PDHonline Course C642 (5 PDH)

IRT: New York's First Subway

Instructor: Jeffrey Syken

2020

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5272 Meadow Estates Drive
Fairfax, VA 22030-6658
Phone: 703-988-0088
www.PDHonline.com

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New York’s First Subway

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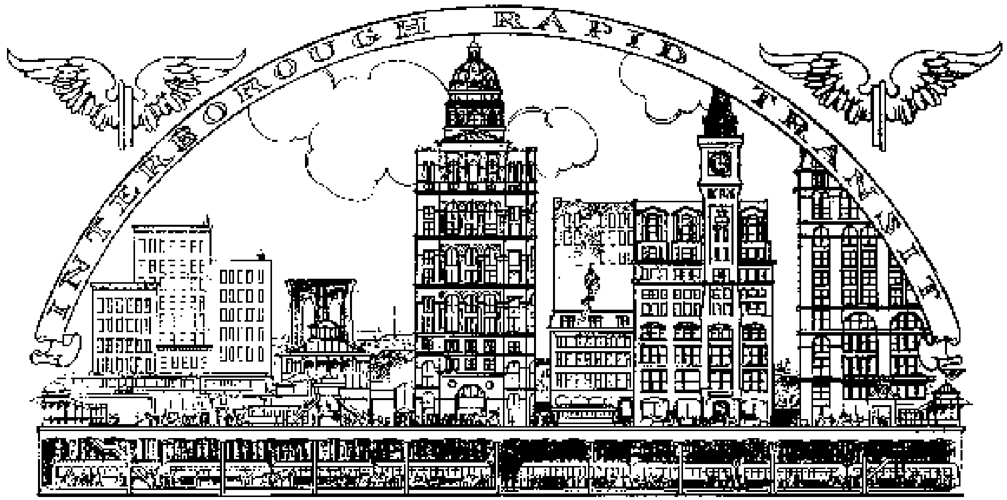
Battery to Harlem in 15 Minutes

Setting Precedents

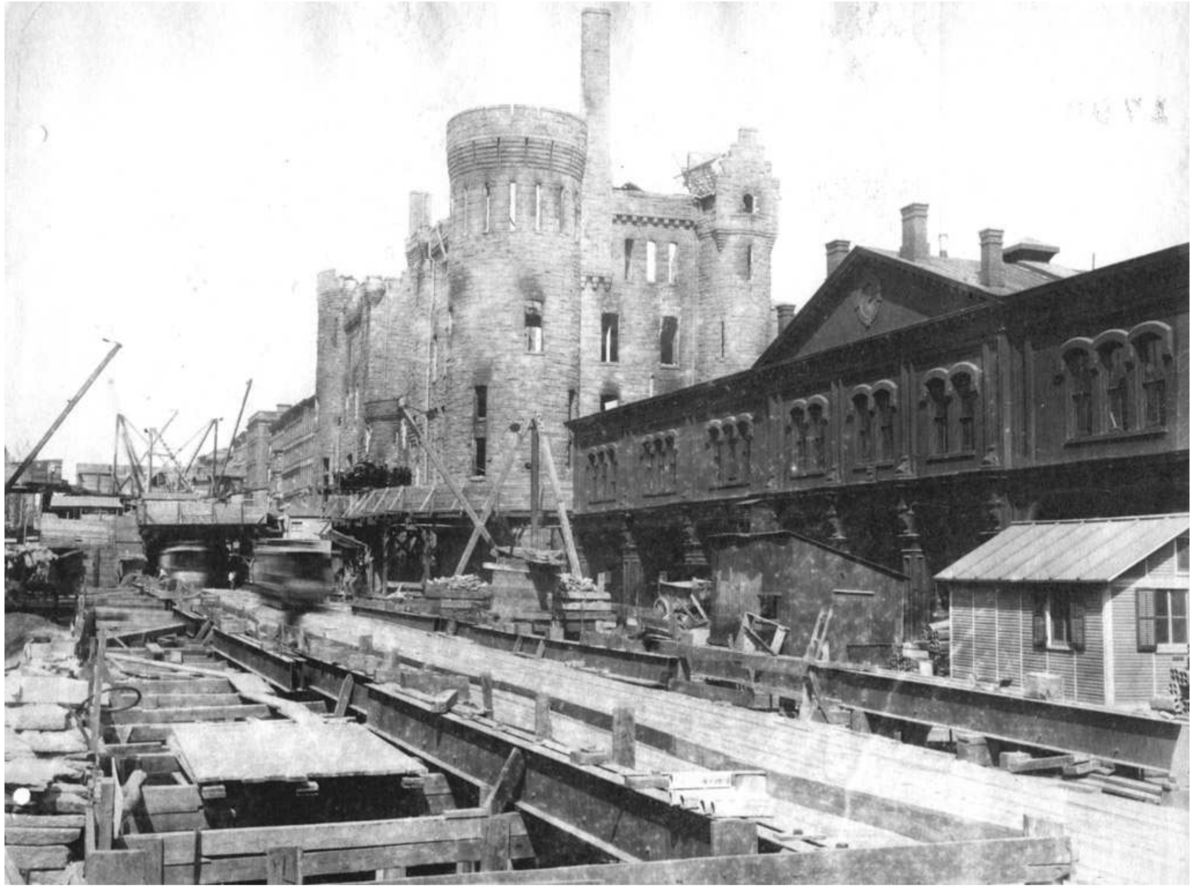


The completion of the *Interborough Rapid Transit* (IRT) railroad in the *New York City* (NYC) boroughs of *Manhattan*, the *Bronx* and *Brooklyn* (commonly referred to as the "Subway") demonstrated that underground railroads could be built beneath the congested streets of the city and made possible a comprehensive system of subsurface transportation extending throughout the territory of Greater NYC. In March 1900, when NYC's Mayor *Robert Van Wyck* ceremoniously broke ground at *Borough Hall Manhattan* for the new subterranean railroad, there were many well-informed people, including prominent financiers and experienced engineers, who predicted failure for the enterprise. The railway was to be owned by the city, built and operated under legislation unique in the history of municipal governments. Provisions for the occupation of city streets, payments by the city and city supervision over construction and operation were scrupulously outlined. The experience of the elevated railroad companies in building their lines had demonstrated the uncertainty of depending upon legal precedents. It was not believed, at that time, that the abutting property owners would have any legal ground for complaint against the elevated structures, but the courts found new laws for new conditions and spelled out new property rights of light, air and access which were made the basis for an unprecedented volume of litigation.

“Just what are the rights of the owners of property abutting upon a street or avenue, the fee in and to the soil underneath the surface of which has been acquired by the city of New York, so far as the same is not required for the ordinary city uses of gas or water pipes, or others of a like character, has never been finally determined…”

New York State Supreme Court

RE: owing to the magnitude of the work, delay might easily result in failure. An underground railroad was something very new in NYC. No one could say for certain that the abutting property owners might not make damage claims substantial enough to entitle them to their day in court, a day which might stretch into many months or several years.



"…to secure to the contractor the right to construct and operate, free from all rights, claims, or other interference, whether by injunction, suit for damages, or otherwise on the part of any abutting owner or other person."

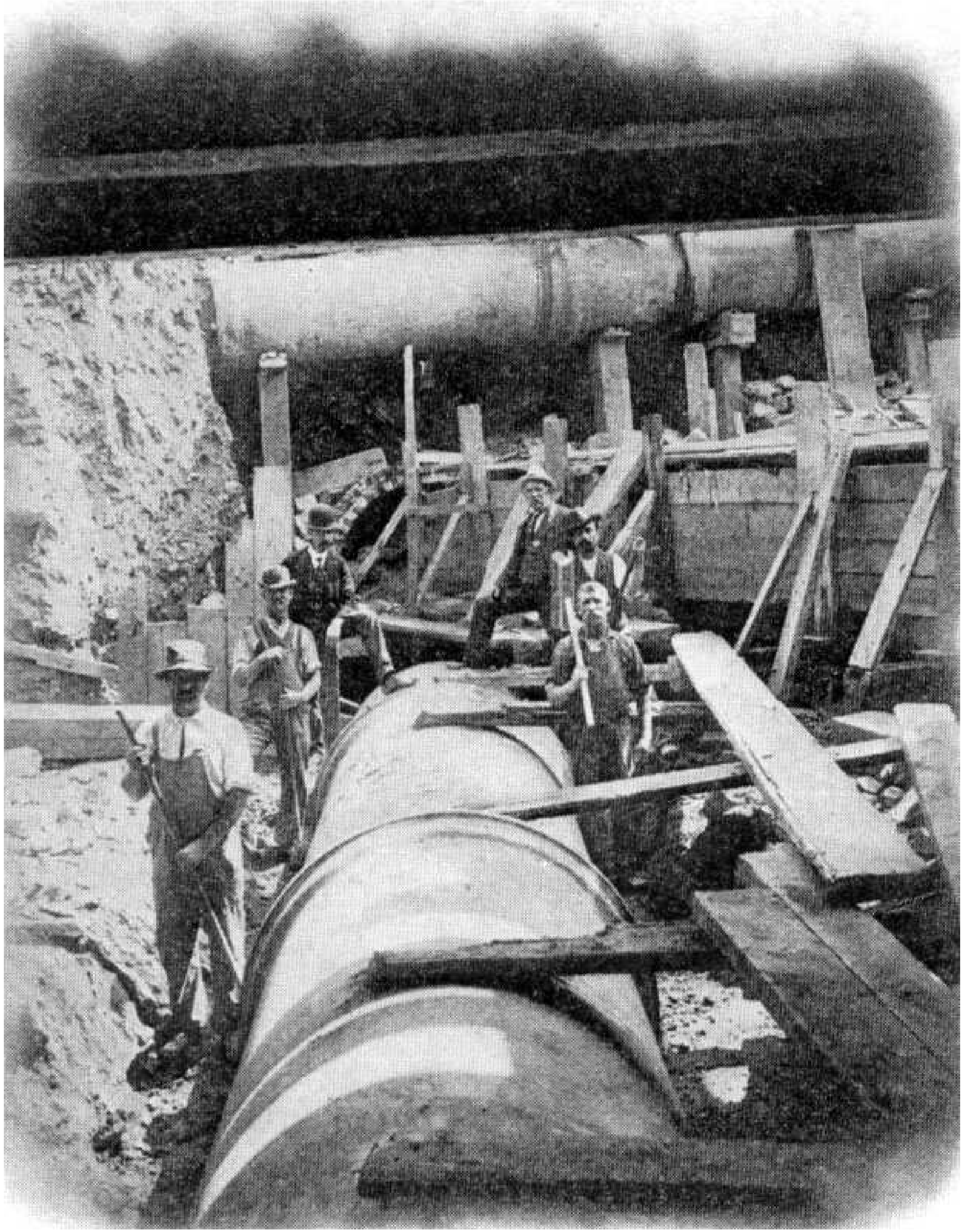
RE: clause in the NYC contract for constructing the IRT Subway

Above: caption: "View of Fourth Avenue at 32nd Street during construction of the IRT Subway, August 1902"

“…a condition absolutely impossible of fulfillment…How is the city to prevent interference with the work by injunction? That question lies with the courts; and not with the courts of this State alone, for there are cases without doubt in which the courts of the United States would have jurisdiction to act, and when such jurisdiction exists they have not hitherto shown much reluctance in acting…That legal proceedings will be undertaken which will, to some extent at least, interfere with the progress of this work seems to be inevitable....”

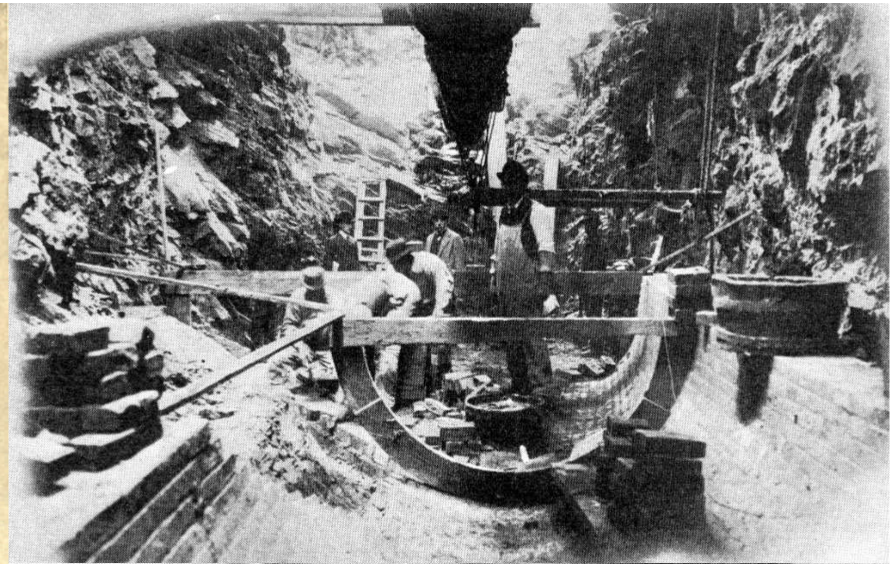
New York State Supreme Court

Another difficulty was the fact that the *Constitution of the State of New York* limited the debt-incurring power of the city. The capacity of the city to undertake the work had been discussed at length in the courts and the *NYS Supreme Court* had mitigated this aspect by suggesting that it did not make much difference to the municipality whether or not the debt limit permitted a contract for the work, because if the limit should be exceeded; *"no liability could possibly be imposed upon the city,"* a view which might comfort the nervous taxpayers but hardly inspired the confidence of the financiers who undertook the contracts. Various corporations, organized during the thirty-odd years of unsuccessful attempts by the city to secure underground rapid transit, claimed that their franchises gave them vested rights in the streets to the exclusion of the new enterprise and they were prepared to assert their rights in the courts. In fact, the *Underground Railroad Company of the City of New York* sought to enjoin the building of the subterranean railroad and carried their contest to the *Supreme Court of the United States,* which did not finally decide the questions raised until March 1904, when the Subway was practically complete. Problematic also were NYC's biennial elections and the fact that the railroad could not be completed in just two years. The attitude and policies of one administration toward the project might be very different from that of its successors.

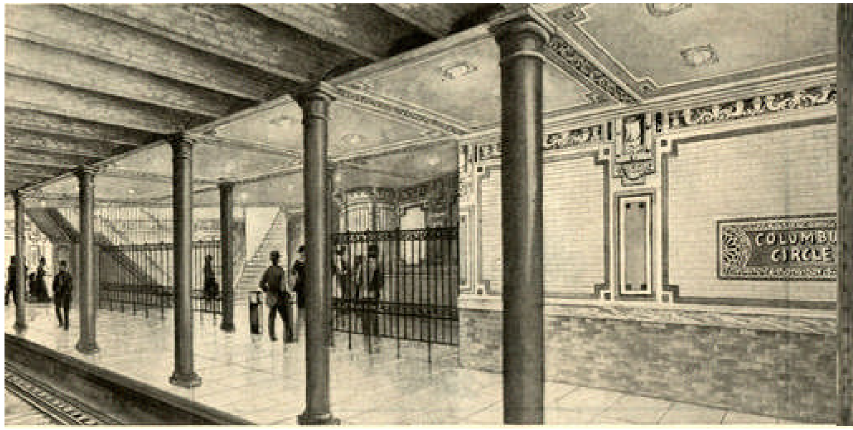


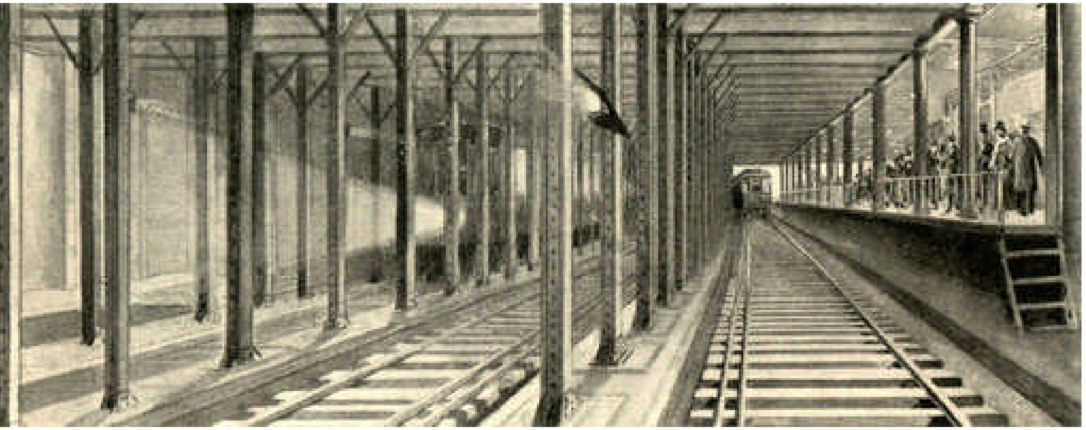
The engineering difficulties were also intimidating. Subsidence of tall buildings along the streets had to be considered and the streets themselves were already occupied with a complicated network of subsurface structures such as sewers, water and gas mains, electric cable conduits, electric surface railway conduits, telegraph and power conduits and many vaults extending out under the streets occupied by the abutting property owners. On the surface there were street railway lines carrying a very heavy traffic load night and day and all the thoroughfares in the lower part of the city were congested with vehicular traffic. The city was unwilling to take any risk and demanded millions of dollars of security to insure the completion of the Subway precisely according to contract, the terms of which were exacting down to the smallest detail.

Left: underground work at *Broadway* & *96th Street*



<u>Above Top</u>: *81st Street* Sewer
<u>Above Bottom</u>: *45th Street* and Broadway
<u>Left</u>: view looking north on *Broadway* from *Post Office Building*





The builders of the IRT did not underestimate the magnitude of the task before them and retained experienced experts for every part of the work. The subway was built near the surface and was easily accessible, well-lit, dry, clean and well ventilated. The stations and approaches were generous in their proportions and the stations themselves were furnished with many conveniences previously unknown. There was a separate express service with its own tracks and the stations were so arranged that passengers could pass from local to express trains and vice-versa without delay and/or payment of an additional fare. Special precautions were taken and devices adopted to prevent a failure of electric power and the delays which would ensue. An electro-pneumatic block signal system was devised excelling any system previously used. The third rail for conveying the electric current was covered so as to prevent injury from contact. Special emergency and fire alarm signal systems were installed throughout the length of the railroad. At a few stations, where the IRT was not near the surface, improved escalators and elevators were provided. The cars were designed to prevent danger from fire and improved types of motors were adopted, capable of supplying high-speed combined with complete control. Strength, utility, beauty, efficiency and convenience were considered for all parts of the IRT's structures and equipment, stations, Power House and electrical sub-stations.

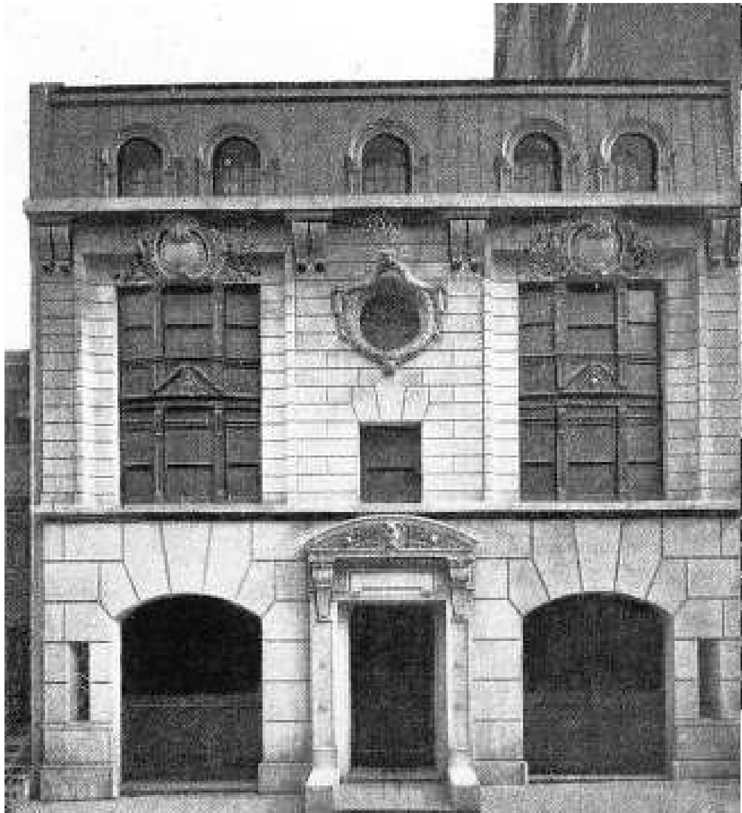
Left: caption: "A typical station of the new subway, showing proposed arrangement and architectural details"

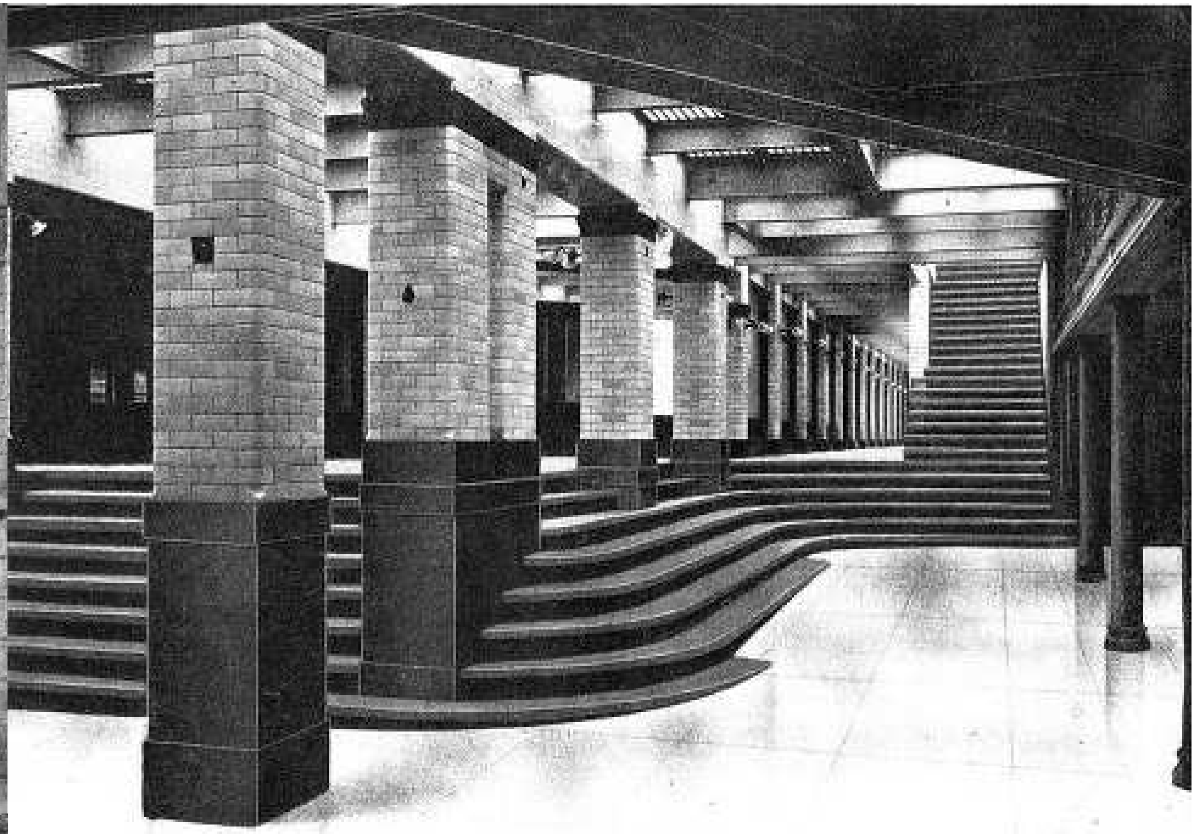
Right: caption: "A view of the interior of the new subway in New York, showing the general arrangement of tracks and stations "

"The railway and its equipment as contemplated by the contract constitute a great public work. All parts of the structure where exposed to public sight shall therefore be designed, constructed, and maintained with a view to the beauty of their appearance, as well as to their efficiency."

