two 80 k. w., 110-220 volt, motor generator sets for car battery charging.

Two 40 k. w., 110 volt motor-driven exciters.

Two 25 k. w., 35 volt motor generator sets, for baggage truck charging.

One 55 cell storage battery for emergency excitation.

Switchboard —

Six panels for control of two 1,000 k. w., 60 cycle turbo-generators.

Eleven panels for 60 cycle lighting and power circuits.

One panel for control of two 25 k. w. motor generator sets.

Two panels for baggage truck charging circuits.

Two panels for control of two 80 k. w. motor generator sets.

One panel for metering and controlling car battery charging and elevator control circuits.

Boiler House, Sunnyside Yard:

Equipment—

Three Babcock & Wilcox boilers, 600 h. p. each.

Three Bayonne, chain-grate stokers, 9 ft. wide x 12 ft. long.

One boiler feed pump heater.

Two boiler feed pumps.

Three water and fire pumps, 1,000 gals. each.

One motor-driven coal and ash-handling system, 20 tons per hour.

One steel smoke stack, 200 ft. high, 9 ft. diam. at top.

Sub-Stations:

No. 1, in Power House, Long Island City.

Equipment—

Three rotary converters, 2,000 k.w., 650 volts, 3,000 amperes, 6 phase, 25 cycle, 187½ r. p. m., with starting motors.

Nine air-blast transformers single phase, 25 cycle, 750 k.v.a., 11,000-430 volts.

Two blowers, motor-driven, 15 h. p., for supplying air to transformers.

Five type C oil circuit breakers—Three 600 amperes, 11,000 volts.
Two 1200 amperes, 11,000 volts.

Four remote controlled rotary panels.

Three control panels for remote controlled circuit breakers.

One station load panel.

Eleven remote controlled d. c. feeder panels.

Two control panels for remote controlled d. c. circuit breakers.

No. 2, in Service Plant, 31st St.

Equipment—

Three rotary converters, 2,000 k.w., 650 volts, 3,000 amperes, 6 phase, 25 cycle, 187½ r. p. m. with starting motors.

Nine air-blast transformers, single phase, 25 cycle, 750 k.v.a., 11,000-430 volts.

Two blowers, motor-driven, 15 h. p., for supplying air to transformers.

Ten type C oil circuit breakers, 600 amperes, 11,000 volts,

Three starting transformers, 116 k. v. a., single phase, 11,000-530 volts.

Four remote controlled rotary panels.

Four control panels for remote controlled circuit breakers.

One station load panel.

Two 25 cycle, a. c., feeder panels.

Nineteen remote controlled d. c. feeder panels.

One elevator d. c. feeder panel.

Three control panels for remote controlled d. c. circuit breakers.

Three tunnel alarm panels.

One panel for Station fire alarm.

Five 60 cycle, a. c., signal feeder panels.

No. 3, west of Hackensack Portal.

Equipment—

Three rotary converters, 2,000 k.w., 650 volts, 3,000 amperes, 6 phase, 25 cycle, 187½ r. p. m. with starting motors.

Nine air-blast transformers, single phase, 25 cycle, 750 k.v.a., 11,000-430 volts.

Two blowers, motor-driven, 15 h. p., for supplying air to transformers.

Twelve type C oil circuit breakers, 600 amperes, 11,000 volts.

Three starting transformers, 116 k.v.a., single phase, 11,000-530 volts.

Three Westinghouse electrolytic lightning arrester sets, type A, 11,000 volts.

One 55 cell control battery.

One battery charging set, 16 h. p. induction motor, direct connected to 10 k.w. d.c. generator.

Eight a. c. feeder panels.

Three control panels for rotary converters.

Five d. c. feeder panels.

One battery panel.

One blower panel.

One tunnel alarm panel.

One rotary transfer panel.

One d. c. feeder transfer panel.

No. 4, 6,140 ft. east of Manhattan Transfer:

Equipment—

Three rotary converters, 2,000 k. w., 650 volts, 3,000 amperes, 6 phase, 25 cycle, 187½ r. p. m. with starting motors.

Nine air-blast transformers, single phase, 25 cycle, 750 k. v. a., 11,000-430 volts.

Two blowers, motor-driven, 15 h. p. for supplying air to transformers.

Seven type C oil circuit breakers, 600 amperes, 11,000 volts.

Three starting transformers, 116 k. v. a., single phase, 11,000-530 volts.

Three Westinghouse electrolytic lightning arrester sets, type A, 11,000 volts.

One 55 cell control battery.

One battery charging set, 16 h. p. induction motor, direct connected to 10 k. w. d. c. generator.

One station panel.

Three a. c. feeder panels.

Three control panels for rotary converters.

Eight d. c. feeder panels.

One battery panel.

One blower panel.

One rotary transfer panel.

One d. c. feeder transfer panel.

Auxiliary Sub-Stations:

A—Sunnyside Yard, west end of boiler house:

Equipment—

Contains high tension feeders and circuit breakers, transformers and motor generator sets for furnishing direct current for yard lights and power, and the charging of car storage batteries.

Equipment—

Three 250 k. w. 110-220 volt, 3-wire motor generator sets, for car battery charging, building lighting and power.

Two 1,500 cu. ft. per min. compound Nordberg steam-driven air compressors.

Two a. c. feeder panels.

Three a. c. machine panels.

Three d. c. machine panels.

Two blank d. c. machine panels.

Eighteen car battery charging panels of 14 circuits each.

Five power and lighting panels.

One fire alarm panel.

B—Over Long Island shaft to No. 3 and No. 4 tunnels:

Equipment—

Contains electric apparatus for control of high-tension feeders to auxiliary Sub-stations C and D, for control of lighting in tunnels No. 1, No. 2, No. 3 and No. 4, from point about midway between the 1st Ave. and Long Island shafts to Sunnyside portals—for control of the ventilating fans in the Long Island City shaft houses, and for control of sump pumps in Long Island shafts and at Sunnyside portals.

Two 125 k.v.a., 3 phase, 60 cycle transformers, 11,000-440 volts.

Five panel switchboard for control of pumps, fans and lights.

C—Over 1st Ave. shaft to No. 3 and No. 4 tunnels:

Equipment—

Contains electric apparatus for control of lighting in tunnels No. 3 and No. 4 from point about midway between 1st Ave. and Long Island shafts to 6th Ave. portals; for control of ventilating fans in auxiliary Sub-station C, and for control of sump pumps in 1st Ave. shaft to No. 3 and No. 4 tunnels.

One 125 k.v.a., 3 phase, 60 cycle transformer, 11,000-440 volts.

One 75 k.v.a., 3 phase, 60 cycle transformer, 11,000-440 volts.

Two panel switchboard, for control of fans, pumps and lights.

D—Over 1st Ave. shaft to No. 1 and No. 2 tunnels:

Equipment—

Contains electric apparatus for the control of lighting in tunnels No. 1 and No. 2 from point about midway between 1st

Ave. and Long Island shafts to 6th Ave. portals; for control of ventilating fans in auxiliary Sub-station D, and for control of sump pumps in 1st Ave. shaft to No. 1 and No. 2 tunnels.

Equipment otherwise identical with C.

E—North side westward tunnel, 700 ft. west 11th Ave. portal:

Equipment—

Contains electric apparatus for control of lighting in tunnels under North River from 10th Ave. portals to a point about midway between E and Weehawken shaft, and for control of ventilating fans and sump pumps in E.

Two 75 k.v.a. 11,000-440 volt, 3 phase, 60 cycle transformers.
2 panel switchboard, for control of fans, pumps and lights.

F—Weehawken shaft, between westward and eastward tunnels:

Equipment—

Contains electric apparatus for the control of lighting in tunnels under the North River and Bergen Hill, from a point midway between E and F to Hackensack portal, and for the control of ventilating fans and sump pumps in F.

Two 75 k.w. 11,000-440 volt, 3 phase, 60 cycle transformers.
Two panel switchboard, for control of fans, pumps and lights.

Switching Stations:

For feeding and sectioning 650 volt D. C. Circuits:

No. 1 A—Sunnyside Yard, 1,300 ft. east of Interlocking Station Q.

For interconnection between the Long Island R. R. and P. T. & T. R. R. third rails, and for feeding Sunnyside yard third rails. Records interchange of power by wattmeters between the P. T. & T. R. R. and Long Island R. R.

Main circuit breakers controlled from Sub-station No. 1.

Yard circuit breakers controlled by hand.

Ten remote controlled circuit breakers; four feeding the P. T. & T. R. R third rails and six feeding the Long Island R. R. third rails.