RE: excerpt from clause in the IRT construction contract

<u>Above</u>: IRT Subway kiosk



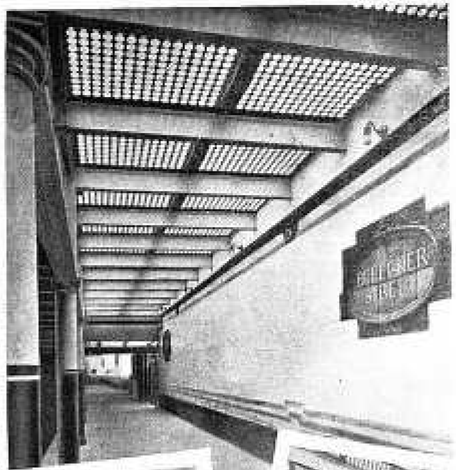


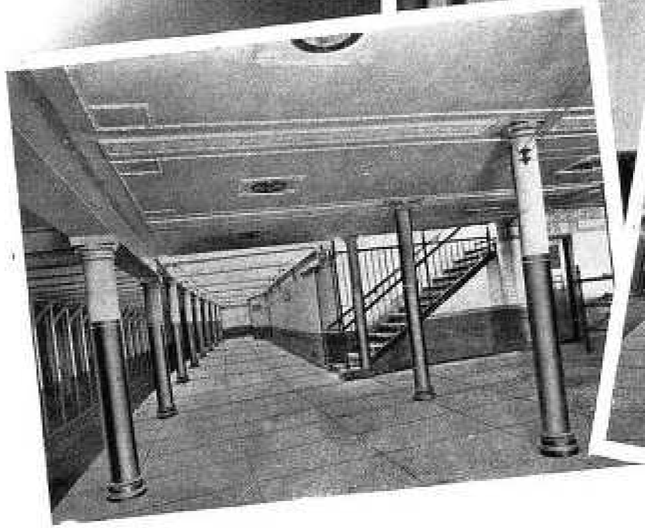
Top Left: exterior of IRT sub-station
Top Right: interior of *23rd Street* IRT station
Left: *Fulton Street* IRT entrance

“In the new subway in New York crowding will be eliminated by the simple device of providing one stairway for entrance and one for exit, and by making the platforms large enough to accommodate several hundred persons at once. There will be broad staircases, of easy grade, ticket booths designed with reference to appearances as well its use, and the stations will have lofty vaulted ceilings well lighted by day through bulls-eye glass and at night by electric lamps. The decorations will be of tiles, faience, and glazed terra-cotta, with the name of the station plainly marked in panels. All the ornamentation has been designed to help the passenger recognize his station without the necessity of listening for the announcement of the guard or reading the signs. Express stations at the City Hall, Fourteenth Street, Forty-second Seventy-second, and Ninety-sixth streets naturally divide the local stations into groups. For each group a general scheme of decoration has been devised, and no two stations in a group are decorated in the same colors…”

***Harper’s Weekly*, January 31st 1903**

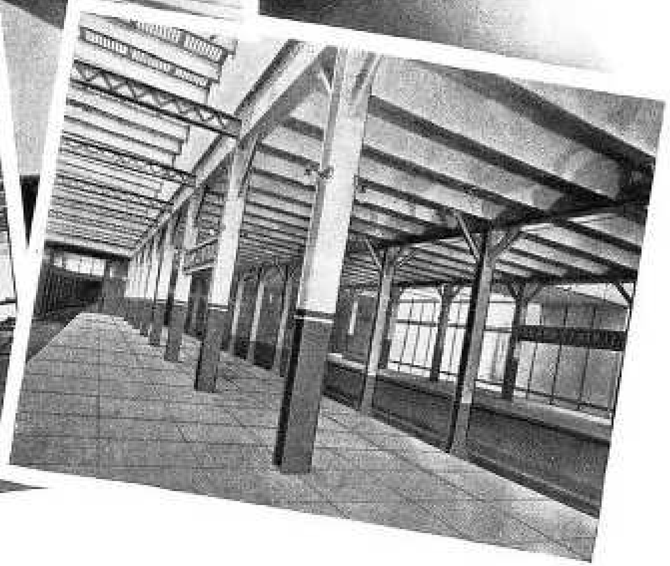
BLEECKER STREET.





SPRING STREET.

STATIONS, N. Y. SUBWAY.

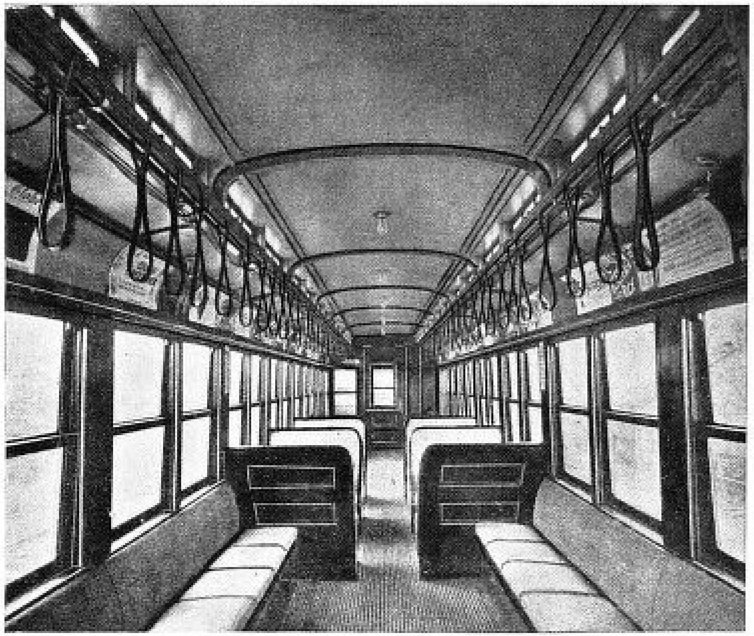


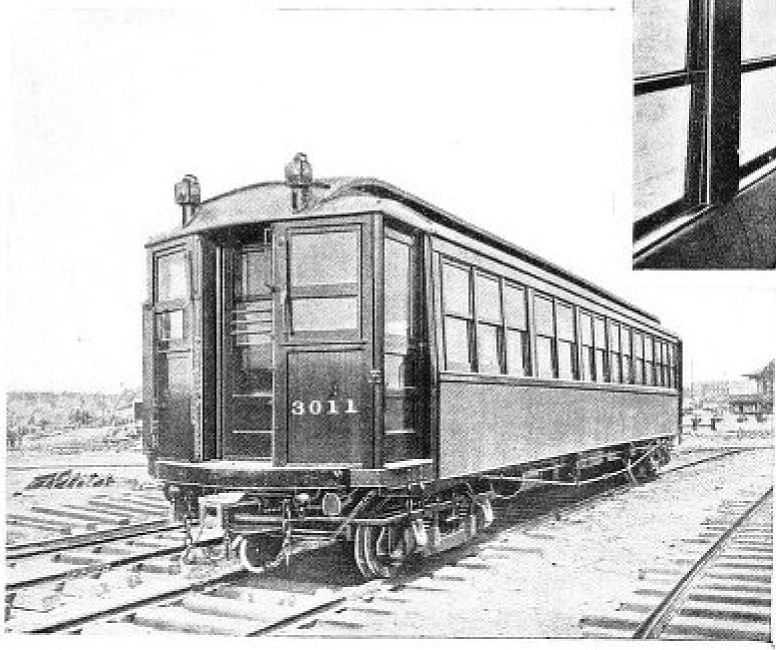
GRAND CENTRAL EXPRESS.

"…Repeated experiments have convinced the architects and engineers that the moisture and drip familiar to explorers of caves and tunnels can be avoided in the Subway stations by building air-chambers behind walls and ceilings. Accordingly, this method of construction has been adopted, and the underground will be damp-proof. The tunnel will be cooler in summer and warmer in winter than the upper air. Subway trains will be made up of coaches a little larger than the new cars of the Elevated roads, five in local trains and eight in expresses. The third rail and the motor-car have been adopted for propelling the trains, and the same system will be employed to run the suburban trains of the New York Central, Harlem, New Haven, and Portchester roads to the City Hall loop. The cars will be heated and lighted by electricity. The carrying capacity will be greater than that of the four lines of the present elevated system, owing chiefly to the greater speed of trains and the ease with which passengers can enter and leave stations and trains. Thirty miles an hour, including stops, will be the rule for expresses, and local trains will make considerably better time than the Elevated under existing conditions. Where the tunnel is near the street level, there will be fewer stairs to climb than at Elevated stations, and where the street is not readily accessible by stairways, such as at the One Hundred and Twenty-fifth Street Viaduct, elevators will be provided."

***Harper's Weekly*, January 31st 1903**

INTERIOR.

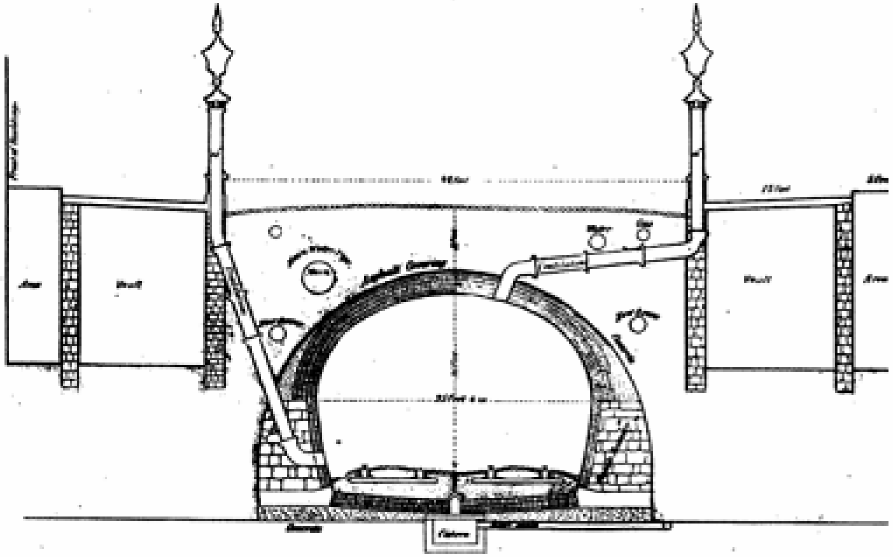
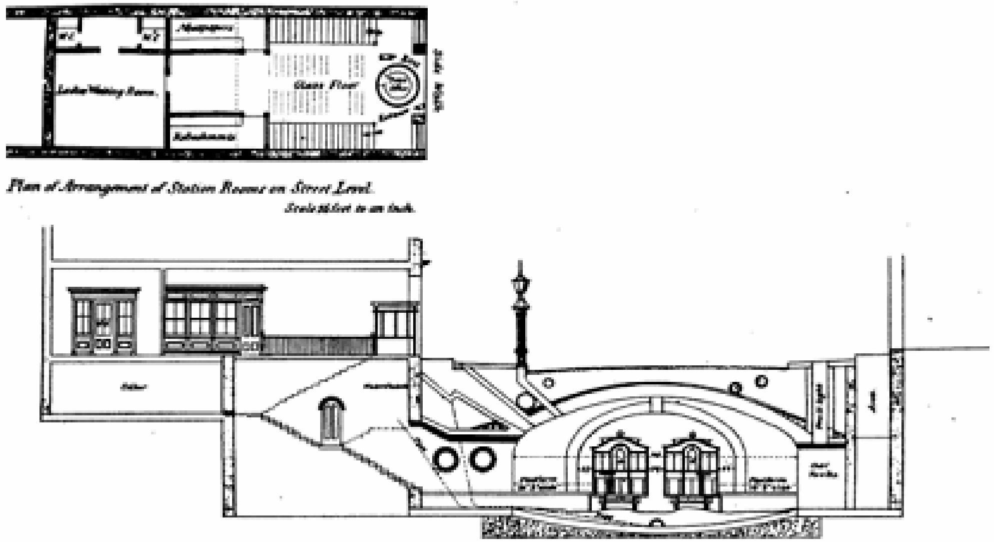




COMPOSITE CAR N. Y. SUBWAY.

The Rapid Transit Act

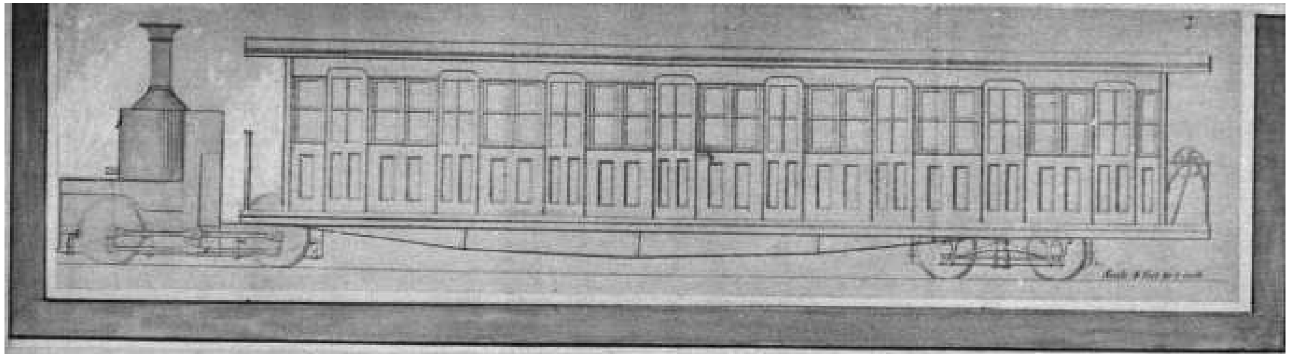
From 1850 to 1865, the surface horse railways proved sufficient for the requirements of the traveling public. As the city grew rapidly northward, to and beyond the *Harlem River*, the service of surface railroads became inadequate. As early as 1868, forty-two well known businessmen of the city became, by special legislative act, shareholders of the *New York City Central Underground Railway Company* created for the purpose of building a sub-surface railway from *City Hall* to the Harlem River, but nothing came of it. In 1872, also by special act, "Commodore" *Cornelius Vanderbilt* and others incorporated *The New York City Rapid Transit Company* to build an underground railroad from City Hall to connect with the commodore's *New York & Harlem Railroad* at *59th Street* (with a branch to the tracks of the *New York Central Railroad*) but the enterprise was soon abandoned. Numerous companies were incorporated in the succeeding years under the general railroad laws to build underground railroads, but were not realized. Among them were the *Central Tunnel Railway Company* (in 1881), *The New York & New Jersey Tunnel Railway Company* (in 1883), *The Terminal Underground Railway Company* (in 1886), *The Underground Railroad Company of the City of New York* (a consolidation of the NY&NJTR and the Terminal Co., in 1896), and *The Rapid Transit Underground Railroad Company* (in 1897).

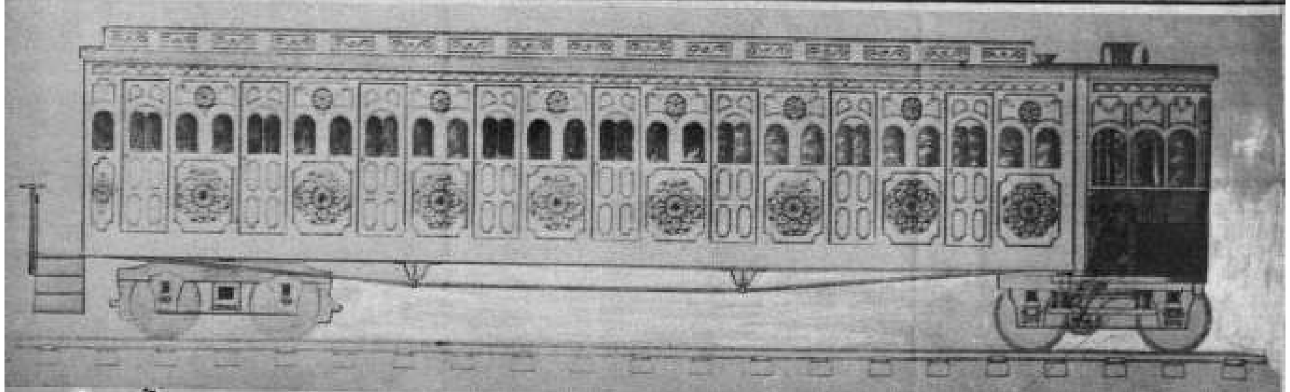
 

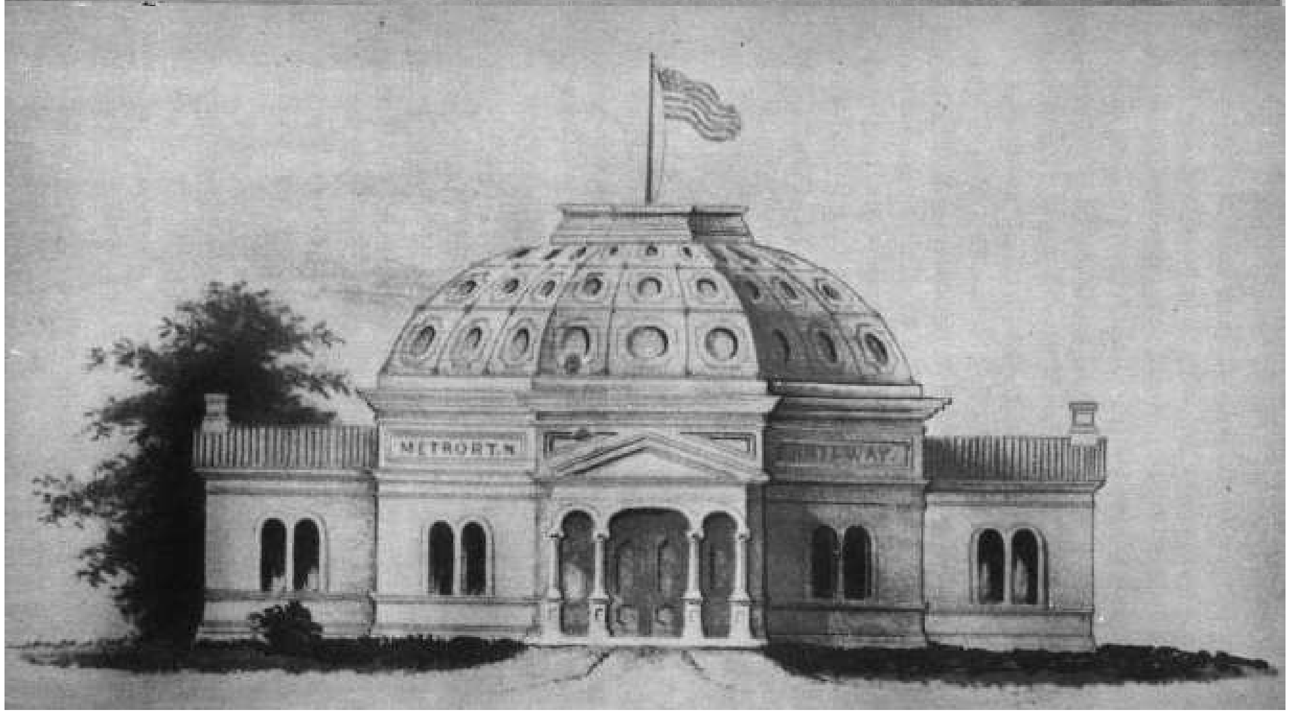
In 1864, plans were made for the *Broadway Underground* proposed by the *Metropolitan Railway Company* (organized by *Hugh B. Willson*). It covered almost the identical route of the IRT Subway from the *Battery* to *Central Park* and called for the construction of twelve miles of sub-surface railway. The chief points of difference were that the 1864 Subway was to be only a two-track line and the tunnel was to be of brick and stone masonry; not steel and concrete (as was actually built) and was to be operated by steam locomotives rather than electric traction.

<u>Left</u>: caption: "A.P. Robinson's Plans For Subway, 1864, Section of Tunnel Showing Sub-Surface Structures and Ventilation (Section of Tunnel with Details of Sewers, Water, and Gas Pipes, and Ventilation.)"

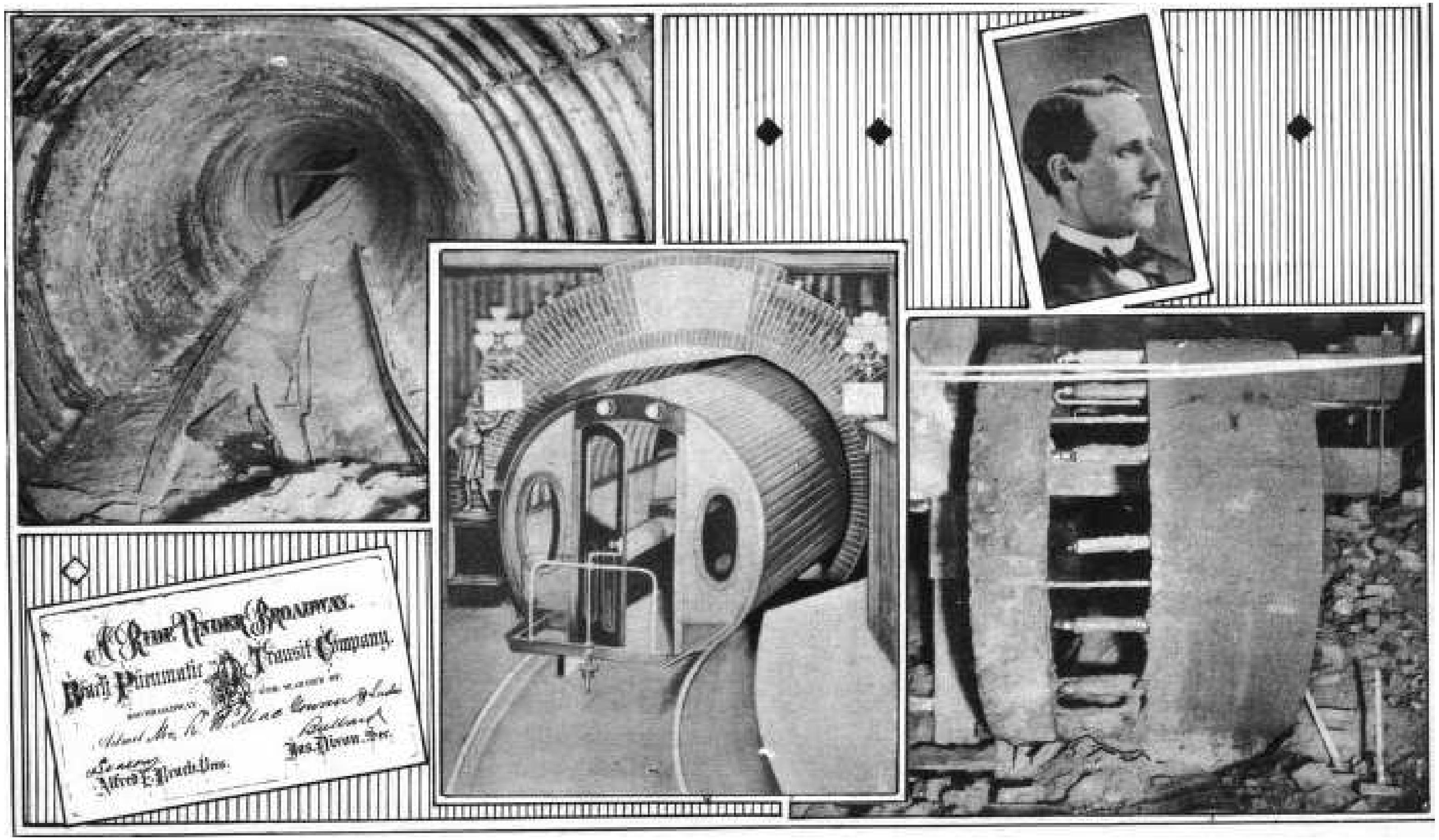
<u>Right</u>: caption: "Plate 2, A.P. Robinson's Plans For Subway, 1864, Section of Tunnel at Street Station."







Top: caption: "Type of Car Planned for Metropolitan Subway in 1864"
Bottom: "Robinson's Plan for Subway Station in Parks, 1864"



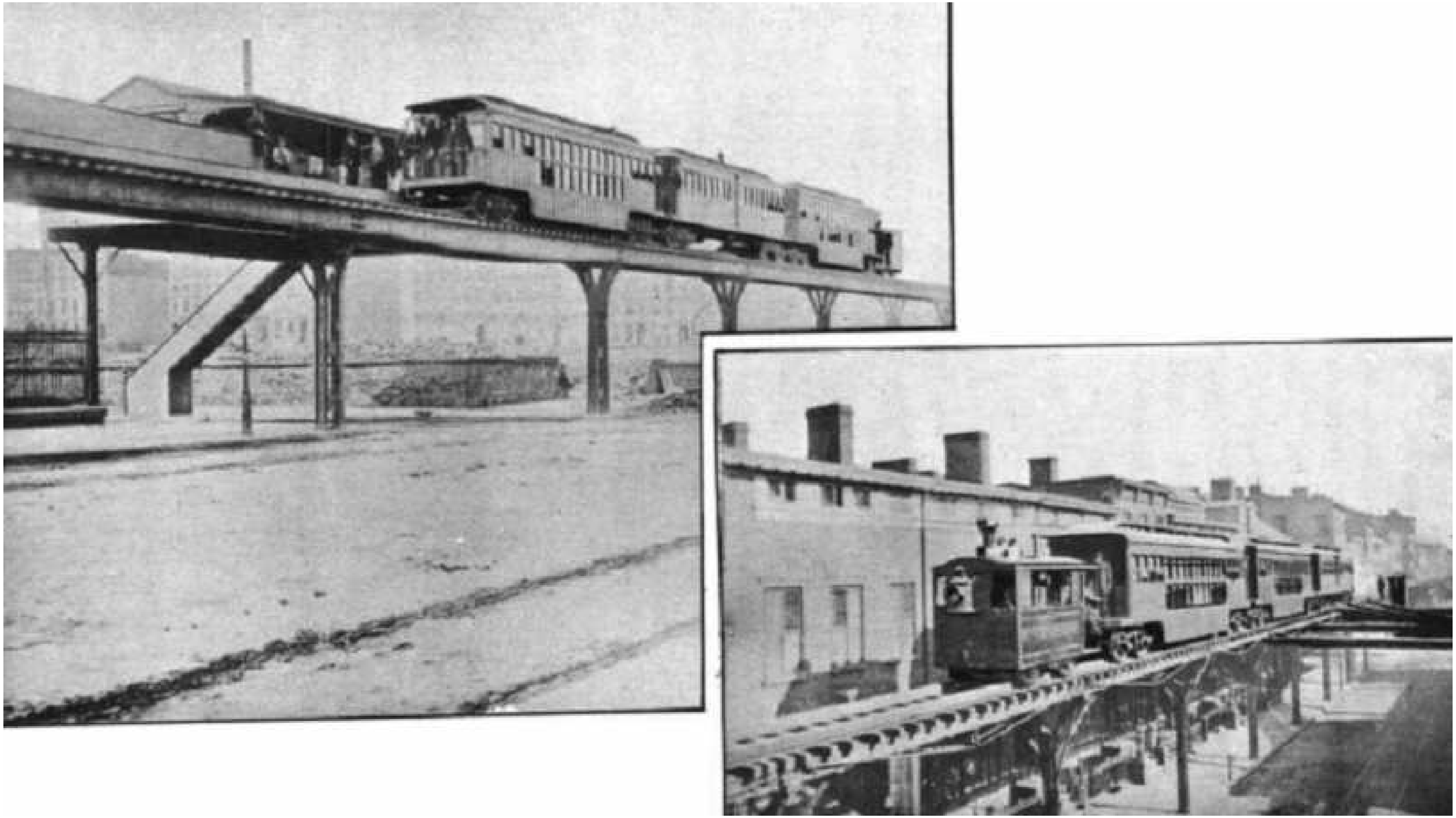
“The pneumatic system appears to be admirably adapted to the purposes of rapid city transit, since the ventilation is perfect and the freedom from all jarring and dust is complete. Mr. Beach is indefatigably laboring to accomplish its introduction here, and it is to be hoped his efforts will meet with due encouragement and reward…”

RE: excerpt from: “The Pneumatic Dispatch, with Illustrations” by *Alfred Ely Beach*. Obtaining in 1868 a charter to build an experimental pneumatic railway below *Broadway*, Beach opened his 312-foot tunnel in early 1870. It ran for about a year with about 75K passengers. Opposition by *Boss Tweed* and *Tammany Hall* (whose interests lay in the elevated lines) sealed its fate.