One load panel.

Six hand-operated circuit breakers, feeding third rails in Sunnyside yard.

No. 2 A—In tunnel No. 3, 2,000 ft. west of 1st Ave. shaft.

For cross-connecting and sectioning third rails in No. 3 and No. 4 tunnels, between Sub-stations No. 1 and No. 2.

Four remote controlled circuit breakers.

Two circuit breakers for sections east, controlled from Sub-station No. 1.

Two circuit breakers for sections west, controlled from Sub-station No. 2.

No. 2 B—In tunnel No. 2, 2,000 ft. west of 1st Ave. shaft.

For cross-connecting and sectioning third rails in No. 1 and No. 2 tunnels between Sub-stations No. 1 and No. 2.

Four remote controlled circuit breakers.

Two circuit breakers for sections east, controlled from Sub-station No. 1.

Two circuit breakers for sections west, controlled from Sub-station No. 2.

No. 3 A—One hundred feet east of Weehawken shaft.

For cross connecting and sectioning third rails between Sub-stations No. 2 and No. 3.

Four remote controlled circuit breakers.

Two circuit breakers for sections east, controlled from Sub-station No. 2.

Four circuit breakers for sections west, controlled from Sub-station No. 3.

No. 3 B—7,500 east of Hackensack drawbridge.

For feeding and cross-connecting third rails, between Sub-station No. 3 and switching station 4 A; near drawbridge.

No third rail sectioning at this station.

Two remote controlled circuit breakers.

Circuit breakers controlled from Sub-station No. 3.

Third rail sectioning switches opposite this station to be operated under instructions from Train Director.

The 2,000,000 c. m. feeder on pole line from Hackensack Sub-station feeds third rails at this point.

No. 4 A—Opposite Interlocking Station W, east approach of Hackensack drawbridge.

For feeding, cross-connecting and sectioning third rails between Sub-stations No. 3 and No. 4.

One panel for power, for operating drawbridge motors.

Four hand-operated panels.

Hand-operated switches and circuit breakers to be operated by signalman in Interlocking Station W, under instructions from Train Director.

The 2,000,000 c. m. feeder on pole line from Harrison Sub-station feeds third rails at this point.

No. 4 B—Basement of Interlocking Station N, west end of Manhattan Transfer.

For cross-connecting and sectioning third rails at Manhattan Transfer between Sub-station No. 4 and west end of Manhattan Transfer.

Five hand-operated panels.

Hand-operated switches and circuit breakers to be operated by signalman at Interlocking Station N, under instructions from Train Director.

Transmission Lines:

Meadows—

General—

Located on right of way, 90 ft. south of center line.

Height of steel poles, 50 ft., 55 ft., 60 ft. and 65 ft.

Clearance of cables and wire above ground. 20 ft. 5 in.

Normal sag of line for 300 ft. span, 5 ft.

Poles spaced 300 ft. apart.

Eighty poles on Meadows.

Ultimate capacity of poles, 10 cross arms.

Circuits—

Three 250,000 circular mill., 11,000 volt, 25 cycle, 3 phase circuits from Sub-station No. 3 to Sub-station No. 4.

Two 00-2,200 volt, 60 cycle signal circuits, from Sub-station No. 3 to Interlocking Station N.

One 2,000,000 circular mill., 650 volt negative feeder, from Sub-station No. 3 to Sub-station No. 4.

One 2,000,000 circular mill., 650 volt positive feeder, from Sub-station No. 3 to switching station 3 B.

One 2,000,000 circular mill., 650 volt positive feeder, from Sub-station 4 to switching station 4 A.

One 250,000 circular mill, lightning wire on top of poles.

Space is provided on poles for four 33,000 volt, 25 cycle, 3 phase circuits.

Construction of Poles—

Structural steel, 6 in. x 6 in. and 3½ in. x 5 in. and 3 in. x 4 in., angles latticed. Poles on concrete foundations resting on wooden pile foundations.

Piles vary in length 25 ft. to 80 ft. 8 to 10 piles per foundation.

Height of poles crossing Hackensack River, 195 ft.

Distance between poles, 750 ft.

Clearance of this span complies with U. S. Government regulations.

Tunnels—

In all tunnels the power and telephone cables are located in 3½ in. square terra cotta ducts in the benches.

Power cables are installed in benches on the right hand side and telephone cables on the left hand side, with reference to normal traffic.

Westward Tunnel, North River:

Three 3-conductor, 250,000 c.m., 25 cycle, 11,000 volt, paper-insulated, lead covered cables.

One 3-conductor, No. 4 B. and S. gauge, 60 cycle, 11,000 volt, paper insulated, lead covered cable; from the east end of tunnel to Weehawken shaft.

One 2-conductor, No. 00, 60 cycle, 2,200 volt, rubber insulated, lead covered cable.

Eastward Tunnel, North River:

Two 3-conductor, 250,000 c.m., 25 cycle, 11,000 volt, paper-insulated, lead covered cables.

One 3-conductor, No. 4, B. and S. gauge, 60 cycle, 11,000 volt, paper insulated, lead covered cable; from east end of tunnel to Weehawken shaft.

One 2-conductor, No. 00, 60 cycle, 2,200 volt, rubber insulated, lead covered cable.

Tunnel No. 1, East River:

One 3-conductor, 250,000 c. m., 25 cycle, 11,000 volt, paper-insulated, lead covered cable; from Long Island shaft to Station yard.

One 3-conductor, No. 4, B. and S. gauge, 60 cycle, 11,000 volt, paper insulated, lead covered cable; from Long Island shaft to Manhattan shaft.

One 2-conductor, No. 4, B. and S. gauge, 60 cycle, 2,200 volt, rubber insulated, lead covered cable; from Station yard to Long Island portal.

Tunnel No. 2, East River:

Two 3-conductor, 250,000 c.m., 25 cycle, 11,000 volt, paper-insulated lead covered cables; from Long Island shaft to Station yard.

One 3-conductor, No. 4, B. and S. gauge, 60 cycle, 11,000 volt, paper insulated, lead covered cable; from Long Island shaft to Manhattan shaft.

One 2-conductor, No. 4, B. and S. gauge, 60 cycle, 2,200 volt, rubber insulated, lead covered cable; from Station yard to Long Island portals.

Tunnel No. 3, East River:

Two 3-conductor, 250,000 c.m., 25 cycle, 11,000 volt, paper-insulated, lead covered cables; from Long Island shaft to Station yard.

One 3-conductor, No. 00, 60 cycle, 11,000 volt, paper insulated, lead covered cable; from Long Island shaft to Station yard.

One 3-conductor, No. 4, B. and S. gauge, 50 cycle, 11,000 volt, paper insulated, lead covered cable; from Long Island shaft to Manhattan shaft.

One 2-conductor, No. 4, B. and S. gauge, 60 cycle, 2,200 volt, rubber insulated, lead covered cable; from Station yard to Long Island portals.

Tunnel No. 4, East River:

Two 3-conductor, 250,000 c.m., 25 cycle, 11,000 volt, paper-insulated, lead covered cables; from Long Island shaft to Station yard.

One 3-conductor, No. 00, 60 cycle, 11,000 volt, paper insulated, lead covered cable; from Long Island shaft to Station yard.

One 3-conductor, No. 4, B. and S. gauge, 60 cycle, 11,000 volt, paper insulated, lead covered cable; from Long Island shaft to Manhattan shaft.

One 2-conductor, No. 4, B. and S. gauge, 60 cycle, 2,200 volt, rubber insulated, lead covered cable; from Station yard to Long Island portals.

Sunnyside Yard—P. T. & T. R. R.

From the portals of tunnels, the 2,200 volt, single phase circuit in each tunnel is carried on a pole line to Interlocking Station F. No. 00 bare copper wire is used.

From Interlocking Station F, two No. 00 single phase circuits are run on the Long Island R. R. Co's pole line to Interlocking Stations Q and H, and on steel poles across the yard to Interlocking Station R.

The wires for yard lighting, fire alarm system and power are carried on steel poles.

Sunnyside Yard—Long Island R. R.

The Long Island R. R. Co.'s pole line carries seven 250,000 c. m., 3 phase, 25 cycle, 11,000 volt circuits.

Connections are made to two of these circuits and carried across the yard into auxiliary Sub-station A, for furnishing power for operating the motor generator sets.

From Woodside Ave. to west end of the yard there are fifty-five poles.

Height of poles, 30 ft. 4 in. to 79 ft. 4 in.

Number of cross-arms, 9 to 10.

Where line crosses street, or where there is an angle in the line, the cross-arms are double.