"…in New York it seems impossible to keep up with the growth of the city. The elevated and surface lines are operating as many cars as can be accommodated. Every evening during the rush hour, the cars on the principal surface lines run so closely together than there is reason for complaint on the part of pedestrians who are unable to proceed east or west without experiencing much delay and vexation. On the elevated, it is not unusual to see three five-car north-bound trains on the curve at 110th Street. This is about the limit of the present facilities."

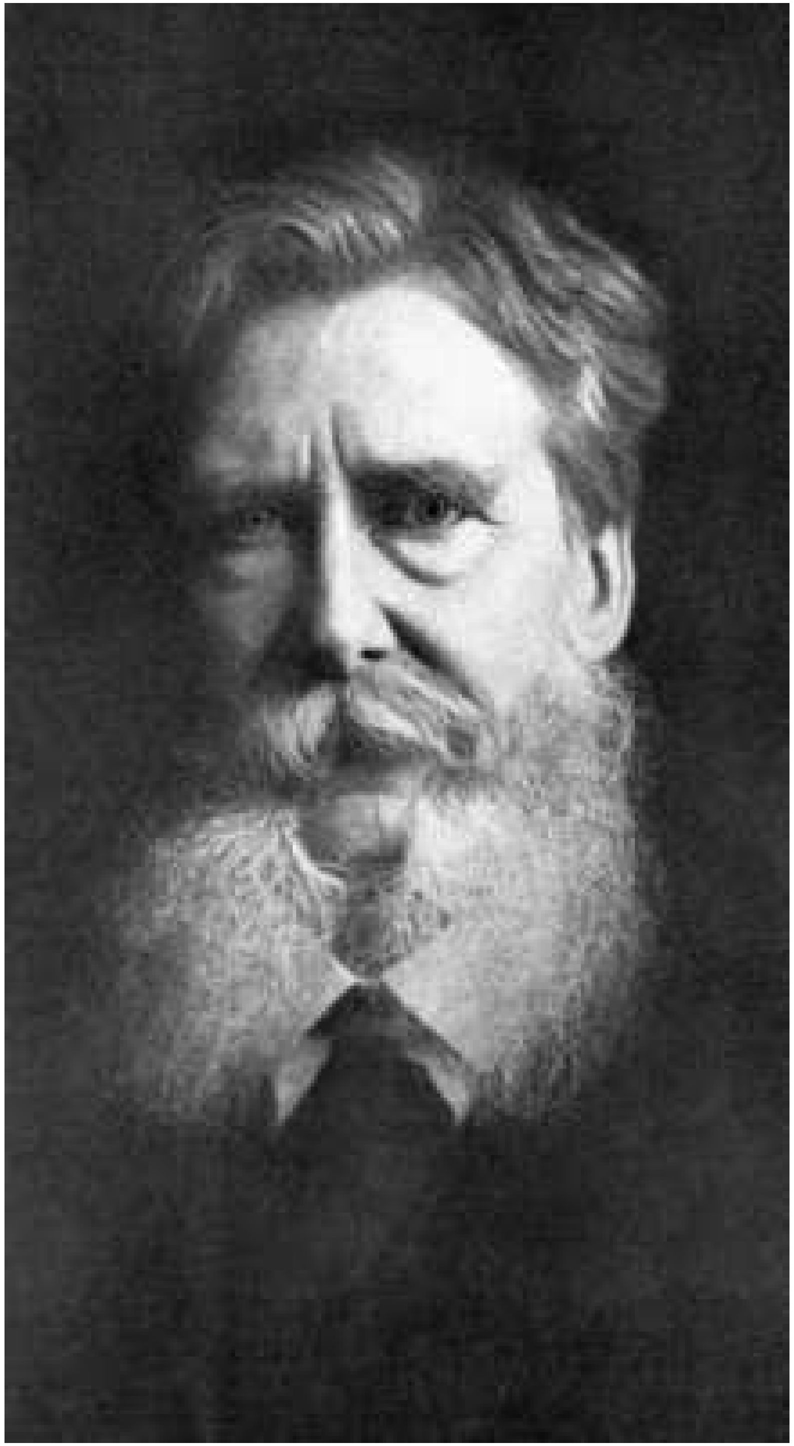
***Street Railway Journal,* 1902**

RE: competition from the electric street railways nearly ruined the *Manhattan Elevated Railway Company* during the 1890s. Its steam driven elevated cars were not only slower and smaller than the electric cars, but also less comfortable and less reliable. Only three years after the switch to electricity began in 1901, the elevated railroads carried 50% more riders than before. The electrification of the elevated lines made obsolete the traffic projections of the IRT Subway builders. It was apparent by 1902 that the subway, designed before the advent of electrical power on the elevated, would be incapable of handling the increased traffic. *William Barclay Parsons*, Chief Engineer of the *Rapid Transit Commission* (RTC), wrote in February 1903 that: *"tremendous increase in passenger travel on all lines during the past year clearly indicates that when the present subway system now under construction from Brooklyn to the Bronx is completed, it will almost be immediately congested."*



<u>Above</u>: caption: “Elevated Railroad Trains Drawn by Dummy Engines, about 1878”

<u>Above</u>: caption: "'An Incident in New York's Great Transportation Problem.' The Brooklyn Bridge connecting New York and Brooklyn carries over half a million people each day. The cars crossing on the four tracks cannot begin to accommodate the crowds, and as a result, thousands of people walk in all kinds of weather in throngs that make even the pedestrian anxious for his own safety. The completion of the new subway will go far toward relieving the congestion, especially at night, at the New York end of the bridge."



All attempts to build an underground railroad under the early special charter and later under the general laws failed. In 1891, the city secured in the passage of the *Rapid Transit Act* (RTA) under which (as amended in 1894) the construction and completion of the IRT Subway was realized. As originally passed, it did not provide for municipal ownership. Rather, it provided that a board of five rapid transit railroad commissioners adopt routes and general plans for a railroad, obtain the consents of the local authorities and abutting property owners or in lieu of the consents of the latter, the approval of the *NYS Supreme Court* and then, having adopted detail plans for the construction and operation, sell the right to build and operate the railroad to a corporation whose powers and duties were well defined in the act. The commissioners prepared plans and obtained the consents of the local authorities while property owners refused their consent. The NYS Supreme Court gave its approval in lieu of the property owners dissent, but upon inviting bids the *Board of Rapid Transit Railroad Commissioners* were unable to find a responsible bidder.

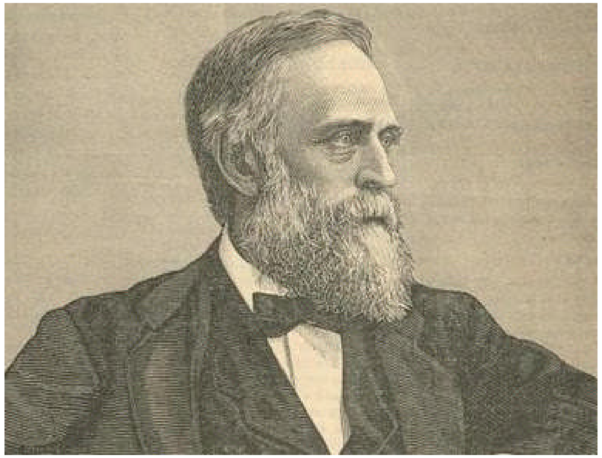
Left: caption: "Alexander E. Orr. President of the Rapid Transit Commission. Capitalist, philanthropist, former president of the Chamber of Commerce, a representative of all that is respectable, stable, in financial and political ideals."
***McClure's Magazine*, March 1905**

Hewitt

"It was evident to me that underground rapid transit could not be secured by the investment of private capital, but in some way or other its construction was dependent upon the use of the credit of the City of New York. It was also apparent to me that if such credit were used, the property must belong to the city. Inasmuch as it would not be safe for the city to undertake the construction itself, the intervention of a contracting company appeared indispensable. To secure the city against loss, this company must necessarily be required to give a sufficient bond for the completion of the work and be willing to enter into a contract for its continued operation under a rental which would pay the interest upon the bonds issued by the city for the construction, and provide a sinking fund sufficient for the payment of the bonds at or before maturity. It also seemed to be indispensable that the leasing company should invest in the rolling stock and in the real estate required for its power houses and other buildings an amount of money sufficiently large to indemnify the city against loss in case the lessees should fail in their undertaking to build and operate the railroad."

***Abram S. Hewitt*, NYC Mayor (1887-1888)**

RE: speaking in 1901 of his efforts in 1884, at which time legislation for underground railroads was under discussion (he had urged municipal ownership)



Abram S. Hewitt **became *Mayor of the City of New York* in 1887 and his views were presented in the form of a bill to the legislature the following year, but his measure found practically no support. Six years later, after the rapid transit commissioners had failed under the *Rapid Transit Act* (RTA) of 1891 (as originally drafted) to obtain bidders for the franchise, the *New York Chamber of Commerce* undertook to solve the problem by reverting to Mr. Hewitt's idea of municipal ownership. Whether or not municipal ownership would meet the approval of the citizens of NYC could not be readily determined therefore it was decided to submit the question to a popular vote. An amendment to the Act of 1891 was drafted (Chapter 752 of the Laws of 1894) which provided that the qualified voters of the city decide at an annual election, by ballot, whether the rapid transit railway should be constructed by the city, at the public's expense, and be operated under lease from the city or should it be constructed by a private corporation under a franchise under the RTA of 1891, as originally passed. At the fall election of 1894, the citizens of the city, by a large margin, decided against the sale of a franchise to a private corporation and in favor of ownership by the city. Several other amendments (which developed as plans for the railway were worked out) were made up-to and including the legislative session of 1900. However, the general scheme for rapid transit in NYC became fixed when the electorate voted in favor of municipal ownership.**

<u>Above</u>: Abram S. Hewitt (ca. 1888)

"Resolved; That a gold medal be struck in recognition of the eminent services of the Hon. Abram S. Hewitt in the cause of civic rapid transit under municipal ownership, and that it be presented to him by the President, with the assurances of the admiration, respect, and affectionate regard of his fellow members of the Chamber of Commerce of the State of New York."

RE: on April 5th 1900, the *Chamber of Commerce* held a meeting at which *Alexander E. Orr*, President of the *Rapid Transit Commission*, reported the signing of the contract for the construction of the Subway. That act marked the beginning of the end of an undertaking that had been vainly attempted for a period of twenty-five years. Just six years before (1894), the Chamber of Commerce had discovered the key to the solution of the problem of rapid transit with municipal ownership and through the efforts of its members, had prepared the way leading to successful achievement of their goal. It had drafted the bill that became the *Rapid Transit Act* of May 1894 and under that law the work had been commenced and would be carried out to final completion. Mr. Orr stated that the result was due mainly to the active influence of the Chamber and the genius and foresight of *Abram S. Hewitt* who had brought to the task a wide experience in civic affairs and an intimate knowledge of the requirements of the case.

<u>Above</u>: medal presented by the Chamber of Commerce to *Abram Stevens Hewitt*

The main provisions of the RTA of 1894, when the contract was finally executed on February 21st 1900, can be summarized as follows:

- **The act was general in terms, applying to all cities in NYS having a population of over one million; it was special in its effect because NYC was the only city having such a large population. It did not limit the rapid transit commissioners to the building of a single railroad, but authorized the laying out of successive railroads or extensions;**
- **A board was created consisting of the Mayor, Comptroller (or other chief financial officer of the city), the president of the *Chamber of Commerce of the State of New York* and five members named in the act;**
- **The board was to prepare general routes and plans and submit the question of municipal ownership to the electors of the city;**
- **The city was authorized, in the event that the electors decided for city ownership, to issue bonds not to exceed $50 million for the construction of the railroad/s and $5 million additional, if necessary, for acquiring property rights for the route. The interest on the bonds was not to exceed 3.5%;**
- **The city was to furnish the right of way to the contractor free from all claims of abutting property owners. The road was to be the absolute property of the city and to be deemed a part of the public streets and highways. The equipment of the road was to be exempt from taxation;**
- **The board was authorized to include in the contract for construction provisions in detail for the supervision of the city, through the board, over the operation of the railroad under the lease**

Additionally, the commissioners were given the broad power to enter into a contract (in the case of more than one railroad, successive contracts) on behalf of the city for the construction of the railroad with the person, firm or corporation which in the opinion of the board was best qualified to carry out the contract and to determine the amount of the bond to be given by the contractor to secure its performance. However, the essential features of the contract were prescribed by the RTA. The contractor selected for building the railroad was to agree to fully equip it at his own expense and the equipment was to include all Power Houses. He was also to operate the road, as lessee of the city, for a term not to exceed fifty years upon terms to be included in the contract for construction which might include provision for renewals of the lease upon terms the board would determine. The rental was to be at least equal to the amount of interest on the bonds which the city might issue for construction and one percent additional. The one percent additional might, at the discretion of the board, be made contingent in part for the first ten years of the lease upon the earnings of the railroad. In addition to the security which might be required by the board of the contractor for construction and operation, the act provided that the city should have a "first lien" upon the equipment of the road to be furnished by the contractor and at the termination of the lease the city had the privilege of purchasing such equipment from the contractor.

The work of construction, instead of being subject to the conflicting control of various departments of the city government with their frequent changes in personnel, was under the exclusive supervision and control of the *Rapid Transit Board* (RTB), a conservative and continuous body composed of the two principal officers of the city government and five individuals of high standing in the community. Provided financiers with sufficient capital could be found to undertake the extensive work under the exacting provisions, the scheme was admirable from the taxpayers' point-of-view. The railroad would cost the city practically nothing and the obligation of the contractor to equip and operate, combined with the agreement to construct, furnished a safeguard against waste of the public funds and insured its prompt completion. The interest of the contractor in the successful operation, after construction, furnished a strong incentive. The rental being based upon the cost encouraged low bids, and the lien of the city upon the equipment secured the city against all risk once the railroad was in operation. But not everyone saw the scheme as enlightened with fears of a private monopoly in control of the city's main transportation artery.

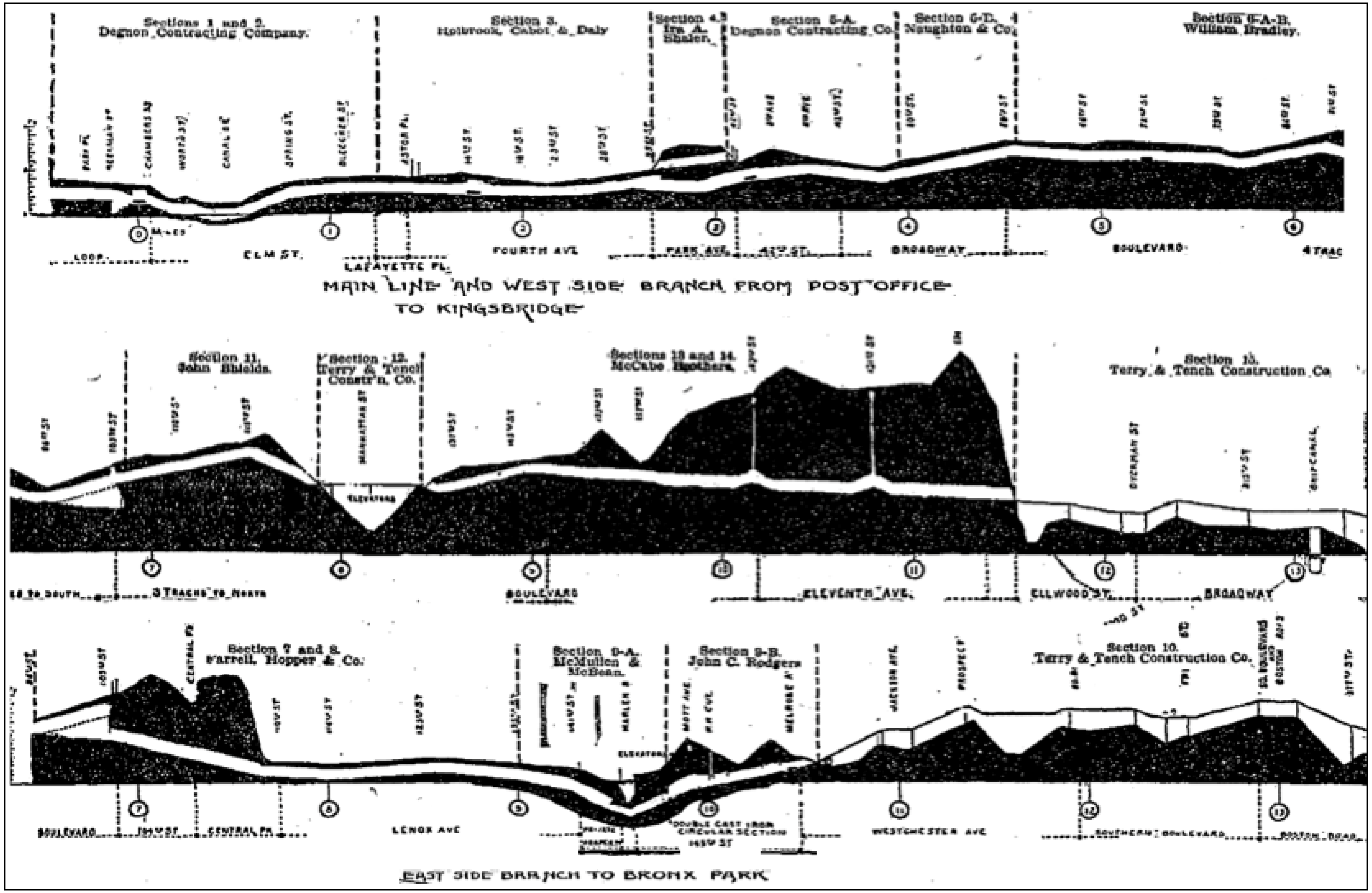
"…I know it is the fashion to speak of this subway as an instance of municipal ownership. It may be such three generations hence. Today it is merely a lending of municipal credit with exemption from taxation for the benefit of individuals…When the voters of the former City of New York voted for municipal construction of a rapid transit road, how many of them contemplated the result which now exists?…The construction and operation of a tunnel railway should never be let in one contract, but always separately, and with power in the city either to construct or to operate without contract. The present contract was, we are informed, instantly sublet in sections, with a profit, said to be eight millions, which will go far toward equipping what will surely be one of the most profitable railways in the world. There were but two real and responsible bidders…Had the contract been for construction alone, divided into sections, the bidders would have been many and the city would have saved the millions. There would scarcely have been difficulty, after construction, in leasing the railway on profitable terms for less than the fifty years period with twenty-five years renewal, for many, many cities have found it possible to lease their railways on good terms for twenty-five year periods…"

***Edward M. Grout*, Comptroller of NYC and RTC commission member**
RE: excerpt from a letter to *Andrew H. Green*

Immediately after the vote of the electors upon the question of municipal ownership, the commissioners adopted routes and plans which they had been studying and perfecting since the failure to find bidders for the franchise under the original RTA of 1891. New general routes and plans were adopted by the board in January 1897 in the face of property owner opposition and a court ruling. The local authorities gave their consent to the new route but the property owners, as on two previous occasions, refused their consent. However, the *NYS Supreme Court* gave its approval and the board was prepared to undertake the preliminaries for issuing a contract. These successive steps and the preparation of the terms of the contract all took time but finally, on November 15th 1899, a contract was adopted and an invitation issued by the board to contractors to bid for the construction and operation of the railroad. Two bids were received; one for $39,300,000 by *Andrew Onderdonk* and the other by *John B. McDonald* for $35 million. McDonald's bid was accepted on January 15th 1900 and, for the first time, it seemed as if a beginning might be made in the actual construction of the IRT Subway. The letter of invitation to contractors required that every proposal be accompanied by a certified check upon a national or state bank (payable to the NYC Comptroller) for $150K and that within ten days after acceptance or within such further period as might be prescribed by the board, the contract be duly executed and delivered. The amount to be paid by the city for the construction was $35 million plus an additional sum (not to exceed $2.75 million) for terminals, station sites and other purposes. The construction was to be completed in four-and-a-half years and the term of the lease from the city to the contractor was fixed at fifty years, with a renewal (at the option of the contractor) for twenty-five years (at a rental to be agreed upon by the city). To secure the performance of the general contract by Mr. McDonald, the city required him to deposit $1 million in cash as security for construction, to furnish a bond with surety for $5 million (as security for construction and equipment) and to furnish another bond of $1 million (as continuing security for the performance of the contract).

“…Under the form of proposal the route was divided into four separate parts, as follows: The entire line extends from City Hall to Kingsbridge Station on the north, and to Boston Road and Bronx Park on the east…The terms of the contract require the contractor to give a bond for $1,000,000, to continue in force during the whole 50 years of lease, and another bond for $5,000,000 to be released on completion of contract. The city agrees to give the contractor all facilities, and is to acquire for him all real estate needed for terminals, etc., and to pay for all real estate and the cost of the terminals with 10% profit to the contractor. The lease of the road is to begin with the completion for operation of each section, and is to continue for 50 years. At the end of that time the lease may be renewed for 25 years, at a rental not less than that paid in the last ten years of the lease…The road must be operated by other power than steam, and this power will doubtless be electric. All the lower part of the line will be underground. On Jan. 16 the Rapid Transit Commission awarded to John B. McDonald the contract for the construction and operation of the whole rapid transit line as given above.”

Engineering News and American Railway Journal, **January 18th 1900**



"…As soon as the contract was awarded to me, I divided the road into fifteen sections, each of which was put in charge of a subcontractor. This added rapidity in the working…"

John B. McDonald

Above: profile map of IRT Subway with Section/s breakdown

Sub-Contractors And Sections

SECTION 1. City Hall Loop, Park Row and Centre Street to center line of Chambers Streets. Degnon Contracting Co., Sub-Contractors. Open cut. Nature of excavation-earth;

SECTION 2. From the center line of Chambers Street along Centre Street and Elm Street to the center line of Great Jones Street. Degnon Contracting Co., Sub-Contractors. Open cut. Nature of excavation-earth;

SECTION 3. Lafayette Place from the center line of Great Jones Street to Astor Place, and Fourth Avenue from Astor Place to 100 feet north of the center line of Thirty-third Street. Holbrook, Cabot & Daly, Sub-Contractors. Open cut. Nature of excavation-rock and earth;

SECTION 4. From 100 feet north of the center line of Thirty-third Street along Fourth Avenue to the center line of Forty-first Street. Ira A. Shaler, Sub-Contractor. Rock tunnel;

SECTION 5-A. From the center of Forty-first Street and Fourth Avenue along Fourth Avenue to Forty-second Street, along Forty-second Street to Broadway, along Broadway to the center line of Forty-seventh Street. Degnon Contracting Co., Sub-Contractors. Open cut. Nature of excavation -earth and rock;

SECTION 5-B. From the center line of Forty-seventh Street and Broadway to the north end of the station at Columbus Circle, Sixtieth Street and Broadway. Naughton & Co., Sub-Contractors. Open cut. Nature of excavation-earth and rock;

SECTION 6-A. From Sixtieth Street and Broadway to Eighty-second Street and Broadway. William Bradley, Sub-Contractor. Open cut. Nature of excavation-earth and rock;

SECTION 6-B. From Eighty-second Street and Broadway to the center line of One hundred and fourth Street and Broadway. William Bradley, Sub-Contractor. Open cut. Nature of excavation-earth and rock;

SECTION 7. From a junction with the main line on Broadway, easterly under private property to One Hundred and Fourth Street, along One Hundred and Fourth Street to Central Park, under the northwest corner of Central Park to the center line of One Hundred and Tenth Street and Lenox Avenue. Farrell & Hopper, Sub-Contractors. Rock tunnel;

SECTION 8. From the Centre line of One Hundred and Tenth Street and Lenox Avenue to 100 feet north of the center line of One Hundred and Thirty-fifth Street and Lenox Avenue. Farrell & Hopper, Sub -Contractors, in sub-let to John C. Rodgers. Open cut. Nature of excavation-earth;

SECTION 9-A. From a point 100 feet north of the center line of One Hundred and Thirty-fifth Street and Lenox Avenue to the center line of Girard Avenue in the Borough of The Bronx. McMullen & McBean, Sub-Contractors. Harlem River Tunnel;

SECTION 9-B. From the center line of Girard Avenue to the west building line of Brook Avenue and Westchester Avenue. John C. Rodgers, Sub-Contractor. Open cut. Nature of excavation-earth and rock;

SECTION 10. Viaduct on Westchester Avenue, Southern Boulevard and Boston Road, from Brook Avenue to Bronx Park. Terry & Tench Co., Sub-Contractors, steel-work; E. P. Roberts, Sub-Contractor, foundations;

SECTION 11. From the center line of One Hundred and Fourth Street and Broadway to 10 feet north of the south side of One Hundred and Twenty-fifth Street on Broadway. John Shields, Sub-Contractor. Open cut. Nature of excavation-earth and rock;

SECTION 12. Manhattan Valley Viaduct, from One Hundred and Twenty-fifth Street to the north building line of One Hundred and Thirty-third Street on Broadway. Terry & Tench, Sub-Contractors, steel-work, E. P. Roberts, Sub-Contractor, foundations;

SECTION 13. From the north building line of One Hundred and Thirty-third Street and Broadway, along Broadway to Eleventh Avenue, along Eleventh Avenue to the center line of One Hundred and Eighty-first Street. James Pilkington, Sub-Contractor. Rock tunnel;

SECTION 14. From the center line of One Hundred and Eighty-first Street and Eleventh Avenue, along Eleventh Avenue to Hillside Avenue at Fort George. John B. McDonald, Sub-Contractor. Rock tunnel;

SECTION 15. Viaduct from Fort George northerly to The Bronx at Kingsbridge. Terry & Tench, Sub-Contractors, steel-work; E. P. Roberts, Sub-Contractor, foundations.

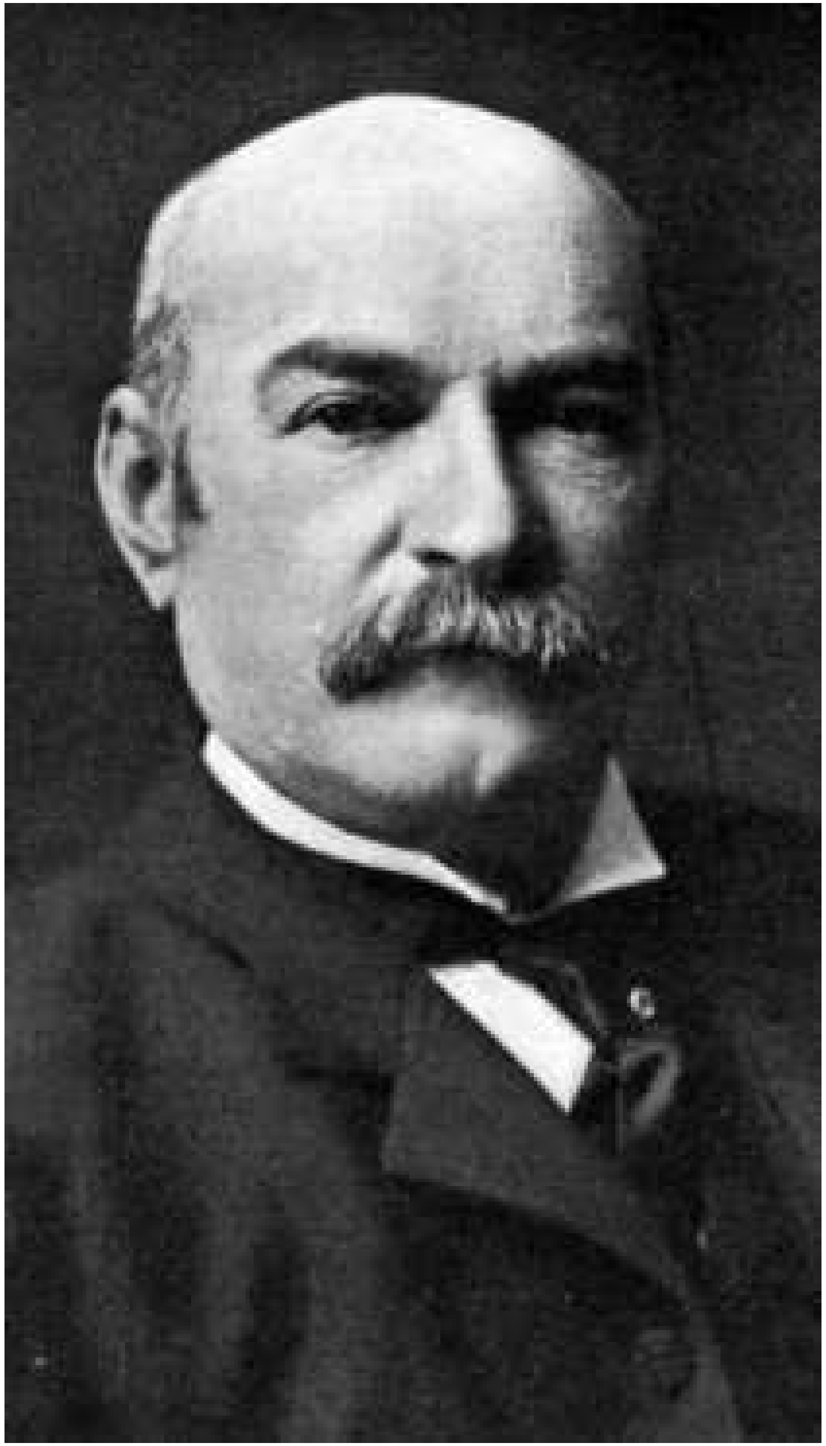
"…The work must be finished in 4.5 years. Briefly summarized, it comprises the following items:

Length of all sections, ft.	**109,570**
Total excavation of earth, cu. yds.	1,700,228
Earth to be filled back, cu. yds.	773,093
Rock excavated, cu. yds.	921,128
Rock tunneled, cu. yds.	368,606
Steel used in structures, tons	65,044
Cast iron used, tons	7,901
Concrete, cu. yds.	489,122
Brick, cu. yds.	18,519
Waterproofing, sq. yds.	775,795
Vault lights, sq. yds.	6,640
Local stations	43
Express stations	5
Station elevators	10
Track, total, lin. ft.	305,380
Track, underground, lin. ft.	245,514
Track, elevated, lin. ft.	59,766

…The Rapid Transit Commission has taken under consideration the extension of the line to the Battery and thence to South Brooklyn…"

***Engineering News and American Railway Journal*, January 25th 1900**

McDonald



"John B. McDonald was born in New York City in 1847. His father, Bartholomew McDonald, was alderman for the old Nineteenth district, and made a fortune as a contractor. John B. McDonald was his father's partner and is his successor. He has made extensive improvements in San Francisco harbor, and has constructed four hundred miles of the Canadian Pacific Railroad. He built one of the elevated lines in Chicago, and nine miles of tunnel through which the city gets water from Lake Michigan; also the tunnel through which electric motors haul freight trains of the Baltimore & Ohio railroad under and across the city of Baltimore. He is building the Jerome Park reservoir in New York. For more than twenty years Mr. McDonald studied the problem of rapid transit in New York, and he probably knows more about it than any other man. From the beginning he has been convinced that the true solution lay in an underground route, dry, brightly lighted with electricity, and with electric motive power, which avoids the vitiation of pure air and affords great speed. In building and equipping the present road he is realizing the ambition of his life."

Munsey's Magazine, **1902**

Left: John B. McDonald, the contractor who built the IRT Subway was described by *McClure's* magazine in March 1905 as:

"a solid, grim man with a thick chest, brawny arms, and an iron jaw; masterful, self-controlled, capable."

"…A few years ago the public regarded subway building in this city as impracticable. After I had studied the subject, I decided that the public was wrong and undertook the job. The difficulties I found were great. They have been overcome, and the tunnel problem is solved for New York. I claim no special credit, except what may attach to the completion of what has been sometimes called my contract. The public is the chief beneficiary, and it must decide who is entitled to credit."

John B. McDonald

RE: excerpt from his October 27th 1904 IRT Subway opening ceremony speech

Unsung Heroes

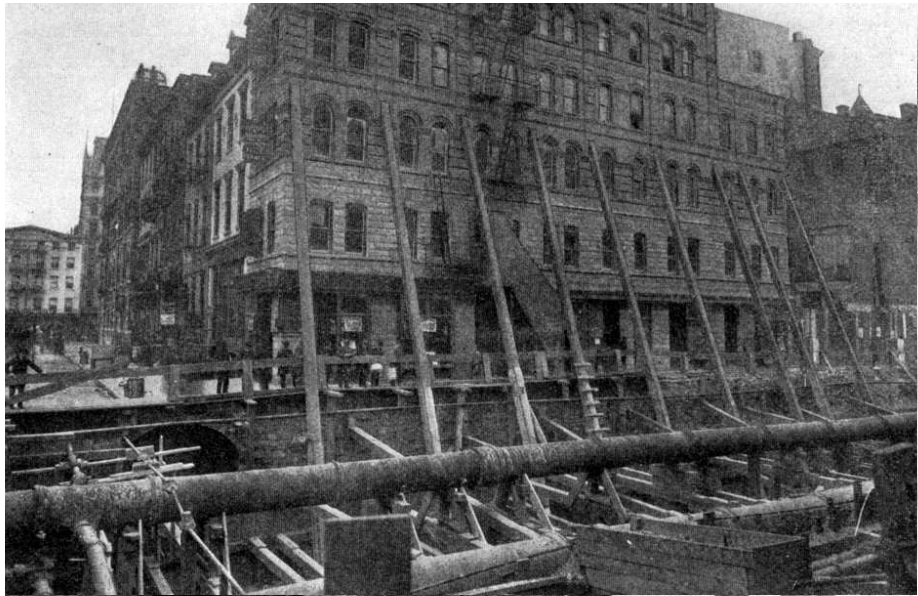
"…While the public of New York has read pages about the great engineer who designed the Subway, the far-seeing financier who backed it, and the hardy contractor who never doubted its practicability, the men who did the actual work of construction are almost strangers to the thousands who now are enjoying the benefits of their labors. The sub-contractors - they were the quiet, untiring, sturdy workers who undertook the direct responsibility of building the tunnel block by block, who saw to it that every inch was bored accurately and quickly, who ruled the men with the drills, picks, and shovels, and these sub-contractors required hardly less nerve than did those who backed the undertaking as a whole. Each separate job was a monster in itself. Each had its enormous difficulties and its uncertainties that might have meant ruin if tireless watchfulness and unbounded energy had not brought success and fortune. As soon as the contract for the Manhattan-Bronx Subway had been given to the Rapid Transit Subway Construction Company - August Belmont, President, and John B. McDonald, contractor - the company called for bids on the different sections into which the work had been divided. There were fifteen of these divisions. The boldest contractors of the city, and some from out of town, made their offers with hesitation and after much thought. Never before had the contracting business of the East faced possibilities of so much promise or of so much doubt. Out of all the firms which became engaged in the work, only two have failed to make handsome profits. It is a singular coincidence that both of these firms came from other cities…The first sub-contract to be completed was Section 5B, Naughton & Co.'s job along Broadway, between Forty-seventh and Sixtieth Streets…"

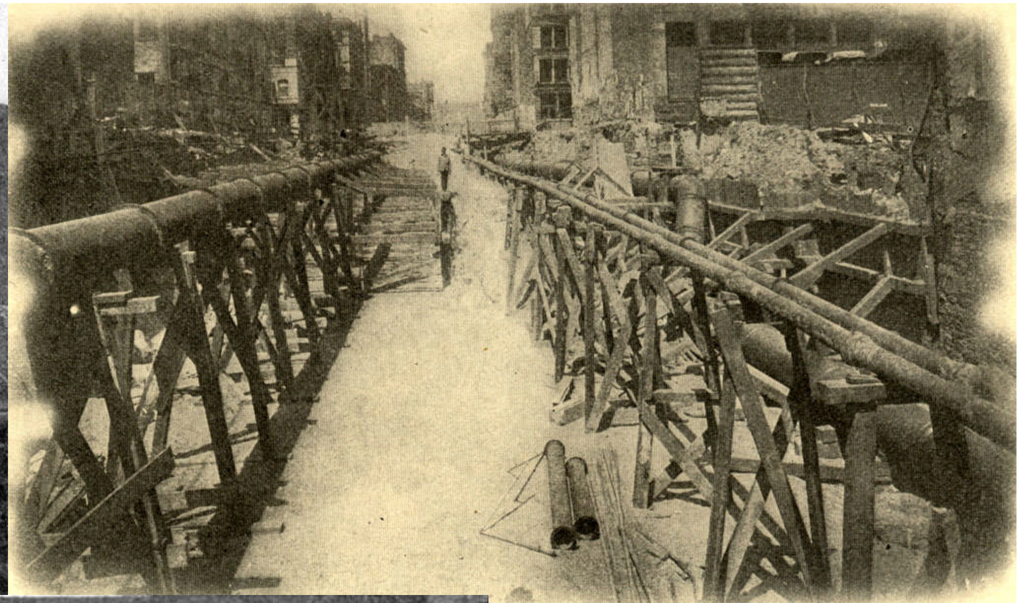
The New York Times, **November 6th 1904**

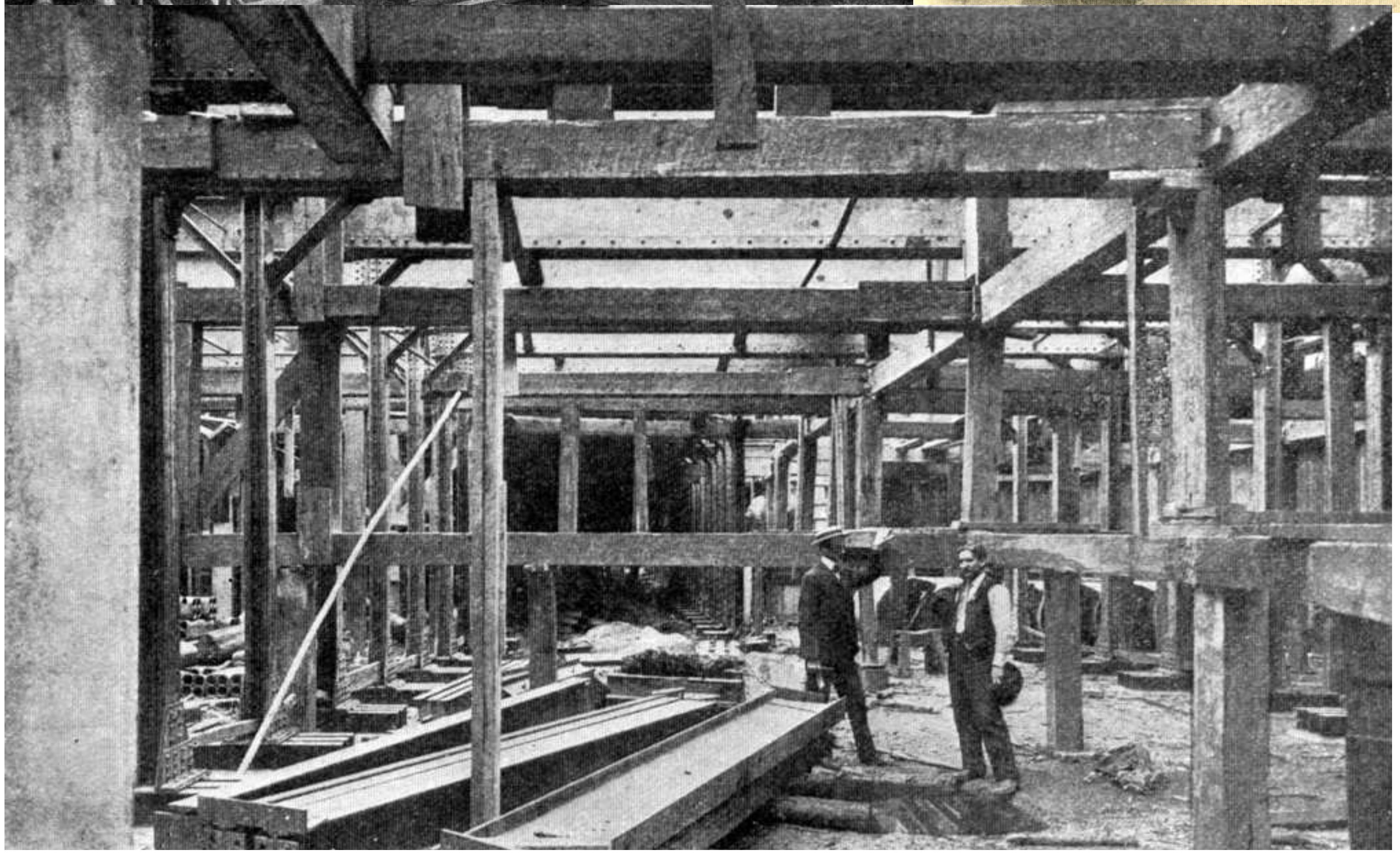
"Rapid Transit Tunnel sub-contracts have been awarded as follows: Carnegie Steel Co. is to furnish the 72,955 tons of structural steel and iron to be used; the Sicilian Asphalt Co. will lay 775,795 sq. yds. of asphalt waterproofing, and the United Building Material Co. will furnish the Portland and other cement. To the Degnon-McLean Construction Co. is awarded Sections 1 and 2, including the post-office loop to Chambers St. and Chambers to Great Jones, on Elm St., for $1,250,000 and $2,000,000, including in the latter $500,000 for shifting sewers and $100,000 for shifting 36-in. main and other water pipe. Mr. E. J. Farrell has Section 7, from 103d to 110th St. and Lenox Ave.; and Section 8, from 110th St. to 100 ft. beyond 135th St. and Lenox Ave.; the two bids approximate $1,600,000, including for this 4,100 ft. of rock tunnel. Mr. John C. Rogers has Section 9, joining the Farrell contract, going under the Harlem River and then east to Brook Ave.; the price is about $2,000,000. Mr. John Shields has Section 11, from 104th St. to 125th St.; no price named. Mr. L. B. McCabe has Section 13, from 133d St. to 181st St., and Section 14, from 181st St. to Hillside Ave. The sub-contracts for Sections 3, 4, 5, 6 and 10, 12 are not yet announced…"

***Engineering News and American Railway Journal,* April 19th 1900**

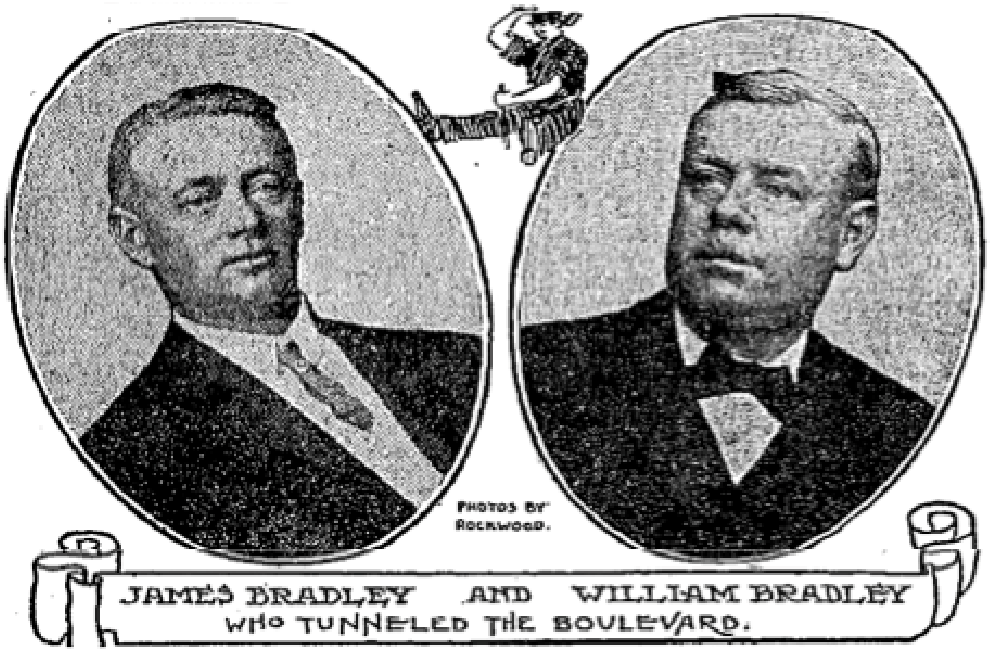
The man who had most sub-contracts and the most difficult problems of construction was *Michael J. Degnon* (above). The sub-contracts for Sections 1, 2, and 5A of the tunnel were bid by the *Degnon-McLean Contracting Company*, but the firm was dissolved later and the *Degnon Contracting Company* took over all the work. The Degnon contracts totaled $8.5 million, including the lower *Broadway* part of the *Brooklyn Extension* tunnel. The three sections of the *Manhattan-Bronx* line represented slightly less than $6 million. Degnon's most difficult tasks included the excavations under *Park Row* (where be had to keep four trolley tracks in operation as the earth was removed and the tunnel built beneath), the *City Hall Loop* (whose course required burrowing under the foundations of the old *Times Building* and bisecting several *Post Office* vaults), digging through quicksand (where a lake once existed in the *Canal Street* neighborhood), supporting *42nd Street's* heavy traffic (over excavations in almost continuous rock) and the handling of many underground obstructions, such as pipe lines, elevated railroad supports and sewers.[47]





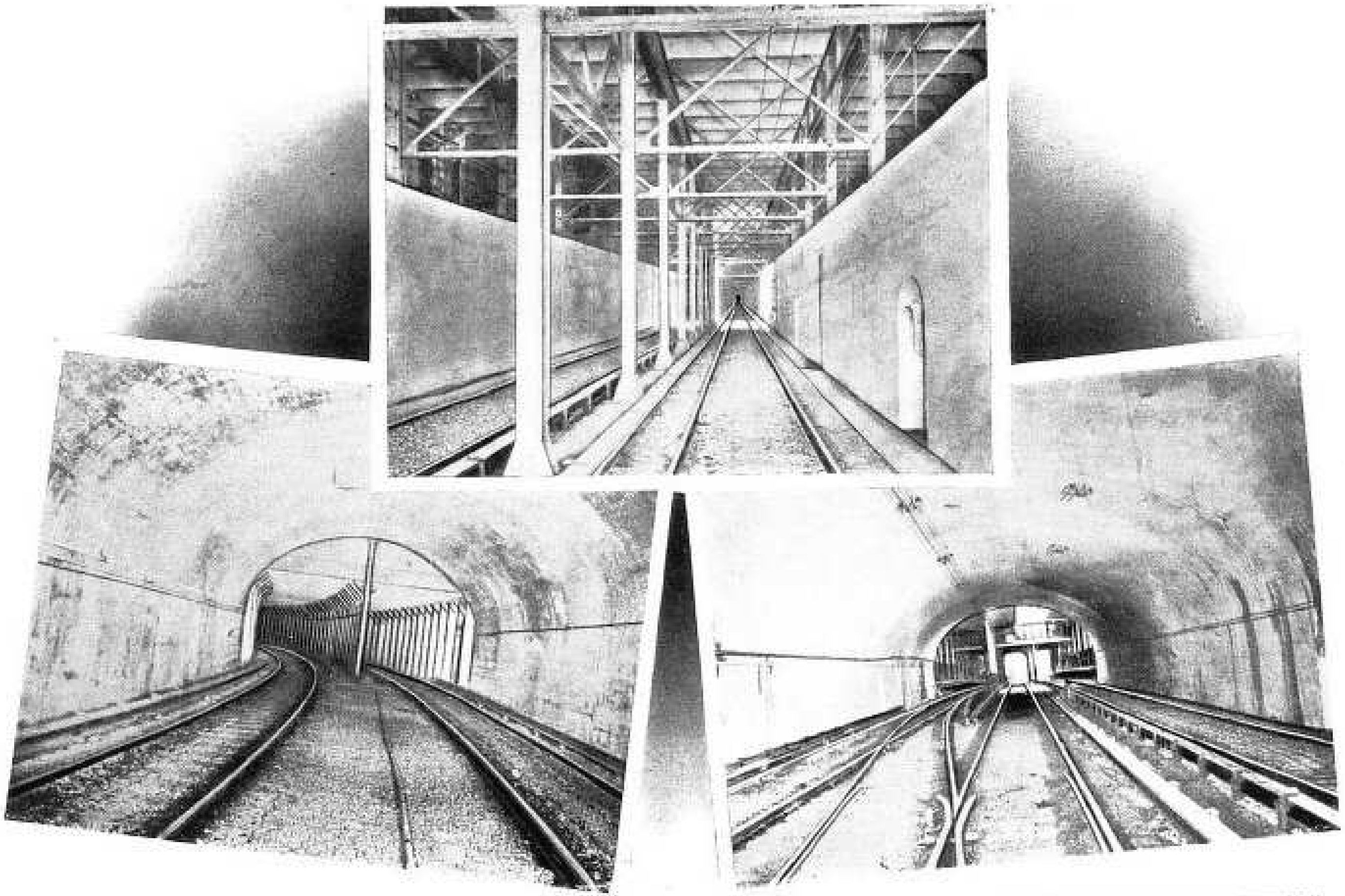


<u>**Top L&R**</u>**: caption: "Underwork at *Elm* and *Bond Street/s*"**
<u>**Left**</u>**:caption: "Underground work at *Broome* and *Elm Street/s*"**



William Bradley's bid for Section 6A-B of the IRT Subway was approximately $500K (he was the sole bidder). The work included many of the "binding points" of the tunnel line - engineering tasks that made the contract a dangerous one to undertake. While it was William who the contracted the work, his active share in the work was no less than that of his brother; James. The tunnel-building efforts of the *Bradley Brothers* in the vacant plot bounded by *86th* and *87th Street/s*, *Broadway* and *Amsterdam Avenue*, is a good example of the complexity of the tunnel work. Rock-crushing machinery, blacksmiths' shops, repair yards, wheelwrights' layouts, supply and storage houses and all the other requirements of rock tunneling were provided as well as a compressed-air plant on the riverfront, from which came (through long pipes) the power that operated the rock drills along the section (all the machinery was operated by compressed-air). [49]

104TH STREET JUNCTION.