On lower arm, 15 pair telephone cable from Interlocking Station Q to Interlocking Station H.

Structural iron poles, latticed, built of 6 x 6 x 13-16 in. and 5 x 5 x 3-8 in., and 3½ x 3½ x 7-16 in. angles.

Foundations, concrete on wooden piles.

Average span, 150 ft. Longest span, 174 ft.

Working Conductors, etc.:

The third rail on main line tracks is one hundred and fifty pounds per yard, special composition.

An over-running shoe is used, and wood protection is installed over the rail.

Porcelain insulators are used throughout and are located about nine feet, six inches apart.

A petticoat insulator is used for the third rail within and a block insulator outside the tunnels.

Third rails are anchored about every fifteen hundred feet.

Sectioning switches are located about fifteen hundred feet in the tunnels.

Yard tracks are equipped with 25-lb. third rails.

The 25-lb. third rails are inverted, and supported on porcelain insulators.

Over ladder tracks, and at points where usual third rail cannot be installed, a 25 lb. rail is used as an overhead conductor.

These rails are suspended from the steel work by porcelain insulators.

The following types of bonds are used:

Rail.	Type.	Cir.Mils.	Length.
150 lb.	Compressed Terminal.	450,000	Five inch and ten inch.
100 lb. P. S.	Pin Terminal.	273,397	Twenty-five and twenty inch.
100 lb. P. S.	"	400,000	Forty-nine and fifty-three and one-quarter inch.
100 lb. P. R. R.	"	300,000	Twenty-five inch.
85 lb. P. S.	"	300,000	Fifteen inch.
25 lb.	"	0,000	Twelve inch.
25 lb.	"	00	Twenty - four and one-quarter inch.

The feeders for all third rails on the main line tracks are 2,000,000 c. m. paper insulated, lead covered cables.

Third rail sections in yards are fed from Sub-stations through 1,000,000 c. m. paper insulated, lead covered cables.

Feeders are connected to third rails through pot-heads.

Terminals on pot-heads for 2,000,000 c. m. feeders are two way, and take six 350,000 c. m. leads to the rail.

Pot-heads for 1,000,000 c. m. cables have one way terminals for three 350,000 c. m. leads to rail.

Pot-heads for 750,000 c. m. cables have one way terminals for two 350,000 c. m. leads to rail.

Jumpers between 150 lb. third rails are made of 2,000,000 c. m. rubber insulated cable.

Jumpers between 25 lb. third rails are made of 750,000 c. m. cable.

Bare cables, 5,000,000 c. m., are used for negative conductors between the rails, the Power House and Service Plant Sub-stations.

Bare cables, 2,000,000 c. m., are used for negative conductors at Sub-station No. 3 and Sub-station No. 4.

Fire Protection and Tunnel Alarm System:

Pennsylvania Station:

There are twenty fire alarm boxes located in the Station and yard. The switchboard is located in the Service Plant Sub-station, and gongs and indicators are located at various points in the Station.

A fire alarm box connecting with the city fire alarm system is located in the Station Master's office. Hydrants with hose connections are located throughout the Station.

Sunnyside Yard:

There are fourteen alarm boxes located within the yard.

The fire alarm switchboard is auxiliary Sub-station A.

A whistle-blowing machine is located in the boiler house, also a fire alarm box connected with the city fire alarm system.

Tunnel Alarm System:

Alarm boxes are located in all tunnels at intervals of about 800 feet. These boxes are equipped with two levers; one painted blue and marked "Power," and the other painted red and marked "Fire."

If it is desired to cut off the power from third rail the blue lever is pulled, which sends in two rounds of the box number to the Sub-station feeding the third rail, and trips the circuit breakers in the Sub-station and Switching Station.

The alarm is also given in the offices of the Train Director, Train and Locomotive Despatcher, Power Director and the Interlocking Station controlling the movement of trains in the section in which the trouble occurs.

If the red lever is pulled the power is cut off the third rail, and four rounds of the alarm are sent in as above.

Telegraph and Telephones:

Pennsylvania Station—

Six position telephone switchboard, equipped with 400 extensions and one hundred and twenty trunks.

System—

A combination of common battery and magneto.

Two hundred extensions now in service.

Thirty trunk lines to Chelsea Exchange. Seven operators.

Tunnels—

Ducts carrying telegraph and telephone cables are in benches on left side, with reference to normal traffic.

Sixty telephones in iron boxes in tunnels.

Sixty loud-ringing bells for tunnel telephones.

Pole Lines—

Two hundred and seven reinforced concrete poles 35 to 65 ft. high. Top, 8 in.; bottom, 14 to 21 in.

Weight of poles, 5,000 to 17,500 lbs.

All cross-arms of Oregon and Washington fir wood.

Interlocking Stations—

Monitor telephone switchboard in every tower.

Telegraph—

Fifty line switchboard.

One duplex telegraph circuit to Philadelphia.

Ten telegraph instruments. Central messenger system.

Fire alarm and tunnel alarm system.

Pneumatic tubes to Station Master, General Yard Master, Baggage Agent and Pullman offices.

Telegraph Motor Room—

Battery for telegraph circuits, annunciators and office buzzers.

Miscellaneous—

Fifteen pair cable in each tunnel for telegraph and telephone service.

All the clocks in the Station are controlled and regulated by the Master Synchronizing Clock in the Train and Locomotive Despatcher's office.

One-hundred-and-ten pair cable in No. 1 tunnel from cable terminal room in Penna. Station to the Long Island shaft; and from the Long Island shaft a one-hundred pair cable in No. 1 tunnel and on Western Union Co's pole line to Interlocking Station Q.

The Long Island R. R. Co's cable from Jamaica will connect with the cable at this point.

From Penna. Station, a fifty pair cable and a thirty pair cable to the telephone line terminal pole at Hackensack portal.

On the pole line there are thirty-four open wires and a forty pair cable to the terminal pole at the west end of the line, opposite Sub-station No. 4.

From this point there is a thirty pair cable and a fifty pair cable to the New York Division pole line, and thence by New York Division pole line to G Y tower.

A forty pair cable from G Y tower to Manhattan Transfer.

Sumps:

There are 17 drainage sumps in the system, all operated by automatic electrically-driven centrifugal pumps, except the sub-aqueous sumps in mid-river, which are automatic, direct-acting, air-driven piston pumps.

Sunnyside Portal, Tunnel 4—

Capacity of sump, 25,778 gals. Estimated total seepage and rainfall, 860 gals. per min. Number of pumps, 1, Capacity 500 gals. per min. Pump submerged. Greatest discharge lift, 29 ft. Length discharge pipe, 47 ft. Speed of pump, 1,120 r. p. m. Horse power of motor, 7½.

Sunnyside Portal, Tunnel 2—

Capacity of sump, 12,983 gals. Estimated total seepage and rainfall, 195 gals. per min. Number of pumps, 1. Capacity 250 gals. per min. Pump submerged. Greatest discharge lift, 26 ft. Length discharge pipe, 430 ft. Speed of pump, 1,120 r. p. m. Horse power of motor, 5.

Sunnyside Portals, Tunnels 1 and 3—

Capacity of sump, 57,938 gals. Estimated total seepage and rainfall, 1,515 gals. per min. Number of pumps, 2. Capacity of each, 500 gals. per min. Pumps submerged. Greatest discharge lift, 27 ft. Length discharge pipe, 65 ft. Speed of pumps, 1,120 r. p. m. Horse power of motors, 10.

Long Island Shaft, Tunnels 3 and 4—

Capacity of sump, 58,726 gals. Estimated total seepage, 19 gals. per min. Number of pumps, 2. Capacity: one 100 gal. per min. One 1,000 gal. per min. Pumps submerged. Greatest discharge lift, 84½ ft. Length discharge pipe, 135 ft. Speed of pump (1,000 gals.) 1,120 r. p. m. Speed of pump (100 gals.) 1,700 r. p. m. Horse power of motors, 7½ and 40.

Long Island Shaft, Tunnels 1 and 2—

Capacity of sump, 58,726 gals. Estimated total seepage and rainfall, 6 gals. per min. Number of pumps, 2. Capacity: one 100 gal. per min., one 500 gal. per min. Pumps submerged. Greatest discharge lift, 84 ft. Length discharge pipe, 165 ft. Speed of pumps, 1,700 r. p. m. Horse power of motors, 7½ and 20.

East River Sub-Aqueous Sump, Tunnels 3 and 4—

Location, lowest point under East River. Capacity of sump, 16,167 gals. Estimated total seepage and rainfall, 5 gals. per min. Number of pumps, 2. Capacity: 100 gals. per min. Greatest discharge lift, 102 ft. Length discharge pipe, 1,115 ft. Size 6½ in. x 5 in. x 10 in. direct-acting, single cylinder, air-driven.