PARK AVE. AND 41ST ST. N. Y. SUBWAY. BROADWAY AND COLUMBIA UNIVERSITY.

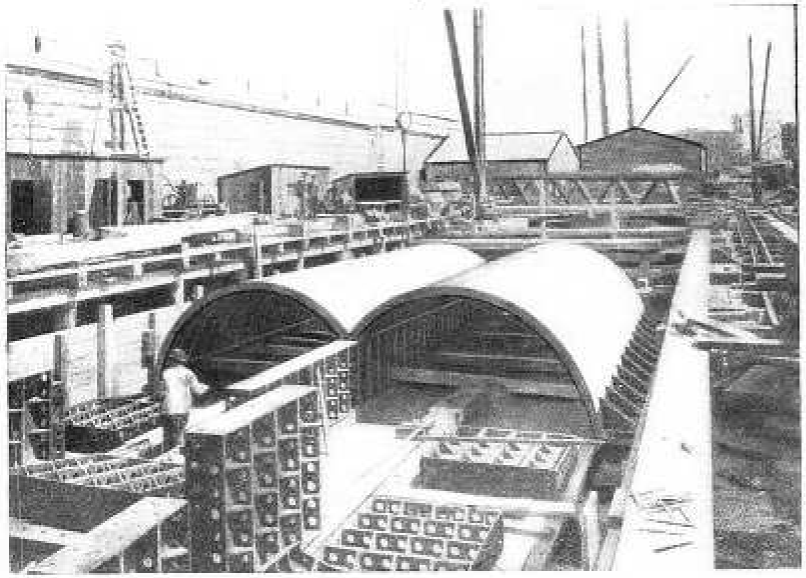
<u>Above</u>: caption: “View from the North Portal of Central Park Tunnel, looking towards Lenox Avenue, 1901”

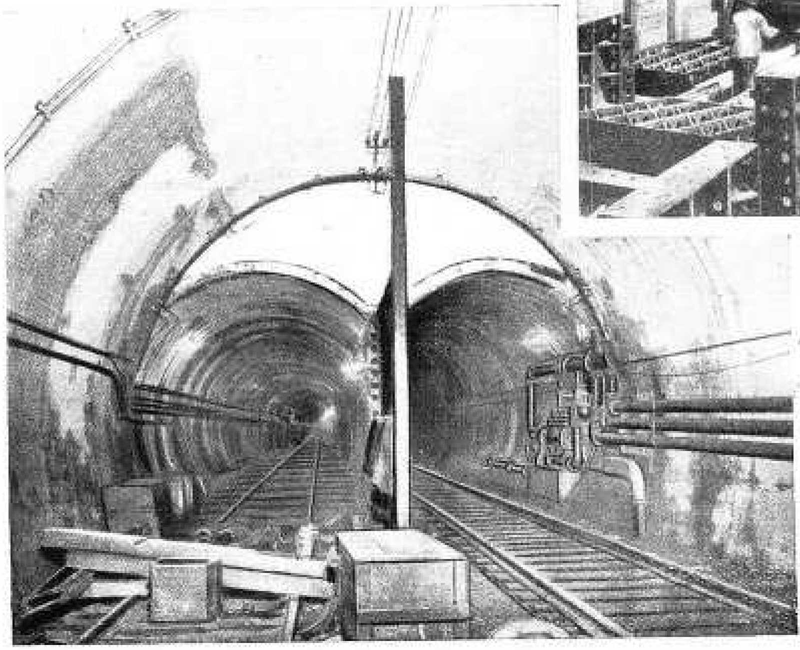
"My experience on public work has taught me sufficient knowledge of strength of material and of force and its effects to utilize them, and how to make use of one to withstand the other. Instead of unwatering the site of the Harlem River tunnel with the use of a coffer dam, thereby resisting the force of the water, as heretofore was customary in doing such work, I used the force produced by the weight of the water above the bed of the river to maintain under the water an air space in which the tunnel was built."

Duncan D. McBean

RE: the contract for the *Harlem River* work (Section 9A) was awarded to the firm of *McMullen & McBean* for their winning bid of $1.5 million. McBean built the top half of the tunnel in a pontoon - a floating open box, and used the top half of the tunnel as a roof for the chamber in which was built the lower half. It was the first sub-aqueous tunnel ever built with a pile and concrete foundation to support it. Where McBean's contract ended (at *Gerard Avenue*, *Bronx*), began Section 9B. The sub-contract was awarded to *John C. Rodgers*, who later made a deal by which he added the greater part of Section 8 to his contract, which was the *Lenox Avenue* division, extending north from *110th Street* and *Central Park*. It had been undertaken initially by *Farrell, Hopper & Co.,* the firm to which Rodgers belonged. The firm had obtained the sub-contract for Sections 7 and 8. No. 7 was the first division of the east-side branch of the IRT Subway, beginning at *103rd Street* and *Broadway* and ending at 110th Street and Lenox Avenue (after going under a corner of Central Park). All the work was done by underground tunneling through rock. Section 8 extended up Lenox Avenue to *135th Street.*

CONSTRUCTING TUBES.

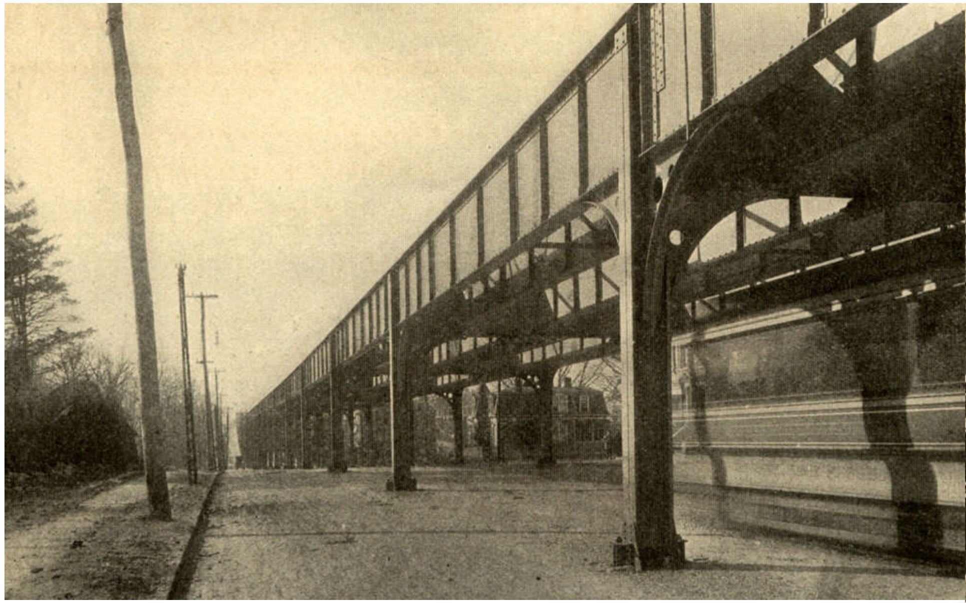


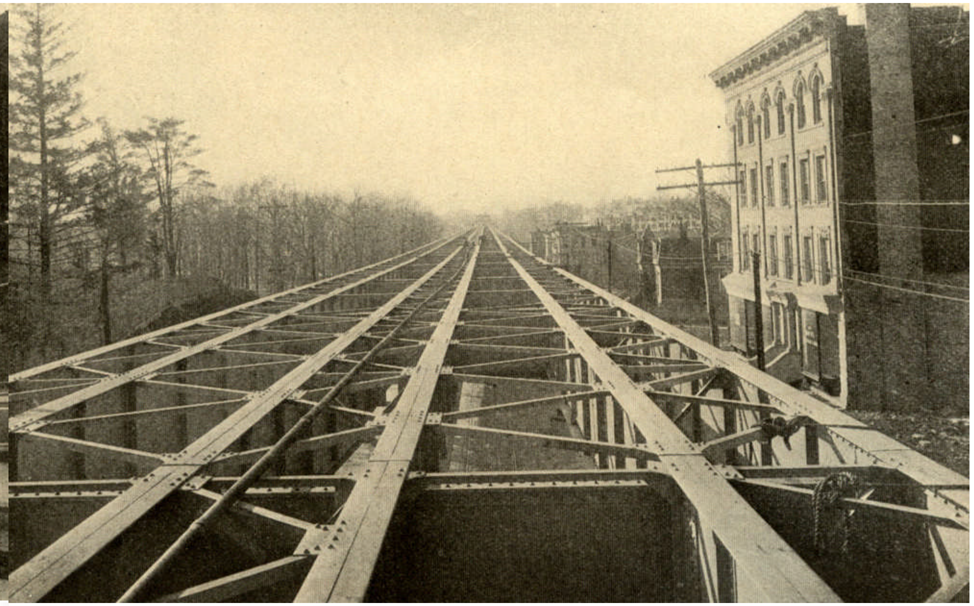


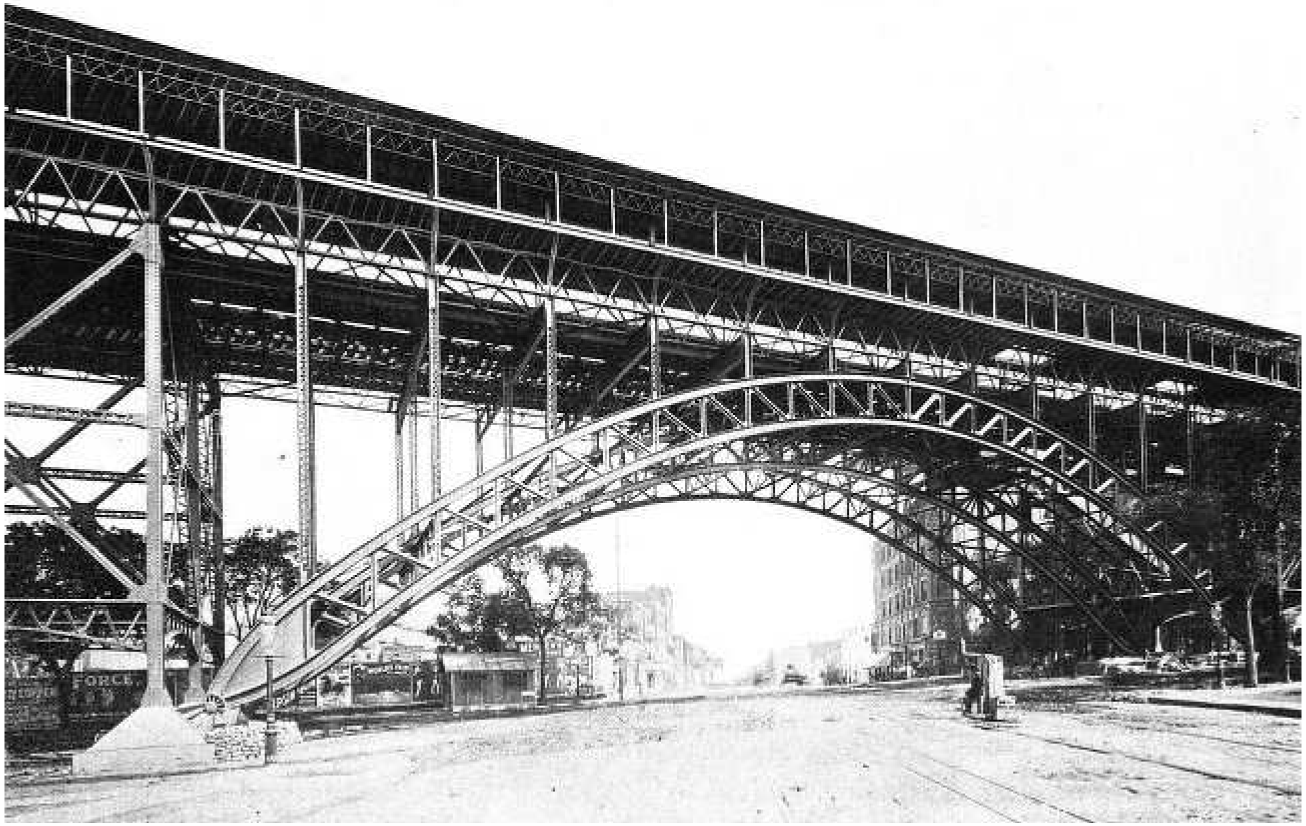
JOINING ARCH AND TUBES.

HARLEM RIVER SECTION N. Y. SUBWAY.

The *Terry & Tench Construction Company* was awarded the sub-contract for Section/s 10 (*Westchester Avenue Viaduct*), Section 12 (*Manhattan Valley Viaduct*) and Section 15 (*Fort George Viaduct*). Besides building three elevated sections of the IRT, they supplied all steel required by other contractors for all underground sections north of *104th Street*. In addition, they held contracts for five million board-feet of lumber and laid all the rails above 104th Street. The most complex work they did on the IRT was the moving of an entire section of steel tunnel frame between *135th* and *136th Street/s*. This section had been finished for a two-track railroad. The RTC changed its plans and authorized three tracks at that point. Terry & Tench moved the whole roof and one side of the steel frame far enough to give the extra room required without incident. Combined, their contracts were worth approximately $1.25 million.





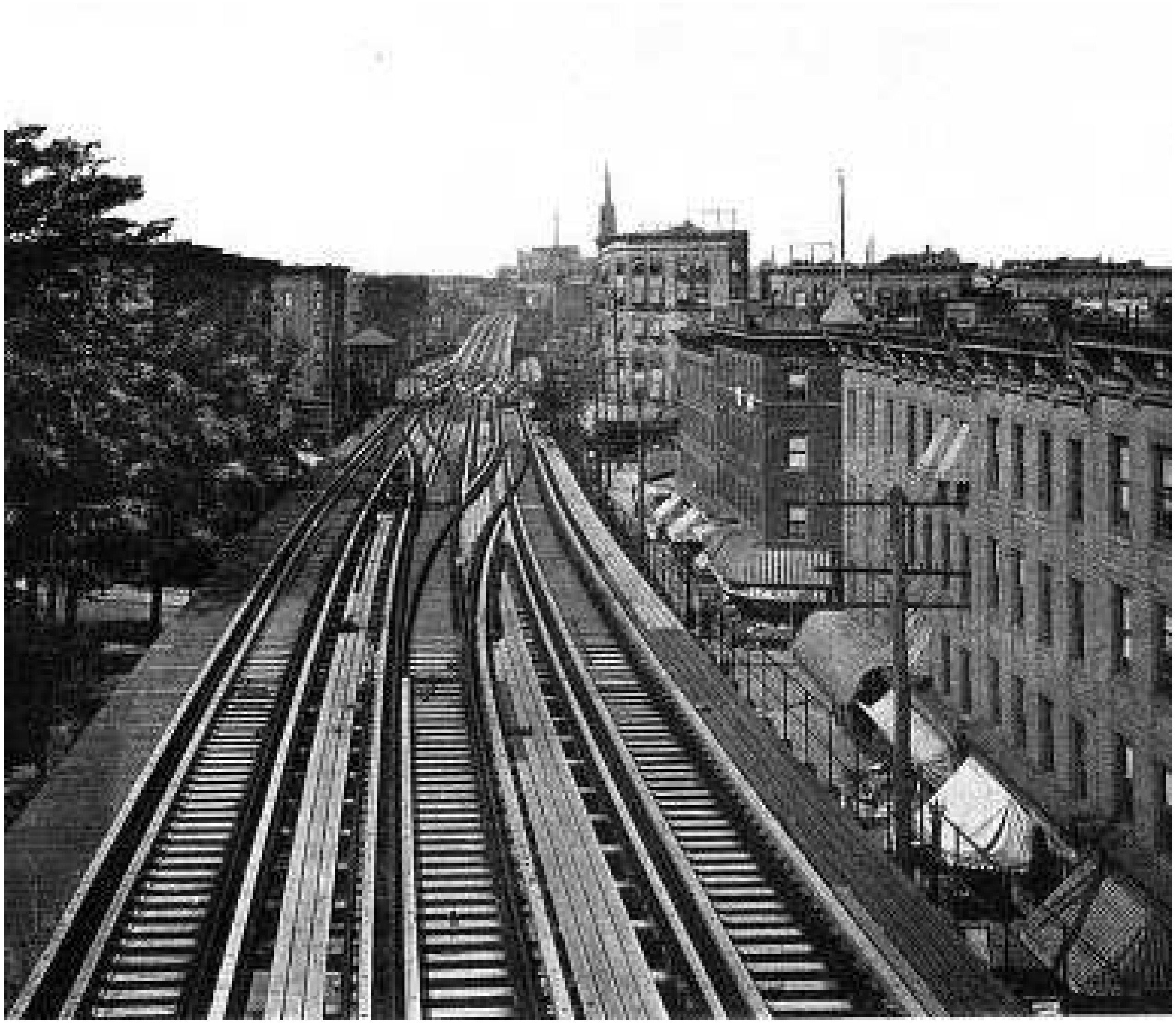


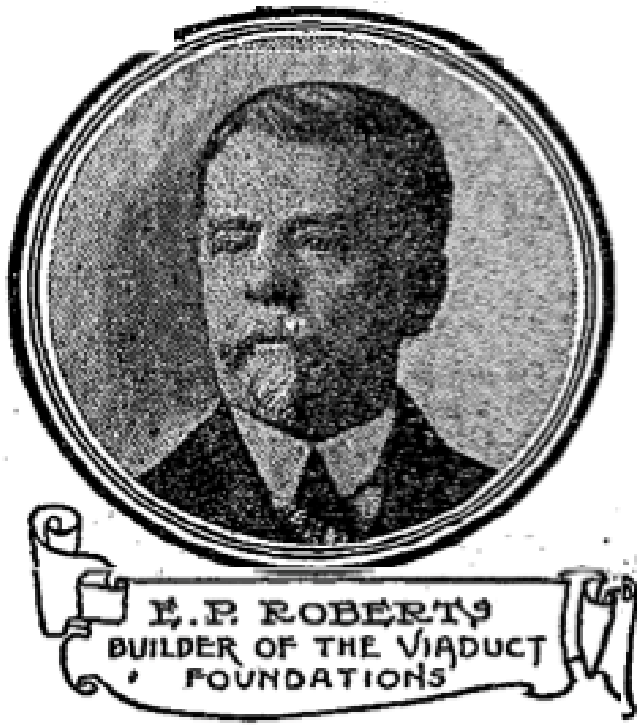
<u>Top L&R</u>: ***Westchester Avenue Viaduct***
<u>Left</u>: ***Manhattan Valley*** **(Harlem)** ***Viaduct***

"…On April 16 the Carnegie Steel Co. took the contract to manufacture 74,326 tons of structural steel and about 4,000 tons of steel rails for this work…this contract requires the Carnegie Works to manufacture 22,439 tons of steel beams, 20,466 tons of riveted steelwork, 7,921 tons of steel columns, 23,500 tons of steel viaduct, and 4,064 tons of steel rails, or a total of 78,390 tons of finished steelwork. It has already been stated that this is the largest contract for steel ever undertaken by a single steel-maker for a single engineering work. It is as much steel as would be required to lay 556 miles of railway track with 80-lb. rails…"

Engineering News and American Railway Journal, **May 24th 1900**

Above: present-day view of steel arch span known as the *Manhattan Valley Viaduct* (looking southeast down *125th Street*)





Left: consulting engineer *Evelyn P. Roberts'* job was to lay concrete foundations for the viaduct sections. Though the smallest of all the sub-contracts, it presented some unique difficulties. Each of the concrete bases for the elevated steel pillars had to be imbedded with great care as there were places where subsurface pipes and/or sewer lines were penetrated causing long delays.

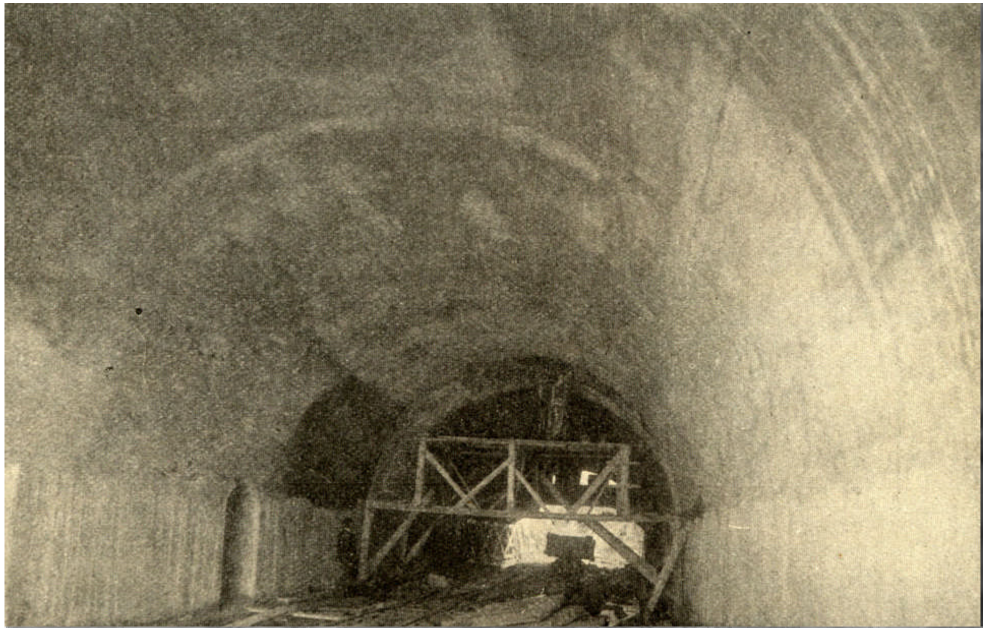
Right: *John Shields* had the work on Section 11, the first section of the west-side branch (from *104th* to *125th Street* and *Broadway)*. His oldest son John Jr., superintended while he provided general supervision. 58
Two younger sons; *Robert* and Henry, assisted.

"…The McCabe Brothers, who undertook the deep tunnel under Washington Heights north of One Hundred and Fifty-seventh Street and the section just south of that point, had made a reputation in Baltimore, chiefly because of their work as sub-contractors under John B. McDonald in building the Baltimore and Ohio tunnel beneath that city. The firm of Holbrook, Cabot & Daly had won its spurs on the subway in Boston. They tackled Section 3 of New York's tunnel, including the Union Square rock blasting. Like the McCabes, they miscalculated and put in too low bids, though they did not go to the wall and were able to finish their work, while the Baltimore firm succumbed to its troubles in less than two and a half years after the tunnel was begun…Section 3, from Great Jones Street and Lafayette Place to Fourth Avenue and Thirty-third Street, went to the Boston firm of Holbrook, Cabot & Daly. Frederick Holbrook was the working member of the firm, and despite his financial reverses, he did his work well to the end. A miscalculation as to the expense of the rock work on the east side of Union Square is said to have been the chief cause of the firm's loss, and then there was the suit won against the contractors by the Everett House, whose proprietor claimed damages on account of the noisy power plant in front of his doors. After the firm got into difficulties there was a reincorporation. The Holbrook, Cabot & Daly Construction Company, with added capital furnished in the nick of time, continued the work. Later, when the building was nearly over, there was another reorganization, the company becoming Holbrook, Cabot & Rollins…"

***The New York Times,* November 6th 1904**

RUFUS P. HUNT,
BOSS OF THE HEIGHTS TUNNEL
PHOTO COPYRIGHT, 1904, BY
PIRIE MACDONALD

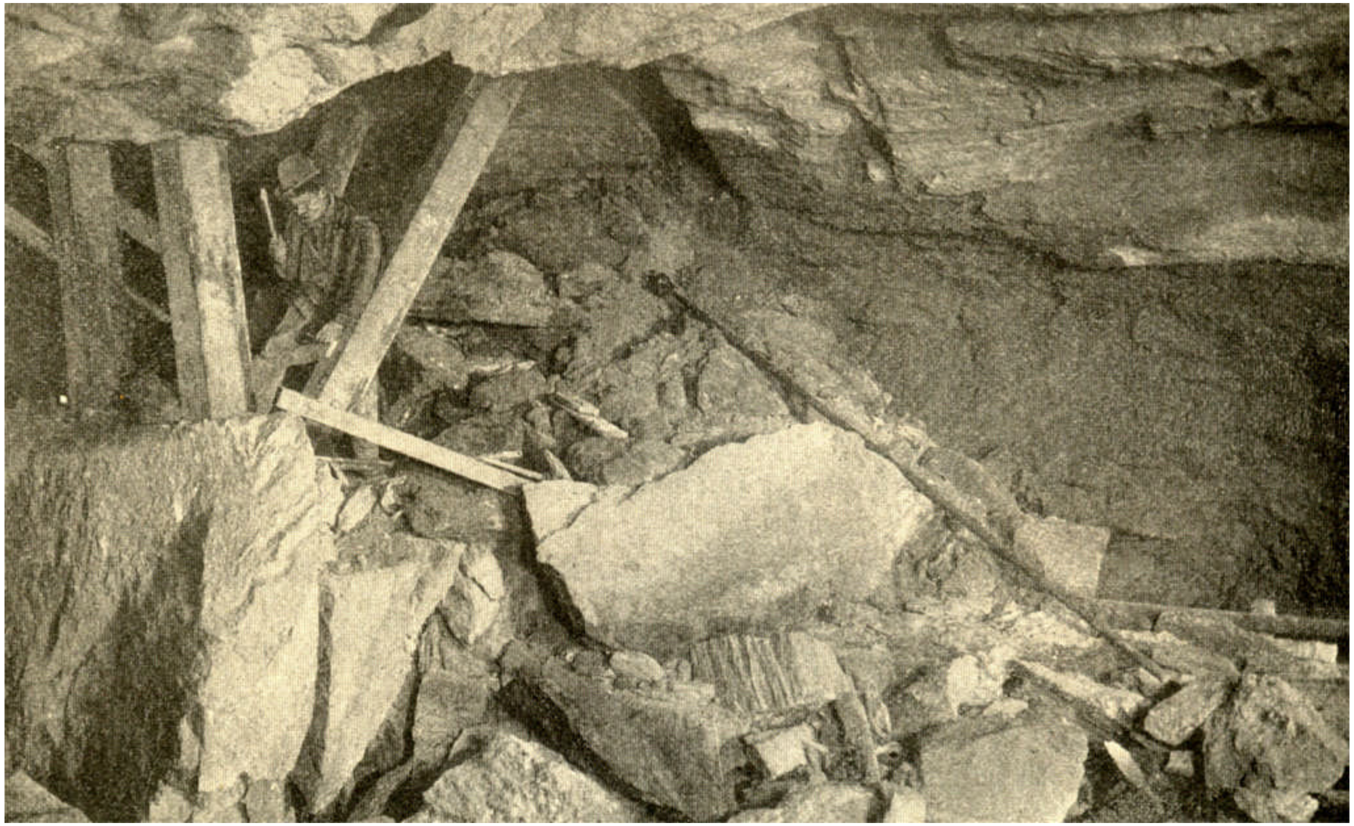
When the *Baltimore* firm of *McCabe Brothers* got into financial difficulties, their contract for Section/s 13 and 14; extending from *135th Street* and *Broadway* to *Hillside Avenue* (beyond *Fort George*), was taken over by the General Contractor (J.B. McDonald), but the actual work devolved upon their superintendent *Rufus P. Hunt*. Though only a salaried employee, Hunt won a solid reputation by his handling of the job. The bid of the McCabe Bros. was roughly $3 million and their work included the deep three-mile tunnel under *Washington Heights* (2.25 miles of which was entirely underground work and the balance; three-quarters of a mile, was open-cut work). He was also in charge of the *Jer-ome Park Reservoir* for McDonald.



<u>Top Left:</u> caption: "Deep tunnel at Broadway and 156th Street"
<u>Top Right</u>: caption: "Concrete-lined Three-Track Arch; 37.5 ft. Span"
<u>Left</u>: caption: "Concrete Lining, Double-Track Arch; 25 ft. Span"

"…On April 16 a contract was also awarded to the United Building Material Co. to supply 1,500,000 barrels of cement…the contract for supplying cement for this road is the largest ever undertaken by a single firm for a single engineering work. In round figures this contract calls for 1,500,000 barrels, or approximately 300,000 tons of cement. Of this total amount about 1,250,000 barrels will be Portland cement. The significance of these figures is perhaps best made plain by a few comparative statements. In 1896, or say five years ago, all the Portland cement works of the United States had an annual output of less than 1,000,000 barrels, and in 1886, or fifteen years ago, less Portland cement was consumed annually in the United States than will be used in this one piece of work…Altogether about 490,000 cu. yds. of concrete will be employed for this purpose. To make this concrete the cement must be mixed with from 2 to 2.5 times its bulk of sand, and from 4 to 6 times its bulk of broken stone…"

Engineering News and American Railway Journal, **May 24th 1900**



"…Contrary to the popular impression, the contract of the late Major Ira A. Shaler - the deep tunnel from Fourth Avenue and Thirty-third Street to Park Avenue and Forty-first Street - turned out to be a profitable one. Major Shaler was killed by a falling boulder in the tunnel after a series or unfortunate accidents that entailed heavy losses. First there was a dynamite explosion, then the cave-in near Thirty-seventh Street. After the sub-contractor's death the work was carried on under the supervision of the general contracting company in the name of the Ira A. Shaler estate. The Belmont interests had to buy up a lot of property damaged by the cave-in, and there were other costly settlements, but despite this the company came through safely. The cave-in was due to a change in the plan by which the tunnel was made to run nearer to the foundations of buildings on the east side of Park Avenue…"

The New York Times, **November 6th 1904**

Above: caption: "Park Avenue, East Heading"

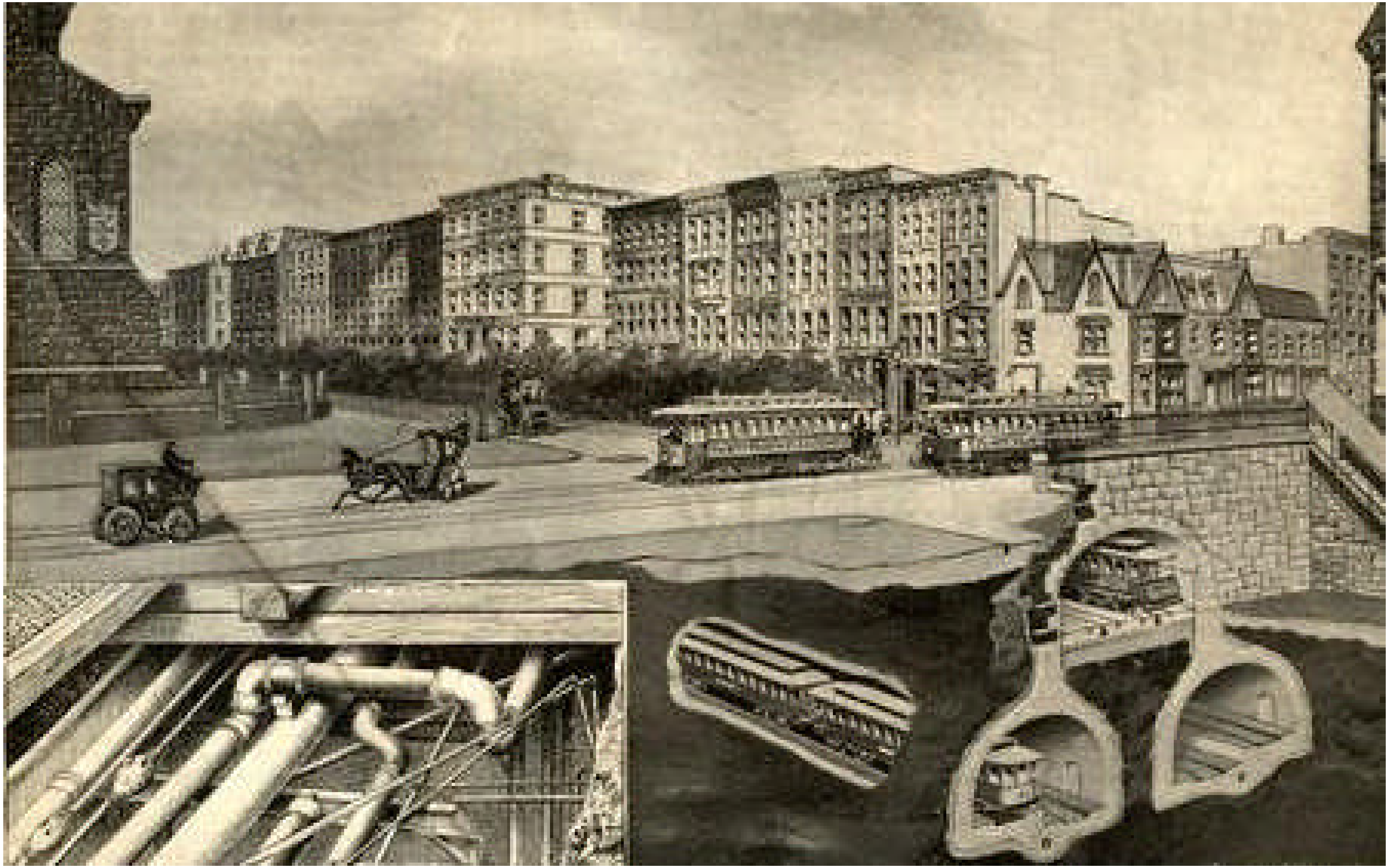
<u>Top Left</u>: caption: "View of 4th Avenue at 20th Street before groundbreaking for the IRT Subway, August 1900"

<u>Top Right</u>: caption: "View of 4th Avenue at 26th Street during construction of the IRT Subway, February 1902"

<u>Left</u>: Caption: "View of 4th Avenue at 23rd Street during construction of the IRT Subway, May 1903"

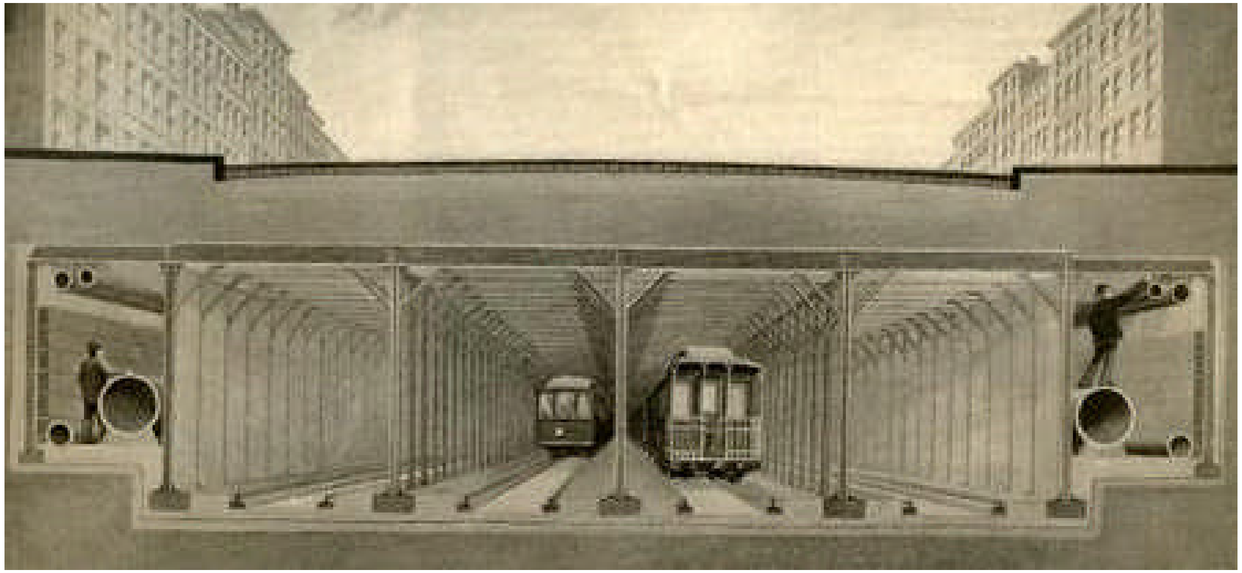
"…It was the intention of the Rapid Transit Engineers to provide special galleries on each side of the subway, and locate the water and gas and other mains within them. Provision was made for these galleries wherever it was possible to use them, and steel was ordered and considerable excavation done in Elm Street, at a cost of about $35,000. The galleries were abandoned, however, because of opposition encountered from the heads of the Sewer, Water and Gas Departments, who raised various objections of a more or less trifling nature. The Rapid Transit Commission, considering that it was its duty to build the tunnel rather than press the question of the pipe galleries to the point of becoming involved in legal complications and delays, decided to leave the question open for future consideration. While we do not dispute the wisdom of the policy pursued by the Commission, there is every argument to be used in favor of the construction of the pipe galleries simultaneously with the building of the tunnel. At present the pipes are merely suspended from falsework during the construction of the subway, and after a section is roofed the soil is filled in around the pipes, leaving them in the unsatisfactory condition which necessitates pulling up the roadway whenever repairs or changes are to be made…"

Scientific American, **May 25th 1901**



<u>Above</u>: caption: "Sectional View at Thirty-fourth Street and Park Avenue, Showing Eight Tracks at Three Different Levels. (Inset at lower left) Antiquated method of laying pipes at present adopted. View at 19th St. and Fourth Avenue."

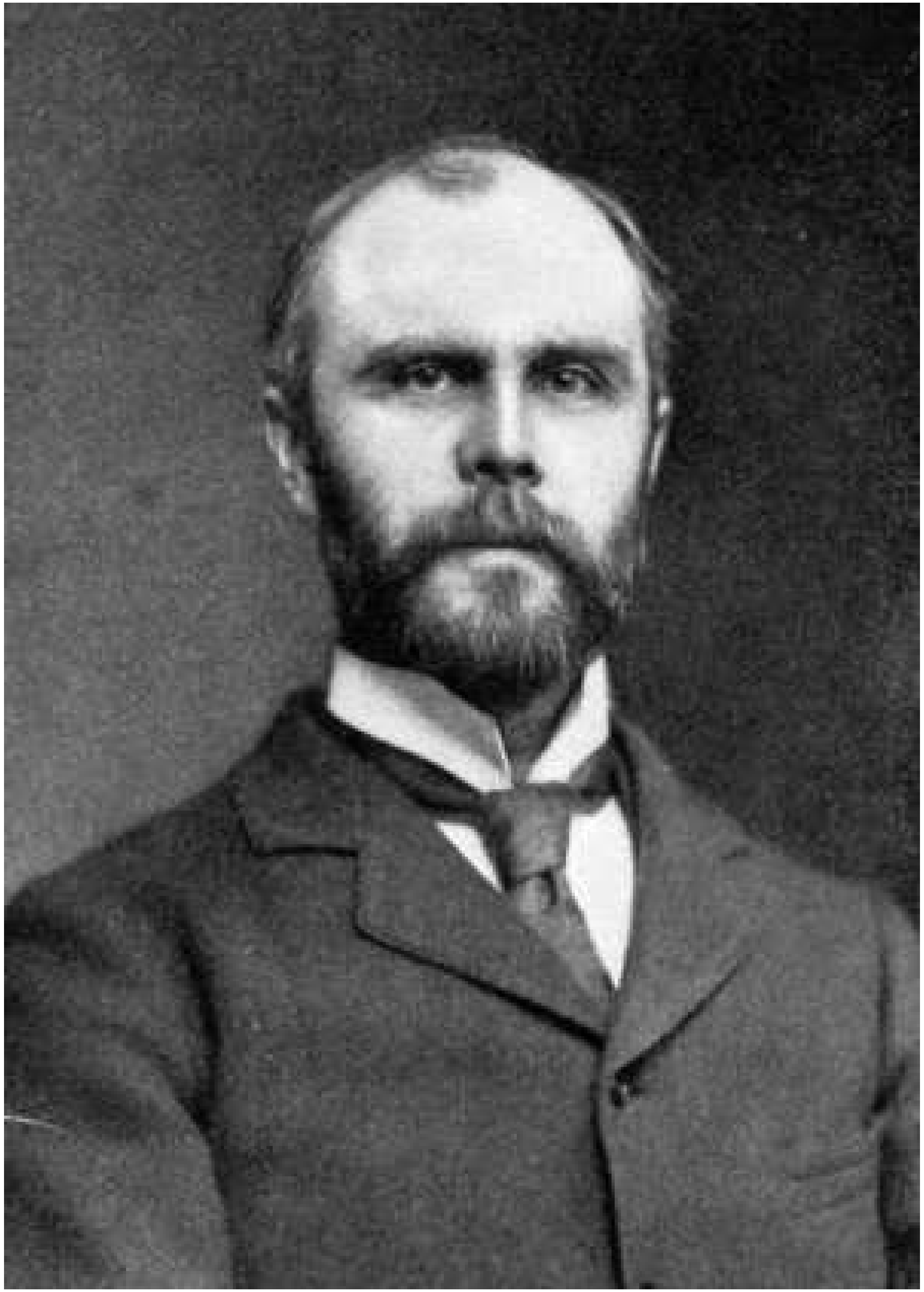
***Scientific American*, May 25th 1901**



"…We present a typical section of the tunnel as it was proposed to construct it, with the two galleries adjacent to the tunnel and separated from it by steel and concrete walls. The larger pipes, such as the water and gas mains, would be carried on the floor of the tunnel, while all other pipes, such as those for compressed air, steam, etc., might be suspended from the roof or carried on brackets extending from the side walls. The galleries would be entered by manholes, or other suitable means of communication. and pipes could be repaired, renewed or inspected without any disturbance of the surface of the street. The construction of the rapid transit subway afforded an opportunity for making proper provision for the mass of electric cables and gas and water pipes, which lie beneath the streets of the city, and are the cause of endless annoyance in the way of excavations for repairs and relaying. The opportunity to build along one or both sides of the subway special galleries to contain these pipes appealed at once to the engineers in charge of the scheme…It is to be regretted that the pipe galleries have been abandoned, chiefly, it would seem, as the result of pressure of a semi-political nature brought to bear upon the Railroad Commission…"

***Scientific American*, May 25th 1901**

Above: caption: "Typical section through the Subway, showing the Pipe Galleries as they should be constructed"



The contract (which covered about two-hundred pages) was minute in detail as to the work to be done and gave sweeping powers of super-vision to the city through the *Chief Engineer of the Rapid Transit Board* (RTB) who, by contract, was made arbiter of all questions, conflicts etc. that might arise as to the inter-pretation of the plans and/or spec-ifications. The city was fortunate in securing for the preparation of plans the services of *William Barclay Parsons* (left), one of the foremost engineers in the country. For years as Chief Engineer of the RTB, he had studied and developed the various plans and it would be Parsons who would tirelessly superintend, on behalf of the city, the work to completion.

"I was thirty-five years of age when I became Chief Engineer of the Rapid Transit Commission. When I look back now I am glad I was not older. I doubt if I could now undertake or would undertake such a work under similar conditions. But I had the enthusiasm of youth and inexperience. Had I fully realized all that was ahead of me, I do not think I could have attempted the work. As it was I was treated as a visionary. Some of my friends spoke pityingly of my wasting time on what they considered a dream. They said I could go ahead making plans, but never could build a practical, underground railroad. This skepticism was so prevalent that it seriously handicapped the work."

William Barclay Parsons

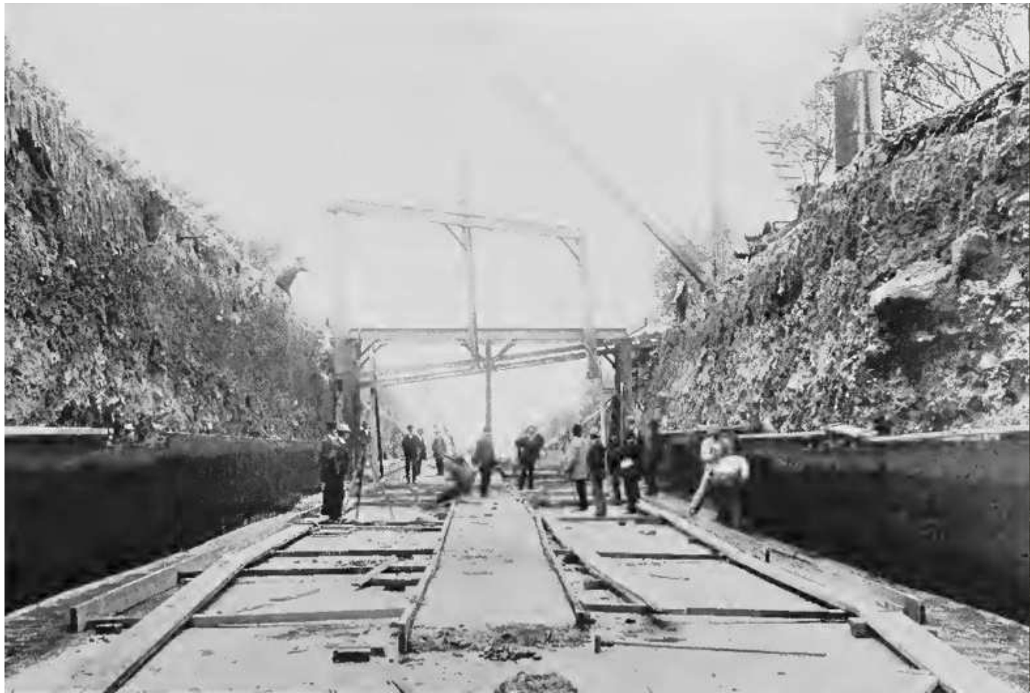
RE: excerpt from comments made in July 1913. On December 1st 1904, Parsons resigned as Chief Engineer of the RTB. The great work which he had mentored was nearly finished - the greater part of it in successful operation, and he sought to resume private practice in his profession. Later he became consulting engineer for the *Interborough Rapid Transit Company* (IRTC). The first New York subway stands as a monument to his skill, courage and foresight as an engineer.

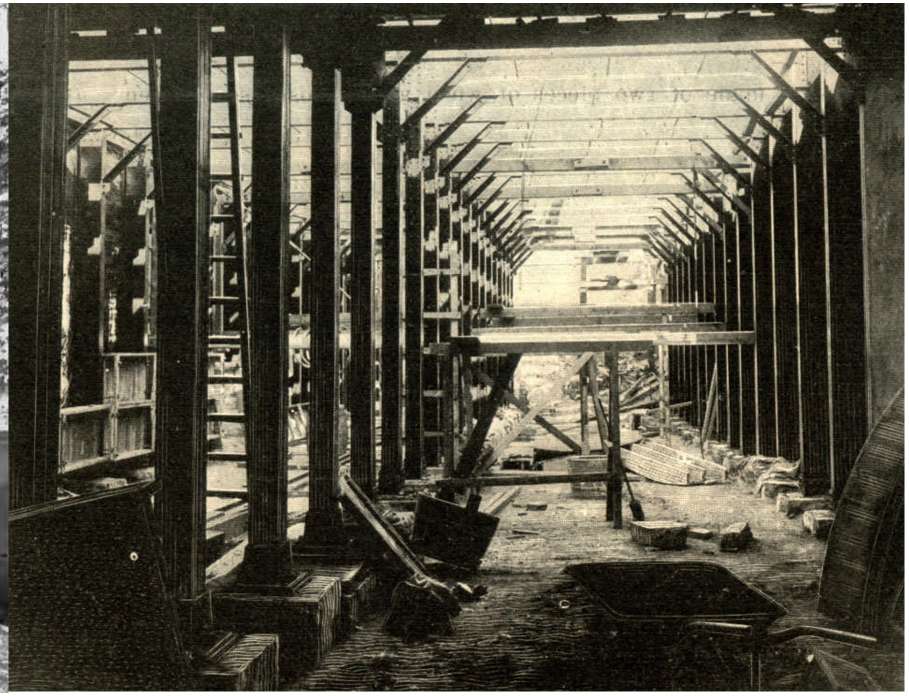
"…From the very first it has been the policy of the engineers of the road to make it a sine qua non, that the rapid transit road must be essentially a high-speed system, which will not merely possess an enormous carrying capacity, but will also transport passengers at a speed that has never been approached by any other road on the island. From the present terminus at City Hall Park, express trains are to be dispatched during the rush hours at two minutes' intervals. They will make stops at Fourteenth, Forty-second, Seventy-second, Ninety-sixth Streets, and the whole run to One Hundred and Fifty-seventh Street will be made in 16.5 minutes…The average running speed of the Rapid Transit express trains, including stops, will be 38 miles per hour; and this means that, at times, the speed will rise to 50 miles an hour, and occasionally over that. The local trains will have an average speed of 18 miles per hour, which is about 50 per cent greater than that of the present local trains on the Manhattan elevated roads. The express stations will be located at intervals of a little less than two miles, while the local stations will average about four to the mile. At one time the question of increasing the number of express stations was mooted; but the Rapid Transit Commission, by advice of its engineers, wisely decided that, since the system was to provide, primarily, an express service, it would defeat the end in view to multiply the stops. It was further urged that the high speed of 18 miles per hour of the local service rendered it unnecessary to multiply the express stations, the passenger being able to quickly cover the distance between the express stations and his own particular stopping-place, by the fast local service. That an average speed of 18 miles per hour can be maintained with stations only a quarter of a mile apart is due to the rapid acceleration which is possible by electric traction…"

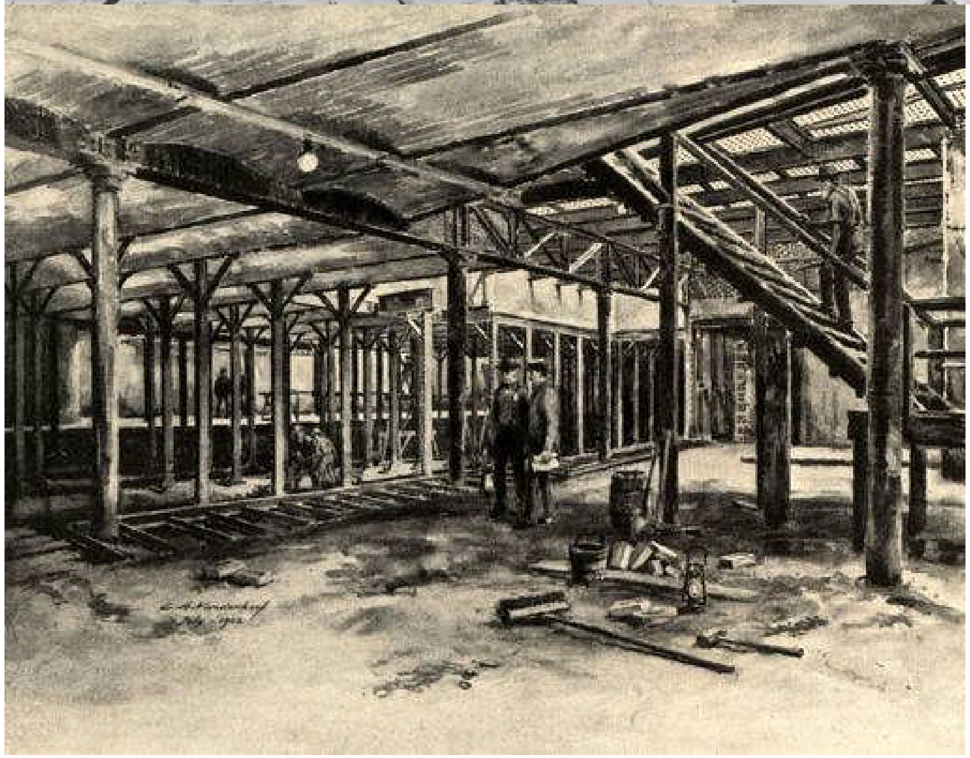
***Scientific American*, May 25th 1901**

"…Another marked characteristic of the Rapid Transit Subway, as distinguished from most other underground railroads, is that the principles of the modern skyscraper are applied in its construction, the roof and sides being supported by steel frames composed of transverse steel beams and light steel columns. With a cement floor and the sides and roof made waterproof and even damp-proof, and then lined with cement, the interior of the tube when completed will, as a matter of fact, look like solid whitewashed stone, but, as in the case of the sheathing of the skyscraper, this will be only a shell. The elimination of grade-crossings and the insertion of "islands" between the tracks at the various express stations, so that by the means of raised passages passengers may transfer from local to express trains, and vice versa, at will, are other noticeable features of the design. It is by such a scheme that the engineers hope to attain a maximum of speed and carrying capacity. Neither the plan nor the carrying of it out in steel and blasted rock could be spectacular. It is rather a task requiring vast patience and the ability to simplify a mass of intricate details…"

***Century Magazine,* October 1902**







<u>Top Left</u>: caption: "First Erection of Steel Frame, Broadway at 185th Street"

<u>Top Right</u>: caption: "Interior view, showing steel framing before concreting"

<u>Left</u>: caption: "Station at Columbus Circle, in course of construction. The steel work is here shown in place, and the concrete roof, floor, and walls are finished. The walls are not yet faced with glazed tiles, and the station work is unfinished"

Enter Mr. Belmont

When the bid was accepted by the city, no arrangements had been made for the capital necessary to carry out the contract. After its acceptance, McDonald not only found little encouragement in his efforts to secure the capital, but discovered also that the surety companies were unwilling to furnish the security required of him except on terms impossible for him to fulfill. It was obvious when the surety companies declined the issue that the whole rapid transit problem was thrown open. After all, the attitude of the surety companies was, in reality, a reflection of the general feeling of business and railroad men towards the venture. During the thirty-two years of rapid transit discussion (between 1868 and 1900), every scheme for rapid transit had failed because responsible financiers could not be found bold enough to take the project on. The scheme finally adopted had put all of the risk upon private capital and left none upon the city while the success of the undertaking depended almost entirely upon the financial backing of the contractor. The requirements of the RTA were rigid and forbade any solution of the problem which committed the city to share in the risks of the undertaking. The crucial point in the whole problem of rapid transit which NYC had struggled for so many years had been reached. Failure appeared inevitable.