East River Sub-Aqueous Sump, Tunnels 1 and 2—

Location, lowest point under East River. Capacity of sump, 16,119 gals. Estimated total seepage and rainfall, 12 gals. per min. Number of pumps, 2. Capacity: 100 gals. per min, Greatest discharge lift, 98½ ft. Length discharge pipe. 1,000 ft. Size 6½ in. x 5 in. x 10 in. direct-acting, single cylinder, air-driven.

First Ave. Shaft, Tunnels 3 and 4—

Capacity of sump, 53,516 gals. Estimated total seepage and rainfall, 52 gals. per min. Number of pumps, 2. Capacity: 100 gals. per min. Pumps submerged. Greatest discharge lift, 98 ft. Length discharge pipe, 124 ft. Speed of pumps, 1,700 r. p. m. Horse power of motors, 7½.

First Ave. Shaft, Tunnels 1 and 2—

Capacity of sump, 53,654 gals. Estimated total seepage and rainfall, 98 gals. per min. Number of pumps, 2. Size of pumps, 200 gals. per min. Pumps submerged. Greatest discharge lift, 95½ ft. Length of discharge pipe, 142 ft. Speed of pumps, 1,700 r. p. m. Horse power of motors, 10.

7th Ave. Sump—

Capacity of sump, 31,000 gals. Estimated total seepage and rainfall, 4,525 gals. per min. Number of pumps, 2. Capacity: 2,500 gals. per min. Pumps submerged. Speed of pumps, 690 r. p. m. Horse power of motors, 75.

Service Plant Sump—

Capacity of sump, 19,550 gals. Estimated total seepage and rainfall, 800 gals. Number of pumps, 2. Capacity: 500 gals. per min. Pumps submerged. Speed of pumps, 850 r.p.m. Horse power of motors, 15.

9th Ave. Sump—

Capacity of sump, 101,300 gals. Estimated total seepage and rainfall, 12,900 gals. per. min. Number of pumps, 3. Capacity: two pumps 7,250 gals. per min.; one pump 250 gals. per min. Pumps submerged. Speed of pumps, 580 and 1,700 r.p m. Horse power of motors, 240 and 15.

10th Ave. Sump—

Capacity of sump, 37,300 gals. Estimated total seepage and rainfall, 7,400 gals. per min. Number of pumps, 3. Capacity: two pumps 4,100 gals. per min. One pump 250 gals. per min. Pumps submerged. Speed of pumps, 690 and 1,700 r.p.m. Horse power of motors, 100 and 15.

11th Ave. Shaft and Shield Chamber—

Capacity of sump, 47,230 gals. Estimated total seepage, 20 gals. per min. Number of pumps, 2. Capacity: one 100 gal. pump. One 1,000 gal. pump. Pumps submerged. Speed of pumps, 1,700 and 1,120 r. p. m. Horse power of motors, 7½ and 30.

North River Sub-Aqueous Sump—Westward Tunnel.

Depth, 11 ft. 3 in. below lining. 5 ft. wide. At lowest grade point. Capacity of sump, 458 gals. Estimated total seepage, .7 gals. per min. Capacity: one 50 gal. pump; one 250 gal. pump. Suction lift, 17 ft. Size 4½ x 4 x 8 in. and 10 x 8 x 12 in. direct-acting, single-cylinder, air-driven.

North River Sub-Aqueous Sump—Eastward Tunnel.

Size, 11 ft. 3 in. deep below iron lining. 5 ft. wide. At lowest grade point. Capacity of sump, 458 gals. Estimated total seepage .7 gals. per min. One 50 gal. pump. One 250 gal. pump. Suction lift, 17 ft. Length discharge pipe, 2,260 ft. Size 4½ x 4 x 8 in. and 10 x 8 x 12 in., direct acting, single cylinder, air-driven.

Weehawken Shaft Sump—Eastward and Westward Tunnels.

Size, 13 ft. 3 in. deep, 17 ft. 3 in. long, 5 ft. wide. Capacity of sump, 37,000 gals. Estimated total seepage and rainfall, 530 gals. per min. Capacity: two pumps, 250 gal. per min. Pumps submerged. Speed of pumps, 1,700 r.p.m. Horse power of motors, 15. Weehawken shield chamber sump drains into Weehawken shaft sump.

Ventilation:

Ventilation is effected largely by the piston action of the moving trains. When a train enters the tunnel a plenum is produced ahead of the train. This region of plenum extends a considerable distance ahead of the train. The movement of trains in the tunnels produces a current of air in the direction of traffic and causes a periodic change of the air.

In addition to this ventilation, fourteen electrically-driven ventilating fans are installed at various points, and are so arranged as to supply a current of air in the direction of traffic.

The fans are of multivane type, belt-driven by electric motors, and cone pulleys are provided so that equipment may be run at full speed, or seventy per cent. or forty per cent. of full speed, with a corresponding change in capacity.

The air is introduced to the tunnels through suitably designed nozzles built into the walls.

In the North River tunnels the fans are placed close to the nozzles, and the ducts are comparatively short.

In the East River tunnels the fans are placed at the top of the various shafts, and suitable vertical ducts are installed in the lining of the shafts.

North River Tunnels:

Fan No. 1—

Hackensack portal. Discharges air eastward in eastward tunnel.

Double inlet pressure fan, 60 in. wheel, driven by a 40 h. p., 25 cycle, 440 volt, 750 r.p.m., three phase induction motor.

Capacity, 87,000 cu. ft. of air per min. at speed of 250 r.p.m.

Fan No. 2—

Weehawken shaft. Discharges air eastward in eastward tunnel.

Double inlet pressure fan, 60 in. wheel, driven by a 75 h. p., 60 cycle, 440 volt, 850 r.p.m. three phase induction motor.

Capacity, 125,800 cu. ft. of air per min. at speed of 287 r.p.m.

Fan No. 3—

Weehawken shaft. Discharges air westward in westward tunnel.

Double inlet pressure fan, 54 in. wheel, driven by a 40 h. p., 60 cycle, 440 volt, 850 r.p.m. three phase induction motor.

Capacity, 100,800 cu. ft. of air per min. at speed of 269 r.p.m.

Fan No. 4—

Eleventh Ave. shaft. Discharges air westward in westward tunnel.

Double inlet pressure fan, 60 in. wheel, driven by a 50 h. p., 60 cycle, 440 volt, 850 r.p.m. three phase induction motor.

Capacity, 98,000 cu. ft. of air per min. at speed of 243 r.p.m.

East River Tunnels:

Fan No. 5—

First Ave. shaft; tunnels No. 3 and No. 4. Discharges air westward in tunnel No. 4.

Double inlet pressure fan, 72 in. wheel, driven by 50 h. p., 60 cycle, 440 volt, 850 r.p.m. three phase induction motor.

Capacity, 78,600 cu. ft. of air per min. at speed of 189 r.p.m.

Fan No. 6—

First Ave. shaft; tunnels No. 3 and No. 4. Discharges air eastward in tunnel No. 3.

Double inlet pressure fan, 54 in. wheel, driven by 20 h. p., 60 cycle, 440 volt, 850 r.p.m. three phase induction motor.

Capacity, 53,500 cu. ft. of air per min. at speed of 203 r.p.m.

Fan No. 7—

First Ave. shaft; tunnels No. 3 and No. 4. Draws air eastward in tunnel No. 3.

Single inlet exhaust fan, 66 in. wheel, driven by 20 h.p., 60 cycle, 440 volt, 850 r.p.m. three phase induction motor.

Capacity, 59,200 cu. ft. of air per min. at speed of 202 r.p.m.

Fan No. 8—

First Ave. shaft; tunnels No. 1 and No. 2. Discharges air westward in tunnel No. 2.

Double inlet pressure fan, 72 in. wheel, driven by 50 h. p., 60 cycle, 440 volt, 850 r.p.m. three phase induction motor.

Capacity, 78,600 cu. ft. of air per min. at speed of 189 r.p.m.

Fan No. 9—

First Ave. shaft; tunnels No. 1 and No. 2. Discharges air eastward in tunnel No. 1.

Double inlet pressure fan, 54 in. wheel, driven by 20 h. p., 60 cycle, 440 volt, 850 r.p.m. three phase induction motor.

Capacity, 53,500 cu. ft. of air per min. at speed of 203 r.p.m.