"Circumstances have made it necessary for me to apply to your honorable body for a further extension of time in which to furnish the securities required by the contract to construct and operate the rapid transit railroad. When I made my bid I had what I believed to be satisfactory assurances that they (the three surety companies named in the bid) would go on my bond in case the contract was awarded to me. But when, after the award, I renewed my application to them, I found them disposed to impose conditions which were unexpected and much more onerous than I had anticipated when I named them as sureties in my proposal. Negotiations lasting over ten days resulted in the statement of the companies of requirements which I deemed unreasonable, and with which, on short notice, I was not prepared to comply. They were finally unwilling to execute the sureties unless cash or its equivalent representing the full amount of their bonds was practically set apart for them. On the 31st I notified the companies that it was useless to continue negotiations on those lines, and since that time I have been planning to substitute other sureties in their place and stead. I feel reasonably certain of providing such substitutes within a reasonable time, providing that the commission will grant me a further extension…"

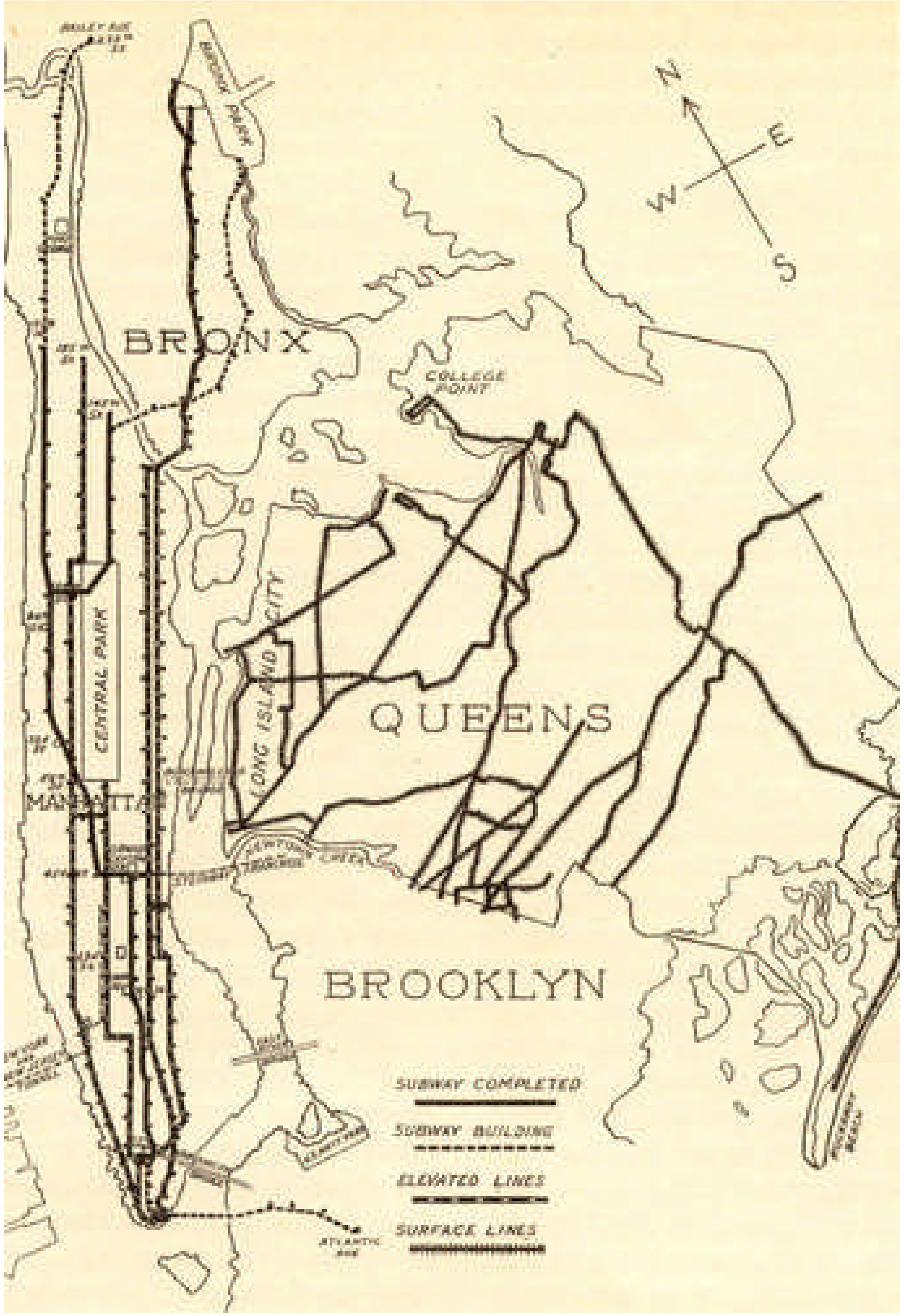
John B. McDonald

Engineering News and American Railway Journal, **February 8th 1900**

It was at this critical point that McDonald sought the assistance of *August Belmont, Jr.* There was no time for indecision or delay. The necessary capital had to be found, the required security given and an organization for building and operating the railroad established. Belmont, looking through and beyond the intricacies of the RTA and the complications of the contract, saw that he who undertook to surmount the difficulties presented by the attitude of the surety companies would solve the entire problem. He quickly realized that the responsibility for the entire undertaking must be centralized in one person with an efficient organization in-place to back him up. Belmont took the matter up directly with the *Board of Rapid Transit Railroad Commissioners* and presented a plan for the incorporation of a company to acquire the security required for the performance of the contract, to furnish the capital necessary to carry out the work and to assume supervision over the whole undertaking. Application was made to the *NYS Supreme Court* to modify the requirements with respect to the sureties and the new corporation was to execute as surety a bond for $4 million, the additional amount of $1million to be furnished by other sureties. This additional amount (in cash or securities) was to be deposited with the city as further security for the performance of the contract. The plan was approved by the board and, pursuant to the plan, the *Rapid Transit Subway Construction Company* (RTSCC) was organized. The NYS Supreme Court granted the application to modify the requirements and the contract was executed on February 21st 1900. As president and active executive head of the RTSCC, Mr. Belmont perfected its organization, collected the staff of engineers under whose direction the work was to be done, supervised the letting of sub-contracts and completed the financial arrangements for carrying out the work.

"New York underground rapid transit railway matters have reached a more settled condition since our last issue was published. Under the arrangement agreed to by the Rapid Transit Commission, respecting the securities required of the successful contractor, Mr. John B. McDonald, August Belmont & Co., proposes: To organize a corporation with a capital of $6,000,000; to secure deposit of 20% of this capital on organization, 20% on May 1, 20% on Nov. 1, and the balance as called; to enter into contract with Mr. McDonald to promote the construction of the tunnel road; to accept the proposal of the board to secure from the Appellate Division a modification of the requirements by striking out the provision requiring construction sureties to qualify in double the amount of liability, and by reducing the minimum amount to be taken by each surety from $500,000 to $250,000; to arrange that Mr. McDonald is to furnish the $1,000,000 continuing bond with sureties who will justify in double that amount; to await the passage of an act of the legislature amending the rapid transit act by permitting the deposit of securities satisfactory to the board and of the value of $1,000,000 in lieu of the continuing bond; to execute as surety Mr. McDonald's bond to secure the performance of the contract for construction to the amount of $4,000,000, which will be accepted by the board; to cause the $1,000,000 cash required by the contract to be deposited with the Comptroller; and, as additional security to the city, to cause the beneficial interest in the bonds to be required of sub-contractors to be assigned to the city so far as may be necessary. Summarized, therefore, the city will have in hand at once in cash and securities for the execution of the contract $8,000,000 instead of the $7,000,000 required under the call for bids…"

Engineering News and American Railway Journal, **February 15th 1900**



"…The people do not realize what this Belmont monopoly has already come to be. It is not only the greatest combination of street-car interests New York ever had, but it promises to be the most piratical. The aim of Belmont - and the European Rothschilds behind him - is complete monopoly. Already he controls the Subway and all the elevated railroads in Manhattan, he owns the surface-car lines in Long Island City, and he has just acquired the old perpetual franchise of the Steinway Tunnel Company, which enables him to build another tunnel to Brooklyn; and he is on the way to obtain other important rights…It is to be noted, also, that large profits are accruing to Belmont from advertising privileges in the Subway, and that there are also provisions in the contract for a freight and express service and even a parlor car service in the Subway "

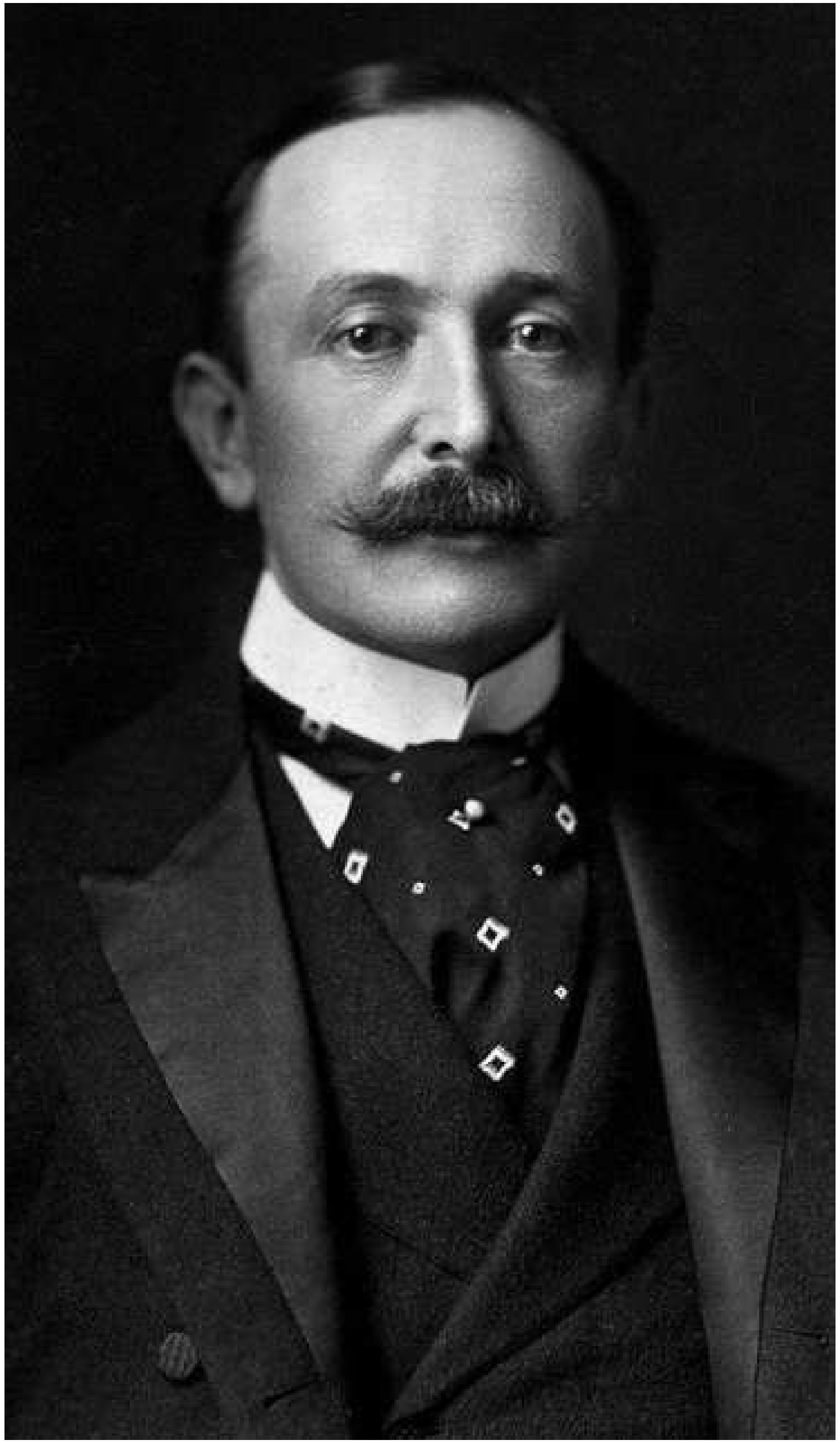
McClure's **magazine, March 1905**

Left: caption: "Giant Proportions of the New Belmont Monopoly. The diagram shows the number of street-railway lines already controlled by August Belmont."

"The New York Underground Rapid Transit Railway was formally placed under construction on March 24 and actual construction was begun by one of the sub-contractors on March 26. The formal opening of the work on March 24 consisted in the digging of the first shovelful of earth by Mayor Robert A. Van Wyck, the fixing of a memorial tablet to mark the spot and the reading of speeches by the Mayor and Mr. Alex. E. Orr, President of the Rapid Transit Commission. Actual work was begun on March 26…"

Engineering News and American Railway Journal, **March 29th 1900**

Above: caption: "Bronze Tablet commemorating Beginning of Construction"



Under the terms of the contract, "Equipment" included: rolling stock, all machinery and mechanisms for generating electricity for motive power, lighting and signaling, the Power House, sub-stations and the real estate upon which they were to be erected. Belmont saw from the beginning the importance of providing this equipment and early in 1900 (immediately after the signing of the contract) turned his attention to selecting the best engineering experts and began planning the organization of an operating company.

Left: ***August Belmont, Jr.***

“…Of course, the Subway is nominally owned by the city…At the end of fifty or seventy-five years, when our great-grandchildren get control of the Subway, the Belmont corporation, protected by a cast-iron contract that gives them an unregulatable five-cent fare, will have paid untold millions in profits. In Boston, the city not only built the subway, but kept control of it. And Boston found a subway easy to build and to lease on these terms. But the commissioners claim that under the circumstances which existed at the time the contract was signed - a combination of Van Wyck and post-panic times - they made the best terms possible to get a subway...”

***McClure’s Magazine*, March 1905**

Interborough Rapid Transit Company

In the spring of 1902, the ***Interborough Rapid Transit Company*** - the operating railroad corporation, was formed by ***August Belmont, Jr.*** (he became president and active executive head of the company). Soon thereafter, McDonald assigned to it the lease (operating part of his contract with the city) such that the IRTC became directly responsible to the city for the equipment and operation of the IRT Subway while McDonald remained as contractor for its construction. In the summer of 1902, the ***Board of Rapid Transit Railroad Commissioners,*** having adopted a route and plans for an extension of the subway under the ***East River*** to the ***Borough of Brooklyn***, the ***Rapid Transit Subway Construction Company*** (RTSCC) entered into a contract with the city (similar in form to McDonald's contract) to build, equip and operate the ***Brooklyn Extension***. ***John B. McDonald***, as contractor of the RTSCC, assumed the general supervision of the work of constructing the extension; and the construction work of both the original subway and the extension was carried out under his direction. In January 1903, the IRTC acquired the elevated railway system by lease for 999 years from the ***Manhattan Railway Company***, thus assuring harmonious operation of the elevated roads and the subway system, including the Brooklyn Extension.

<u>Above</u>: caption: "A Three-Deck Street-Railway Crossroads. Three layers of street-railways are shuffled together at Fourth Avenue and Thirty-Fourth Street, New York. The picture, looking uptown, cuts away the street-paving at Thirty-third Street, exposing the Subway underneath. It shows on top (crossing the picture) a car of the Thirty-fourth Street crosstown line; in the middle, a car of the Fourth Avenue surface line, the tracks of which disappear into the tunnel at the steep Thirty-fourth Street hill; underneath all, the Subway. A downtown express is passing; the express tracks (in the middle) are sunken here, since expresses do not stop at Thirty-third Street. A downtown local is pulling up at the platform."

***McClure's Magazine*, March 1905**

<u>Above</u>: caption: "Photograph depicting the junction of the Second and Third Avenue Elevated ("EL") line/s at Chatham Square in Manhattan (when the trains were still hauled by small steam locomotives)."

"That the enterprise in its results has been conspicuously successful, should be the subject of cordial congratulations by all citizens…At a time when there are so many ill-digested and ill-considered plans under discussion, having for their object not only municipal ownership, but municipal operation of transportation lines, the State of New York has reached the true solution of this problem - that municipal participation is justified to the extent of furnishing credit for the construction of such a work, but should stop short of the operation of the property when constructed. To private interests should be committed the risks and the burden as well as the profit of constructing, equipping and operating the road, the latter not being within the governmental functions or other legitimate province of a municipality."

August Belmont, Jr.

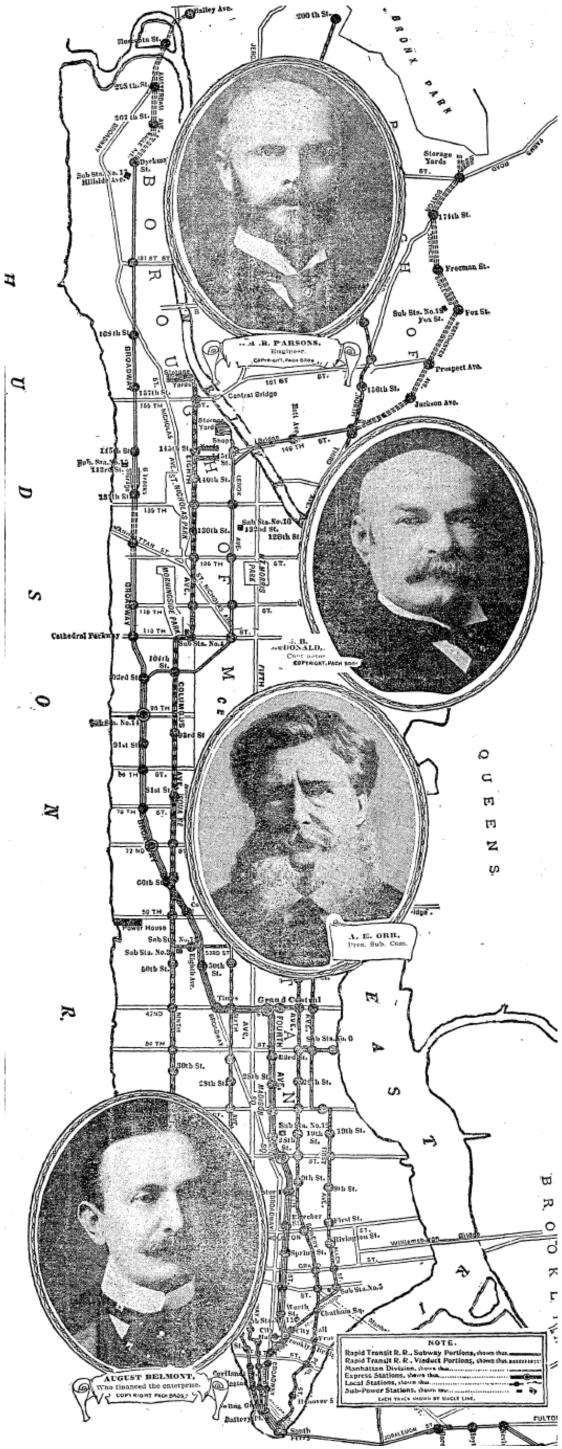
RE: excerpt from his IRT Subway dedication speech; October 27th 1904

Interborough Communication

"Without rapid transit Greater New York would be little more than a geographical expression, It is no exaggeration to say that without interborough communication Greater New York would never have come into being…When the Brooklyn Bridge was opened Greater New York was born. Every addition to transit facilities has stimulated her growth, which can only reach its full development when a complete system of rapid transit shall be rapid in fact as well as in name…If this new underground railroad which we are about to open proves as popular and as successful as I confidently expect it to be it will be only the first of many more which must ultimately result in giving us an almost perfect system of Interborough communication…"

George B. McClellan, Jr., **Mayor of the** ***City of New York***

RE: excerpt from his October 27th 1904 IRT Subway opening ceremony speech



"…There is enough credit in the completion of such an undertaking to go around. To the Rapid Transit Commissioners for their part in evolving a plan; to the legislative and executive departments of this municipality, which urged, and to the members of the Legislature of the State of New York and to its Executive, who made possible the enactment of the requisite laws; to Mr. Parsons, who was responsible for the preparation of the engineering plans; to Mr. McDonald, who was the successful bidder for the contract…as well as to the financial interests involved, should be awarded their fair and redistributive shares of praise and credit for the courage, patience, industry, and intelligence that unitedly have carried this work to completion…"

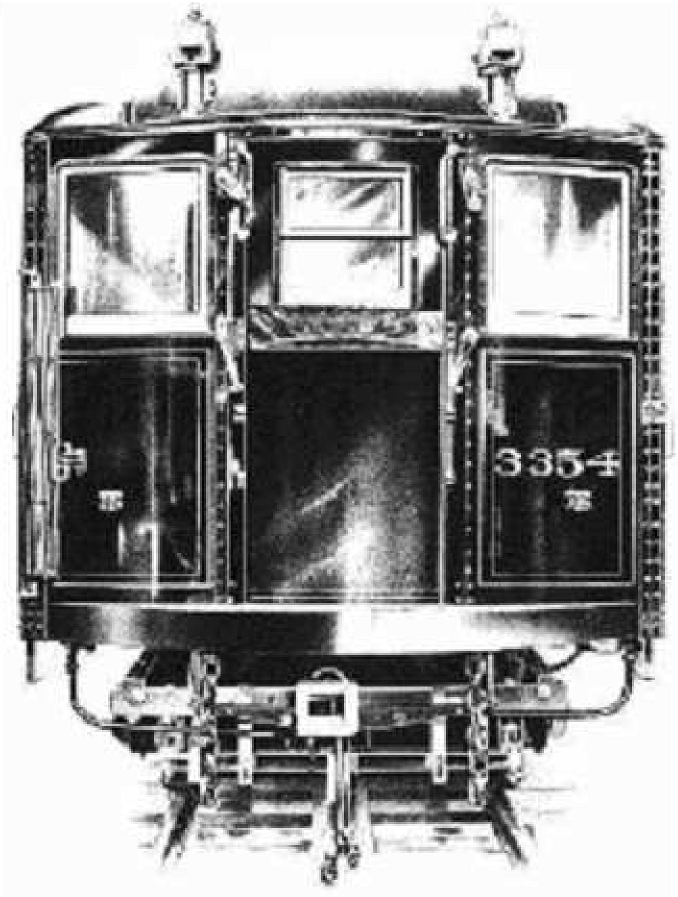
August Belmont, Jr.

RE: excerpt from his October 27th 1904 IRT opening ceremony speech

<u>Left</u>: map of the IRT Subway with photographs (top to bottom) of Parsons, McDonald, Orr and Belmont

"Controller used by the Hon. George B. McClellan, Mayor of the City of New York, in starting the first train on the Rapid Transit Railroad from the City Hall station, New York, Thursday, Oct. 27, 1904. Presented to the Hon. George B. McClellan by August Belmont, President of the Interborough Rapid Transit Company."