Fan No. 10—

First Ave. shaft; tunnels No. 1 and No. 2. Draws air eastward in tunnel No. 1.

Single inlet exhaust fan, 66 in. wheel, driven by 20 h. p., 60 cycle, 440 volt, 850 r.p.m. three phase induction motor.

Capacity, 59,200 cu. ft. of air per min. at speed of 202 r.p.m.

Fan No. 11—

Long Island shaft; tunnels No. 3 and No. 4. Discharges air westward in tunnel No. 4.

Double inlet pressure fan, 54 in. wheel, driven by 20 h. p., 60 cycle, 440 volt, 850 r.p.m. three phase induction motor.

Capacity, 51,600 cu. ft. of air per min. at speed of 202 r.p.m.

Fan No. 12—

Long Island shaft; tunnels No. 3 and No. 4. Discharges air eastward in tunnel No. 3.

Double inlet pressure fan, 54 in. wheel, driven by 20 h. p., 60 cycle, 440 volt, 850 r.p.m. three phase induction motor.

Capacity, 55,000 cu. ft. of air per min. at speed of 204 r.p.m.

Fan No. 13—

Long Island shaft; tunnels No. 1 and No. 2. Discharges air westward in tunnel No. 2.

Double inlet pressure fan, 54 in. wheel, driven by 20 h. p., 60 cycle, 440 volt, 850 r.p.m. three phase induction motor.

Capacity, 51,600 cu. ft. of air per min. at speed of 202 r.p.m.

Fan No. 14—

Long Island shaft; tunnels No. 1 and No. 2. Discharges air eastward in tunnel No. 1.

Double inlet pressure fan, 54 in. wheel, driven by 20 h. p., 60 cycle, 440 volt, 850 r.p.m. three phase induction motor.

Capacity, 55,000 cu. ft. of air per min. at speed of 204 r.p.m.

Track:

All rail, switches and guard rails are of open hearth steel, P. S. section, 100 lbs. per yd. in main and running tracks.

Track in tunnels laid with black gum and yellow pine creosoted ties; screw spikes. All tracks are tie-plated.

Concrete track in tunnels, East River, 1,443 ft.

Pennsylvania Station—

Concrete track in station, 12,660 ft.
Switches are all housed in stock rail.
All frogs, Manard type.
Turnouts, 105.
No. 8 double slips, 44.
No. 8 single slips, 1.
No. 7 double slips, 1.
Diamond crossings, 14.
Of the 105 turnouts, eleven are No. 9, five are No. 10, three are No. 6, eighty-six are No. 8.

Sunnyside Yard—

Sunnyside yard tracks are laid with 85 lb. P. S. sec. O. H. rail.
100 lb. connections, 43.
85 lb. connections, 136.

Ballast—

Penn. Station Yard and Sunnyside Yard, 36,579 cu. yds. ¾ in.
Main tracks and tunnels, 122,100 cu. yds. of 1½ in.
All ballast, trap rock.

Summary—

Tracks and Switches—

Main Tracks	40.8	miles
Yard Tracks	45.8	"
Switches	357	
Slips	46	
Crossings	14	

Signals:

The signaling is three position upper quadrant, and, as a whole, represents one of the largest single installations of the kind yet undertaken. The electro-pneumatic system, with interlocking machines and other equipment and controlling apparatus of the latest and most improved design is employed throughout.

Light signals are used under Penna. Station and Post Office building, throughout the Penna. Station Yard, in the North and East River Tunnels and under the platform shelters at Manhattan Transfer. The use of such a signal in the open—exposed to daylight—is particularly novel, but as conditions made it imperative, an arrangement of lights and lenses was developed after a considerable number of experiments, that gives satisfactory color indications under the worst conditions, viz.—sunlight directly over the lenses.

The change in color or the giving of the different indications is effected by the opening and closing of relays, the lenses being colored and so placed as to give the night aspects of the semaphore signals.

The signaling is uniform and is for speed. Excluding the Penna. Station and yard, where conditions require a positive but more flexible system of control by signal, all high interlocking signals are three-arm with lights vertical; low or dwarf signals are one-arm, and all automatic signals are of one pointed arm with staggered lights except approaching interlockings, where there are two pointed arms with staggered lights, for the purpose of advancing to enginemen the information as to whether the high or limited speed home indication has been given. Top arm indication —speed unrestricted by interlockings. Second arm indication—speed not to exceed thirty-five miles per hour. Third arm or dwarf signal indication —speed not to exceed fifteen miles per hour.

At the Penna. Station, the signaling is for what has generally been termed "one speed," with a calling on arm. In reality, two speeds are indicated—normal speed, which is the highest speed permissible by reason of track and other conditions, and low speed, prepared to stop, which has been termed the "calling on" arm or light, for movements to stub end yard tracks and for use when "proceed" cannot be given by the normal or high speed indication.

The automatic signals are spaced not less than emergency brakeing distance plus 50 per cent. for a train of 400 tons at speeds as determined by grades. Double block indication is given, that is, two danger or stop signals always occur back of a train.

The color indications are, red: stop signal; yellow: caution signal; green: clear signal.

Automatic train stops are used in the tunnels.

The switch equipment is very similar to what has heretofore been used, except that the switch valve bodies have been mounted separately, connection being made between them and the switch cylinders by one-half inch pipes.

Lock and block control has been provided between the Penna. Station and the Long Island approach to the East River Tunnels, so that if necessary any one of the four tunnel tracks can be operated as one block in the reverse direction. The same provision, with the addition of automatic signals for following movements, has been made through North River Tunnels and over the Meadows to Manhattan Transfer Yard.

Approach and route locking provided at all interlockings.

Under normal conditions all compressed air is supplied to the system from the Service Plant at the Penna. Station. The compressors are Nordberg cross compound, two in number, with a capacity each of 2,000 cu. ft. free air per minute.

Connection is also made to the Sunnyside Yard compressors which are of the same type, with a capacity each of 1,500 cu. ft. of free air per minute.

Electric power is also supplied from the Service Plant by transformers stepping down from 11,000 volts to 2,200 volts. Current for all double rail track circuits and automatic signals is stepped down to the required voltage direct from the 2,200 volt mains. At interlockings it is stepped down and distributed at 220 volts.

In all there are 116 automatic signal arms and automatic light signals, and 48 automatic train stops.

Eleven interlockings, with a total of 498 working levers for 410 signal arms and light signals, 350 turnouts and cross-overs, 46 double slips,

46 movable point frogs, and the lock and block control for the running of trains reverse to traffic, with a total ultimate capacity of 733 interlocking levers; the greater number of the spares being intended for what has been planned as a final layout.

There are 507 track circuits, 1,489 insulated joints and 2,610 relays, all kinds included.

Train Starting System—

The arrangement of gates and stairways leading from the concourse to the platforms, and the relation of platforms to tracks, and of tracks to interlocking stations, resulted in what might be considered a special arrangement for a quick understanding between the conductor, the gateman admitting passengers to the platform, and the signalman at the interlocking directly interested in the movement.

This is accomplished by small light-signals or indicators controlled through selecting instruments, and in such a way that each person interested must at a certain time enter into the operation of the system.

Interlocking Stations:

Manhattan Transfer—

N West end Manhattan Transfer. Electro-pneumatic.
Switch levers, 23.
Single switches, 35.
Signal levers, 23.
Signals controlled, 51.
Traffic levers, 5.
Working levers, 51.
Spare spaces, 20.
Total levers, 71.

S East end Manhattan Transfer. Electro-pneumatic.
Switch levers, 22.
Single switches, 32.
Signal levers, 22.
Signals controlled, 55.
Traffic levers, 7.
Working levers, 51.
Spare spaces, 32.
Total levers, 83.

W East of Hackensack River Drawbridge. Electro-pneumatic.
Working levers, 11.
Total levers, 11.

Pennsylvania Station Yard:

A East of 9th Ave. Electro-pneumatic.
Single switch movements, 107.
Double switch movements, 30.
Working levers, 141.
Spare levers, 38—Total 179.

B 8th Ave. and 33d St. Electro-pneumatic.
Single switch movements, 22.
Double switch movements, 4.
Working levers, 30.
Spare levers, 17—Total 47.

C 7th Ave. and 33d St. Electro-pneumatic.
Single switch movements, 26.
Double switch movements, 6.
Working levers, 36.
Spare levers, 11—Total 47.

D 7th Ave. and 32d St. Electro-pneumatic.
Single switch movements, 35.
Double switch movements, 6.
Working levers, 51.
Spare levers, 20—Total 71.

Sunnyside Yard:

F Thompson Ave. Electro-pneumatic.
Single switch movements, 14.
Working levers, 29.
Spare levers, 12.
Spare spaces 6—Total 47.

H Harold Ave. Electro-pneumatic.
Single switch movements, 19.
Working levers, 24.
Spare levers, 23—Total 47.

Q West end yard. Electro-pneumatic.
Single switch movements, 33.
Working levers, 44.
Spare levers, 27—Total 71.

R East end yard. Electro-pneumatic.
Single switch movements, 23.
Working levers, 51.
Spare levers, 20—Total 71.

Bridges:

Railroad—	Steel lbs.
New York Division	2,754,870
Hackensack drawbridge	4,111,046
Erie, N. & P. Br.	254,594
Erie, Greenwood Lake Br.	211,102
Erie, Greenwood Lake Br. reconstructed	652,506
D. L. & W., Boonton Br.	414,725
Erie	265,156
Erie, Main Line and Yard and County Road	3,002,125
N. Y. S. & W. R. R.	473,920
	12,140,044

Highway and Viaduct—

	Steel lbs.
Newark & Jersey City Turnpike.....	1,185,575
Belleville Road.....	377,421
Secaucus Road.....	236,272
	1,759,268

Bridges over Erie R. R., D. L. &. W. R. R. and N. Y. S. & W. R. R. and highway crossings are half through plate girders with waterproofed concrete floors.

Sunnyside Yard:

Railroad—

	Steel lbs.
No. 1. I-beam, length 96 ft.....	91,800
No. 2. I-beam, length 83 ft.....	541,704
No. 4. I-beam, length 172 ft.....	232,311
No. 5. I-beam, length 103 ft.....	170,564

Laurel Hill Ave.—Deck and half through girders length 188 ft..... 1,772,529

Gosman Ave.—Deck and half through girders length 108 ft..... 1,066,868

Total steel, lbs..... 3,875,776
Total concrete in cubic yds. 110,236
Piles, total length, 20,118 ft.

Highway Bridges—

Hunters Point Ave. length	348 ft.	1,072,778
Thomson Avenue, length	773 ft.	3,650,069
Bridge approach, length	1,036 ft.	5,017,068
Honeywell St., length	1,574 ft.	7,363,837
Harold Avenue, north and south.....		3,298,948
Total steel, lbs.		20,402,700

Total concrete in cubic yards.. 54,096
Piles, total length in feet..... 165,182
Total weight of steel, 37,105,010 lbs.,—18,552 tons.

Electric Locomotives:

The locomotive is an articulated machine of double-cab design. Each half carries its own motor and complete equipment and the two halves are permanently coupled at their driving-wheel ends.

The frames, driving-wheels and trucks of the running gear are similar in general character to those of the American type steam locomotive.

Each cab is equipped with Westinghouse automatic and straight air brake apparatus, electric head-lights, pneumatically operated whistle and sand apparatus, motor, unit switches, master controller and other traction equipment.

The machines are so arranged, that, in event of one motor being cut out, the entire machine can be operated from either cab with the remaining motor. The halves are interchangeable, and if one is out of service, it may be replaced by another while repairs are being made.

The unit switch control permits two or more locomotives to be coupled, and all to be operated from either end of any one cab.

There are four running notches on controller, two more than are provided with motor car equipments. This gives greater flexibility of speed regulation and at the same time economizes power consumption during acceleration.

Weights and Dimensions—

Locomotive complete, 155 tons.
Weight on main drivers of each half, 48,800 lbs.
Weight on rear drivers of each half, 48,700 lbs.
Total weight on drivers, 195,000 lbs.
Weight on each truck, 57,500 lbs.
Total length over all, 64 ft. 11 in.
Rigid wheel base of each half, 7 ft. 2 in.
Total wheel base of each half, 23 ft. 1 in.
Total wheel base of locomotive, 55 ft. 11 in.
Height from track to top of roof, 13 ft. 1 in.
Width of cab, 10 ft. 6 in.
Diameter of drivers, 72 in.
Diameter of truck wheels, 36 in,

NOTE—Weights do not include electric steam generators for heating purposes.

Tractive Effort—

Contract-tractive effort per locomotive, 60,000 lbs. for half minute, 50,000 lbs. for two minutes, or 12,000 lbs. at 800 amperes, all with full field.

Normal Service—

To start and accelerate 550 ton train, in addition to the locomotive on 1.93% tunnel grade.

Normal speed with 550 ton train on level tangent track to be not less than 60 miles per hour.

Motor Data—

Direct current, field controlled interpole series motors.
Cast steel frames.
Directly connected through jack shafts and side rods.
Weight of each motor complete with cranks, 43,000 lbs.
Height of center line of motor from track, 8 ft. 2 13-16 in.
Height of motor frame above cab floor, 5 ft. 6½ in.

New York Connecting R. R.: (Projected)

The New York Connecting R. R. will connect with the P. T. & T. R. R. at east end of Sunnyside yard; crossing the East River on a four track bridge, and will join the New York, New Haven & Hartford, at Morrisania. The completion of this link will establish the first all-rail service between New England and the West and South by way of New York City.

Statistics—

Hellgate bridge, one 1,000 ft. riveted steel-arch span, four tracks. Longest arch span in the world.

Lower chord of bridge, 135 ft. above water.

Steel viaduct across Wards Island, 5,000 ft.

Steel bridge across Little Hellgate.

Concrete and steel viaduct across Randalls Island.

Lift bridge across Bronx Kills, and steel viaduct connecting with N. Y., N. H. & H. R. R. at Morrisania.

Foundation, rock in most instances. Other places, foundation partly on rock and partly on hard incompressible gravel.

Cubic yds. of masonry, 350,000

Number of tons of steel, 75,000.

Steel bridge over Hellgate and approaches, approximately three miles long.

SUPERVISOR T.J. SKILLMAN
ASST. " R.S. HARRIS

INDEX

- STATIONS
- INTERLOCKING STATIONS
- SUBSTATIONS
- SWITCHING STATIONS
- TOOL HOUSES
- TELEPHONE AND CALL BELLS
- 3D RAIL DISCONNECTING SWITCHES
- UNDERGRADE BRIDGES
- OVERHEAD BRIDGES
- TUNNELS
- CULVERTS
- SIGNAL BRIDGES
- WATER TUBS
- SMASH BOARDS

CORRECT TO

PENNA. RAILROAD

P.T.&T.R.R.

TRACK CHART

AUG. 17, 1910

DIV. ENGR'S OFFICE

ROBERT A. WELCKE, PHOTO-LITH., 178 WILLIAM ST. N.Y.

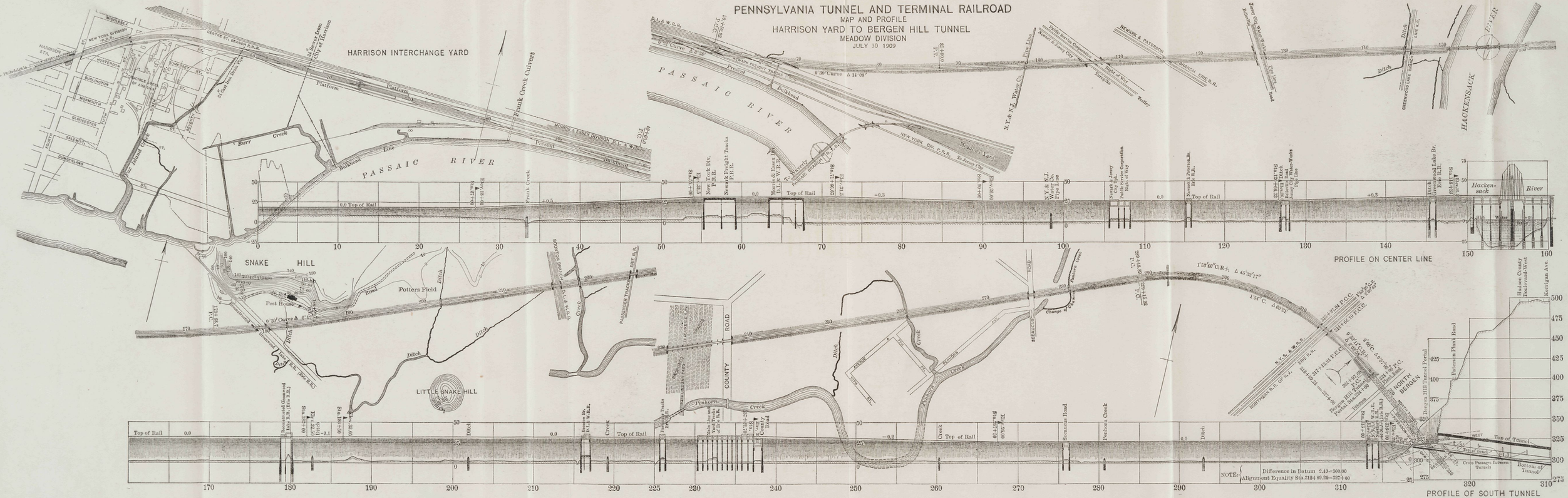
PENNSYLVANIA TUNNEL AND TERMINAL RAILROAD

MAP AND PROFILE

HARRISON YARD TO BERGEN HILL TUNNEL

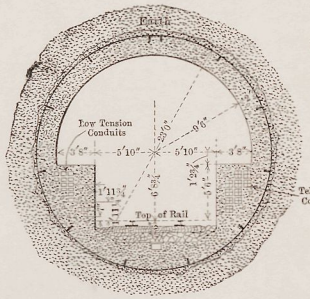
MEADOW DIVISION

JULY 30 1909

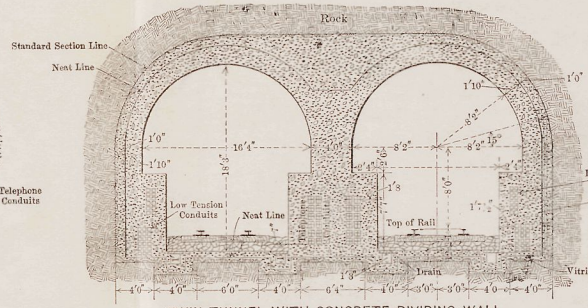


PENNSYLVANIA TUNNEL AND TERMINAL RAILROAD
MAP AND PROFILE
BERGEN HILL TUNNEL, NEW JERSEY
TO
LONG ISLAND SHAFT, BOROUGH OF QUEENS
JULY, 30, 1909
NORTH BERGEN
WEST HOBOKEN
WEEHAWKEN
BOROUGH OF MANHATTAN
NORTH RIVER
EAST RIVER
Pennsylvania Station
NEWTOWN CREEK
Profile of South Tunnel
Profile of Line D
Top of Tunnel
Top of Bench
Bottom of Tunnel

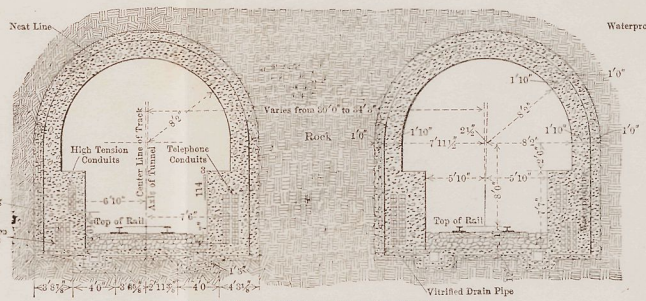
TYPICAL TUNNEL SECTIONS



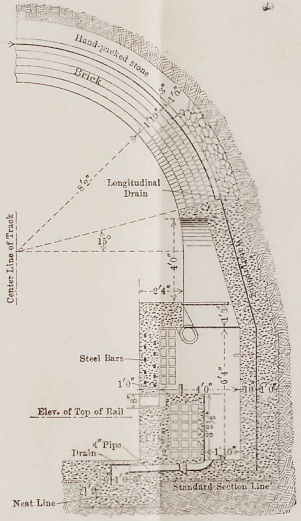
TUBE TUNNEL



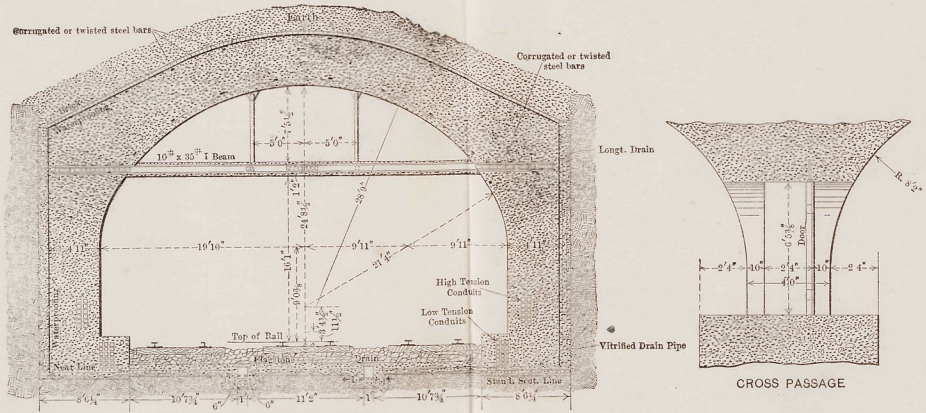
TWIN TUNNEL WITH CONCRETE-DIVIDING WALL



TWIN TUNNEL WITH ROCK-DIVIDING WALL

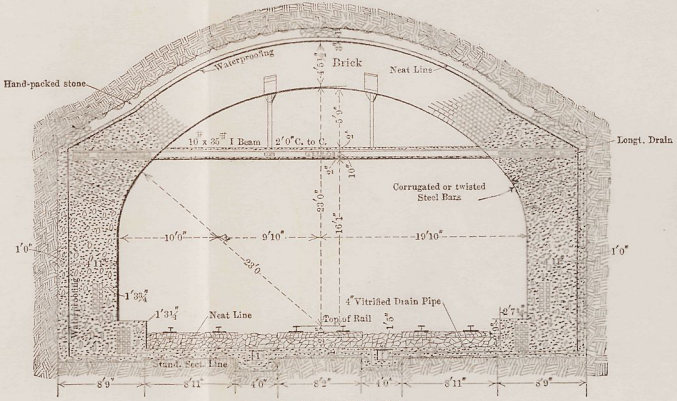


SPLICING CHAMBER
FOR HIGH TENSION CABLES

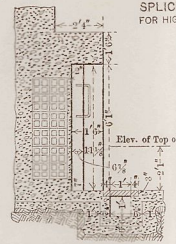


THREE TRACK TUNNEL
CONCRETE ROOF

CROSS PASSAGE



THREE TRACK TUNNEL
BRICK ROOF



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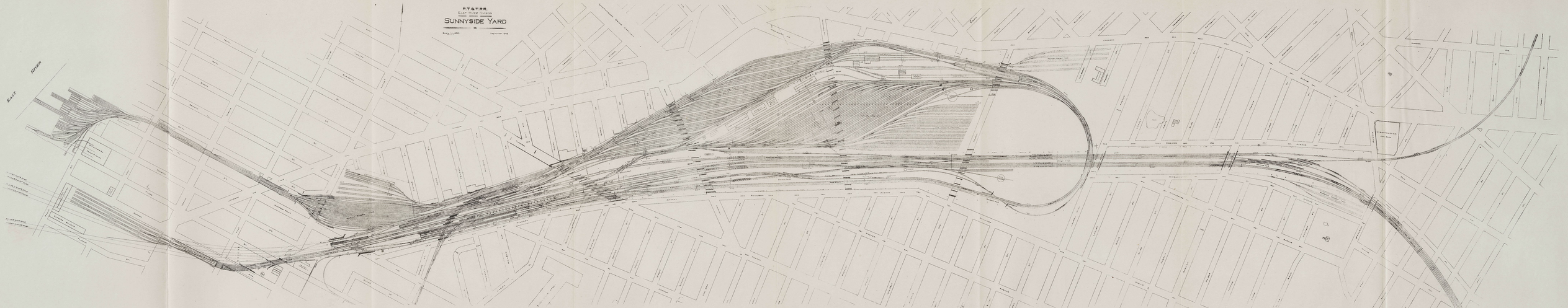
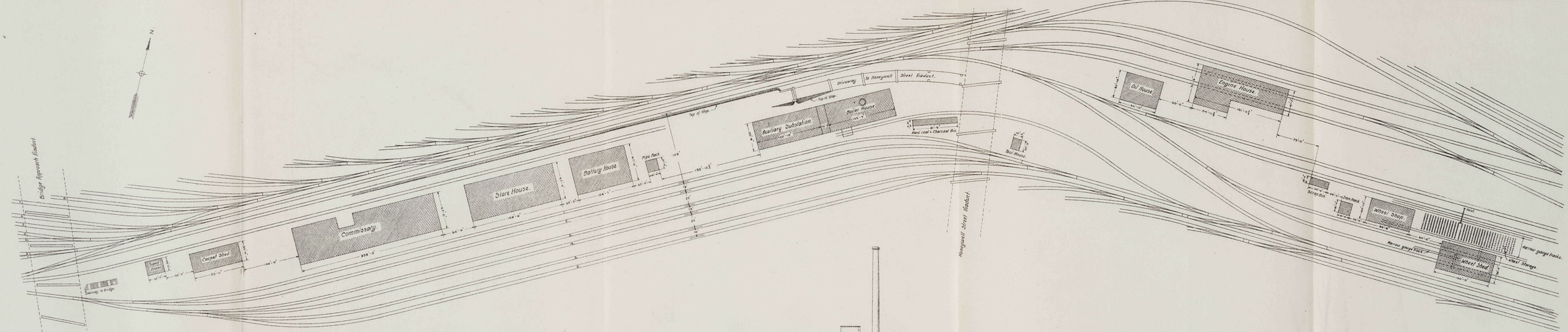
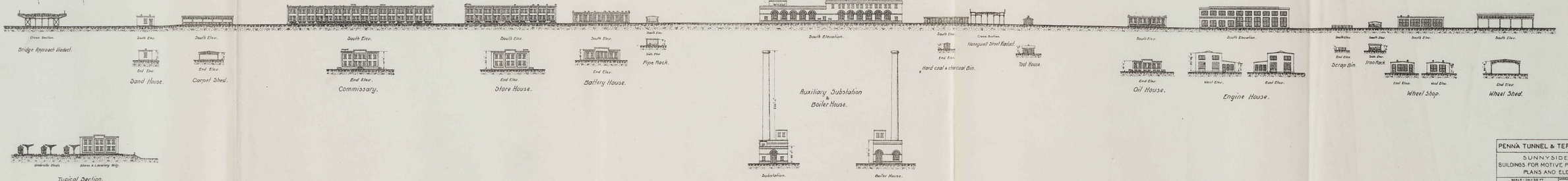

P.T.&T.R.R.
East River Division
SUNNYSIDE YARD
EAST RIVER





Typical Section.

PENNA TUNNEL & TERMINAL R.R.CO.

SUNNYSIDE YARD

BUILDINGS FOR MOTIVE POWER FACILITIES

PLANS AND ELEVATIONS

SCALE: 1 INCH = 50 FT.	SURVEYED	
AUG. 23, 1910	DRAWN AND TRACED	

OFFICE OF CHIEF ENGINEER OF ELECTRIC TRACTION & STATION CONSTRUCTION

J-2574

ROBERT A. WELCKE PHOTO-LITH., 178 WILLIAM ST. N.Y.

59666

P.T.&T.R.R.

PLAN OF CONCRETE TYPE OF TRACK

FOR

EAST RIVER TUNNELS.

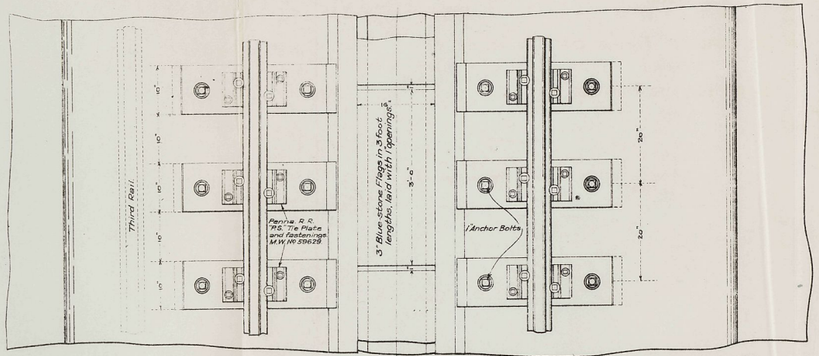
MARCH 16, 1909.

A.A.T.

ORIGINAL ON FILE — OFFICE OF CHIEF ENGINEER M.W. SYSTEM

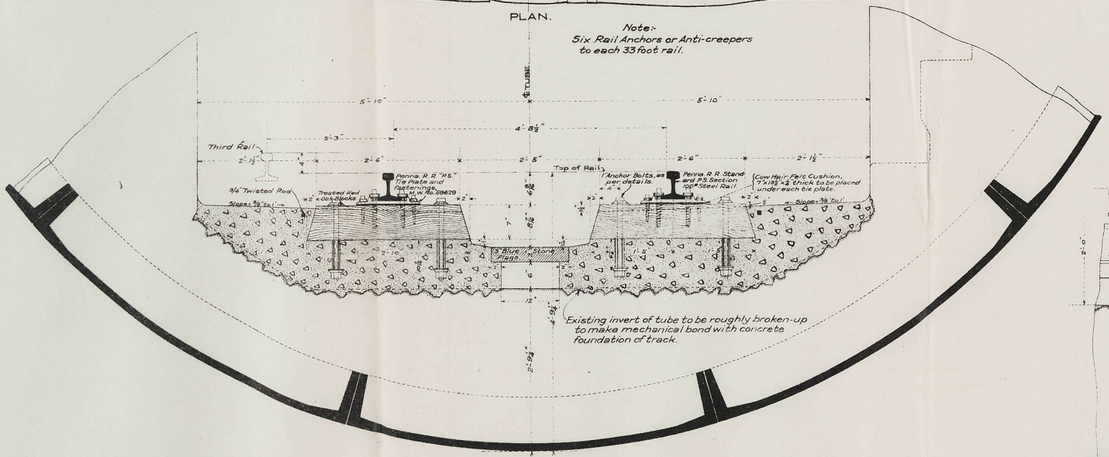
Approved:
Jno. J. Richards
Chief Engineer M.W.

Approved:
A. H. Gerrish
Engineer Maintenance of Way.

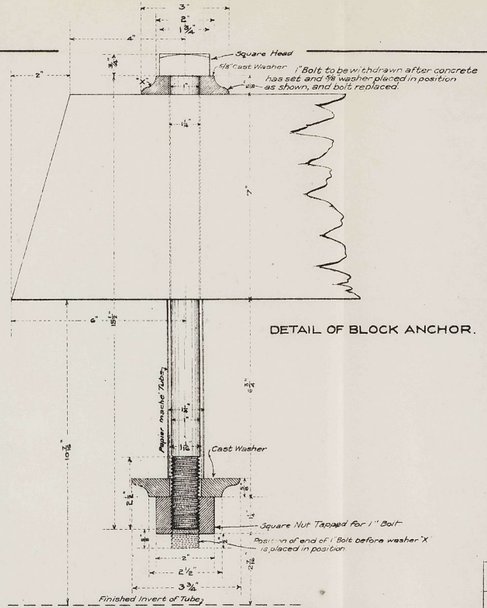


PLAN.

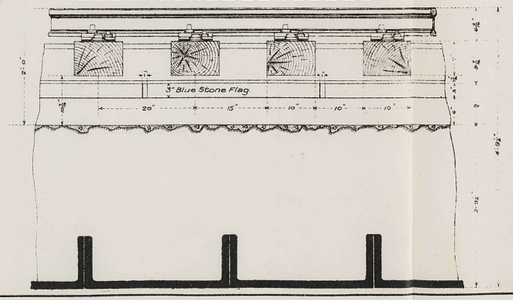
Note:-
Six Rail Anchors or Anti-creepers to each 33 foot rail.

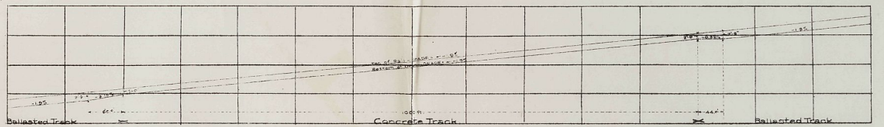


CROSS SECTION.

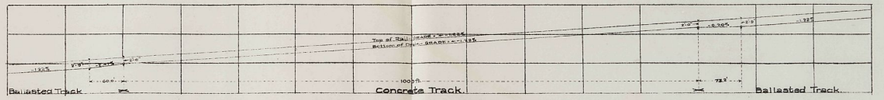


DETAIL OF BLOCK ANCHOR.





PROFILE OF LINE "C."



PROFILE OF LINE "D."

ROBERT A. WELCKE PHOTO-LITH. 116 WILLIAM ST. N.Y.

ORIGINAL TRACING ON FILE

59667

P T & T R R

PLAN OF CONCRETE TYPE OF TRACK FOR SPECIFIED TRACKS IN YARD OF PENNSYLVANIA STATION

MARCH 16, 1909

AAT

Approved: Geo. L. Fernandez
Chief Engineer Maintenance of Way

Approved: L. F. Loree
Engineer Maintenance of Way