RE: inscription on controller handle (left) used by Mayor McClellan who served as motorman (with assistance) of the first IRT Subway train starting from *City Hall* station all the way to *103rd Street,* October 27th 1904



"The story of the travail of a modern city in bringing forth a great public work: how the will of the people, opposed by the street-car mon-opolies, deflected through the Political Boss, ineffectively enforced by the Rapid Transit Commission, blunted by its own dumbness, finally found expression in a great work..."

***McClure's Magazine*, March 1905**

Part 2

The Elm Street Route

On the Basis of a Single Fare

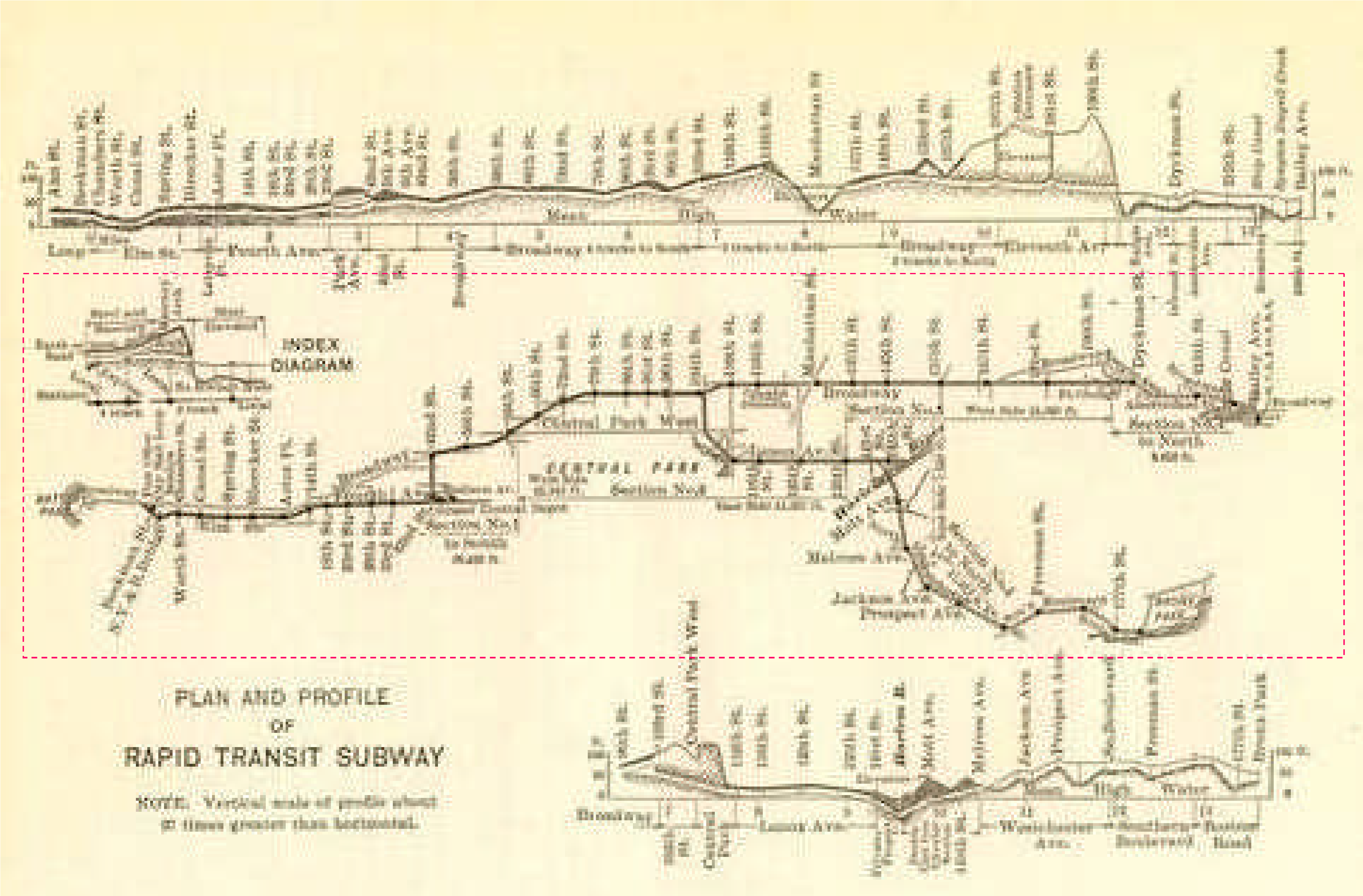
“…the great traffic problem which confronts the city is how to provide more adequate means of communication for the portion of Manhattan Island which lies south of 125th Street, where over eighty per cent of the combined population of the Boroughs of Manhattan and the Bronx reside…Your Commission has wisely recognized in all of its plans that the great majority of the population of New York who daily travel to and fro between their homes and their places of business can afford but a single fare for each trip, and that the best rapid transit system is the one which provides for a single fare advantageous routes for the greatest number of people…The inadequacy of the present service upon the surface lines is due largely to the fact that they are now compelled both to carry people long distances and to distribute them in the same surface cars. This would be remedied by a system under which people could be carried for long distances by underground routes, and distributed by the surface cars, without any increased charge to the passenger. You most aptly described the line best calculated to meet this situation when in your statement to the Rapid Transit Commission on December 17th, 1903, you suggested ‘a north and south line extending at least as far north as the Harlem River . . . and assuring an extensive system of transfers on the basis of a single fare…’”

RE: excerpt from a letter from *Thomas F. Ryan* to *Alexander E. Orr*, President of the RTC, February 25th 1904

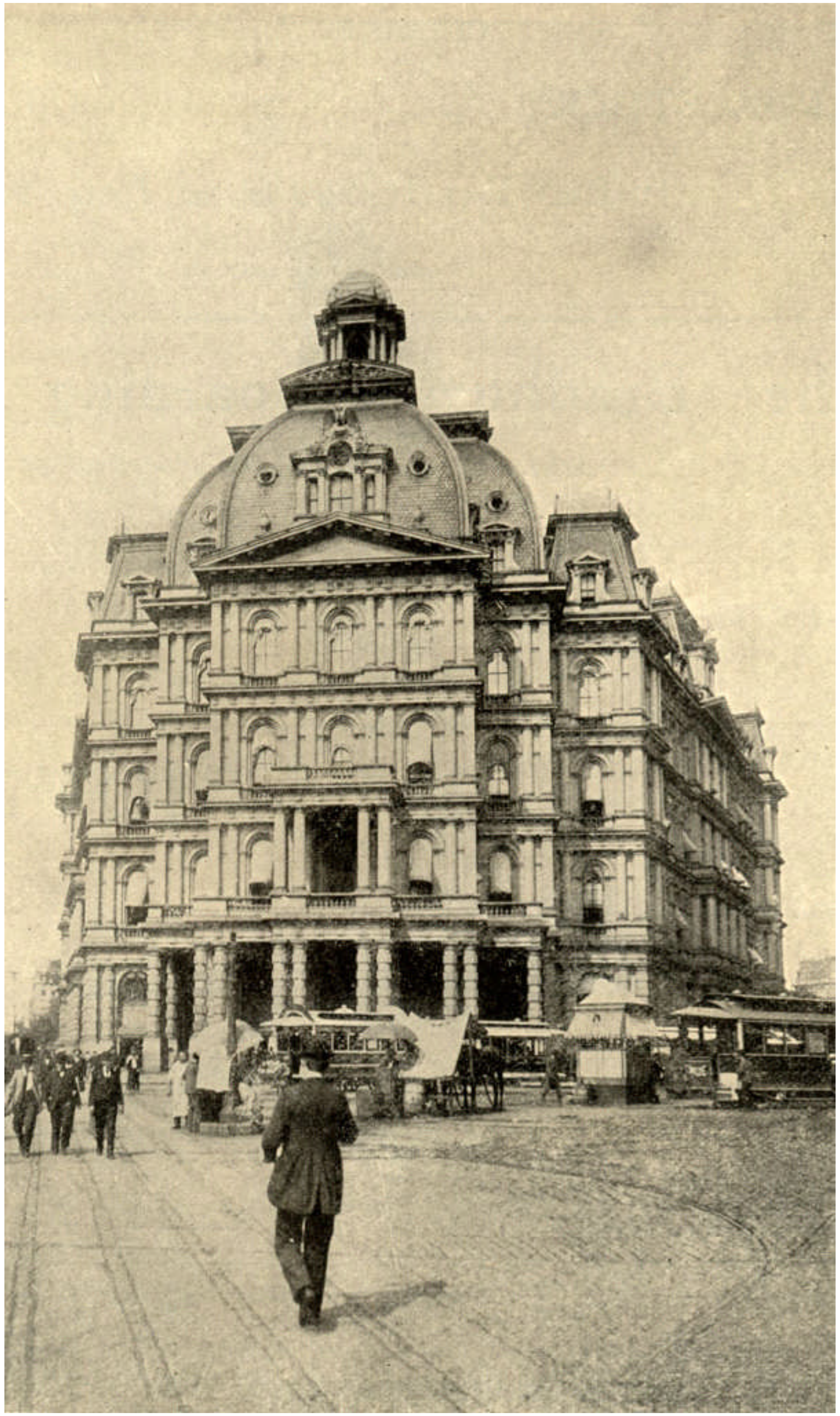
The Letter “Y”

"…If you imagine an enormous capital letter Y, with its base resting at the City Hall Park, and the top of the main stem at One Hundred and Fourth Street; with its right prong ending at Bronx Park, and its left prong ending at Kingsbridge, you will have a rough outline picture of the route of the new road. The whole system will extend over twenty one linear miles on Manhattan Island and in the Bronx. What we will call the main line, from City Hall to One Hundred and Fourth Street, is about seven miles long, and each of the branches is of about the same length. In the far northern part of the city, where the lines cross valleys and low ground, the tracks will be carried on viaducts in the open air - an improved plan of elevated railroad structure. A little more than fourteen miles of the road will lie underground, and it is this part of the work; of course, which has given rise to practically all the problems. The road will be four tracked as far as One Hundred and Fourth Street, the outer tracks devoted to way trains and the inner ones to express trains. The express and way trains will continue to the eastern and western ends of the road, but with only two tracks on each branch…"

John B. McDonald, **1902**



<u>Above</u>: caption: "Plan and profile of Rapid Transit Subway"

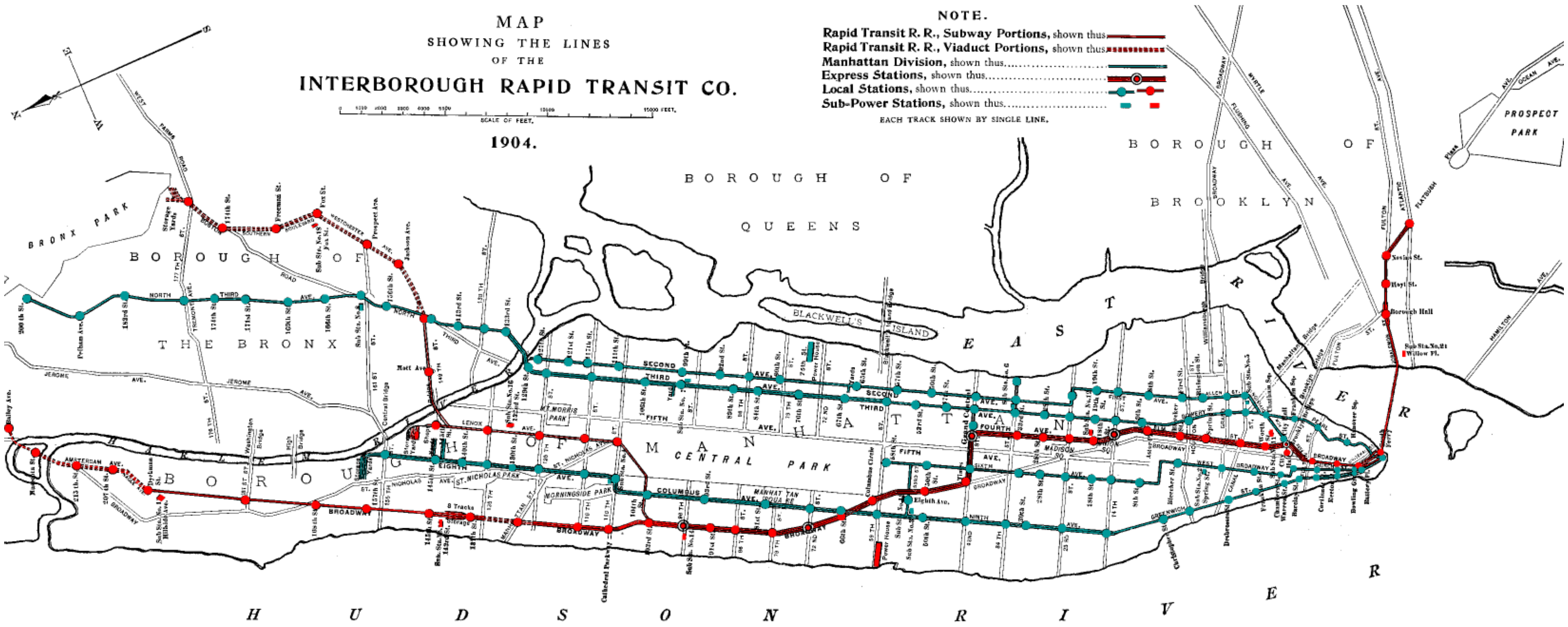


The selection of route for the IRT Subway was governed largely by the amount which the city was authorized by the RTA to spend. The main object was to carry to and from their homes in the upper portions of *Manhattan Island* the army of workers who spent their day in the offices, shops and warehouses of the lower portions. Thus, it was obvious that the general direction of the route/s must be north-south and that the line must extend, as nearly as possible, from one end of the island to the other. The route proposed by the *Rapid Transit Board* in 1895 (after municipal ownership had been approved by the voters in the fall election of 1894) extended from the *Battery* to *185th Street* on the west-side and to *146th Street* on the east-side of Manhattan. This plan was rejected by the *NYS Supreme Court* because of the anticipated cost of running the line under *Broadway*. It was also suggested by the court that the Subway should extend further north. To conform as nearly as possible to the views of the court, the RTC proposed (in 1897) the so-called "Elm Street Route." The plan finally adopted, which reached from the area near the *General Post-office*, *City Hall* and *Brooklyn Bridge Terminal* to *Kingsbridge* (in the *Bronx*) and the station of the *New York & Putnam Railroad* on the *Western Branch* and to *Bronx Park* on the *Eastern Branch* while interfacing with *Grand Central Station* at *42nd Street*. Subsequently, by the adoption of the *Brooklyn Extension*, the line was extended down Broadway to the southern extreme of Manhattan, under the *East River* to *Brooklyn*.

<u>Left</u>: caption: "View of General Post Office south of City Hall, Park Row & Broadway"

"…The rapid transit commissioners first made careful surveys, and a most exhaustive search of all the city maps, plans, and records, in order to select the route which would best serve the public, and along which the fewest obstacles would be encountered. They selected the City Hall Park as the ideal starting point, and Elm Street, Lafayette Place, and Fourth Avenue as the easiest route north. At Forty Second Street the line curves westward, cutting under the building on the corner, which happens to be a drug store. It runs west to Broadway, along which it continues to One Hundred and Fourth Street. Thence the western branch goes by tunnel and elevated viaduct along Broadway and Eleventh Avenue to Kingsbridge. The eastern branch runs under half a mile of Central Park and along Lenox Avenue, dives under the Harlem River, and thence proceeds along Westchester Avenue and the Southern Boulevard to the Bronx Park…"

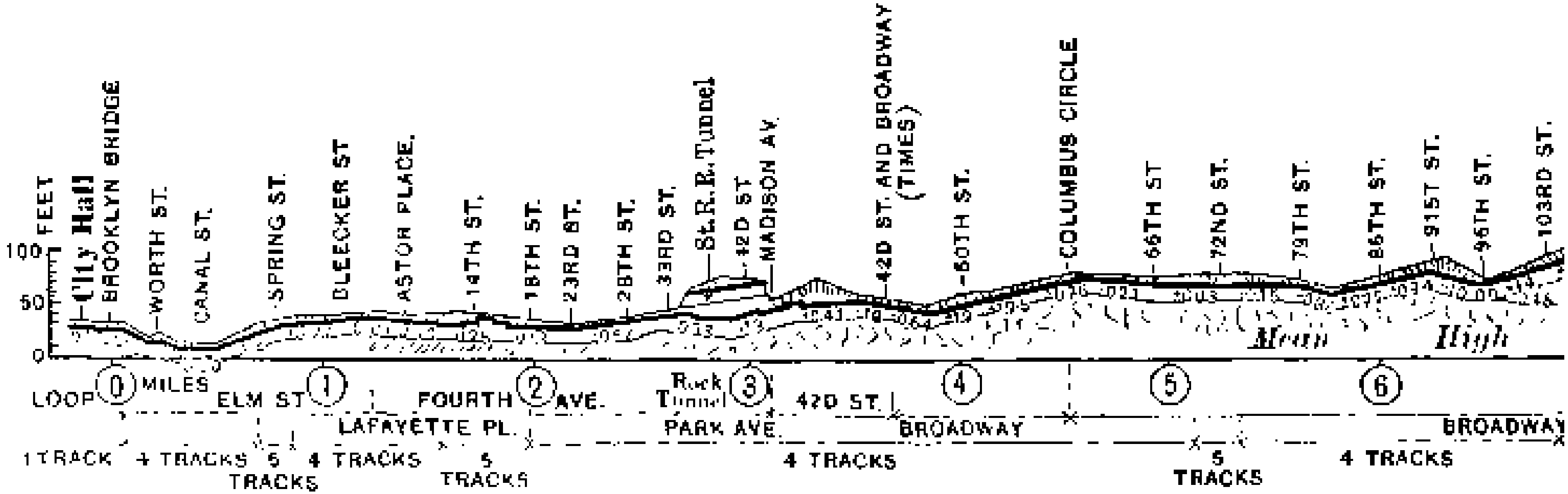
***John B. McDonald*, 1902**



"…This Rapid Transit Subway, to give it its official name, is an underground railway running along the backbone of the narrow island of Manhattan, and, as now being built, extending on into the borough of the Bronx: From its southern terminus to the branch at One Hundred and Fourth street it will consist of four tracks, the outer two of which will be used for local trains, the inner two for expresses. From One Hundred and Fourth street, which is seven miles from the southern terminus, the main line with three tracks, of which the middle one will be used for express-trains, continues northward seven miles more to Kingsbridge, while a branch line of two tracks will swing off to the right, pass under the Harlem River at Bronx Avenue and One Hundred and Forty-fifth street, and thence on to Bronx Park and the Zoo, also a distance of seven miles. The local trains will be run at an average speed of fourteen miles an hour, stopping at stations one quarter of a mile apart, just about as the present elevated trains are operated; while the express-trains will have stations only about every mile and a half and be capable of attaining a speed of at least thirty miles an hour…" 100

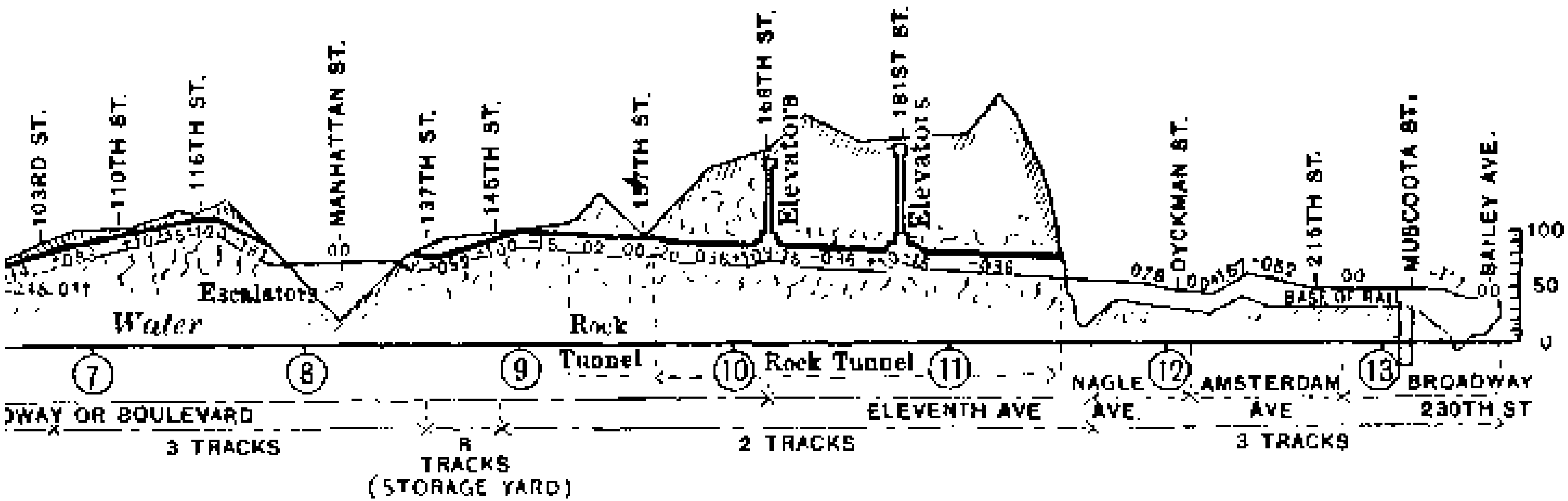
***Century Magazine*, October 1902**

The Main Line



Beginning near the intersection of *Broadway* and *Park Row*, the "Easterly" route of the IRT Subway extended under *Park Row, Center Street, New Elm Street, Elm Street, Lafayette Place, Fourth Avenue* (beginning at *Astor Place*), *Park Avenue, 42nd Street* (and *Broadway*) to *125th Street* where it passed over Broadway by viaduct to *133rd Street* then under Broadway again to and under *Eleventh Avenue* to *Fort George* where it came to the surface again at *Dyckman Street* and continued by viaduct over *Naegle Avenue*, *Amsterdam Avenue* (and Broadway) to *Bailey Avenue*, at the *Kingsbridge* station of the *New York & Putnam Railroad*, crossing the *Harlem River Ship Canal* on a double-deck drawbridge. The length of this route was 13.5 miles of which about two miles were on viaduct. The stations began at the base of the Y and followed the route up (north) to the fork at *103rd Street* and Broadway (a.k.a. "Main Line"). From *Borough Hall Manhattan* to the 96th Street station, the line was four-track.

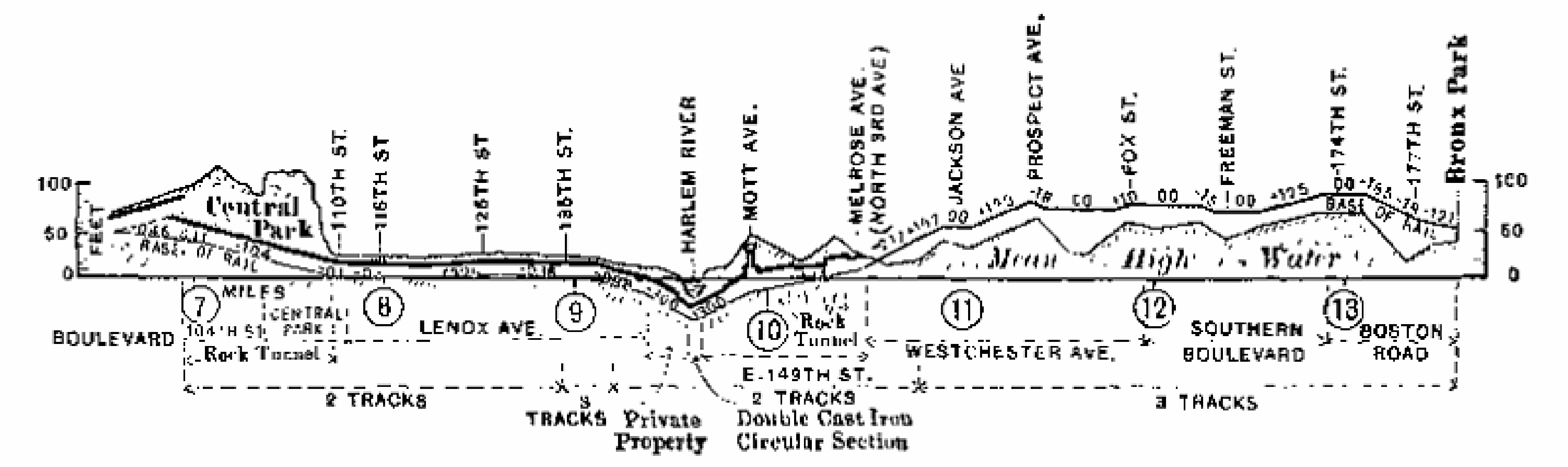
The Fort George (Western) Branch



The stations of the "Fort George" or "Western Branch" were located at the following points: *103rd Street*, *110th Street* (*Cathedral Parkway*), *116th Street* (*Columbia University*), *Manhattan Street* (near *128th Street*), *137th Street*, *145th Street, 157th Street, 168th Street* and *181st Street*. Beyond *Fort George, Manhattan* (in the *Bronx*): *207th Street*, *215th Street, Muscoota Street, Bailey Avenue* (at *Kingsbridge*, near the *New York & Putnam Railroad* station). Including the 103rd Street station, there were three tracks to 145th Street and then two tracks to Dyckman Street then three tracks again to the terminus at Bailey Avenue. There was also a storage yard below *Broadway* (between *137th* and *145th Street/s*).

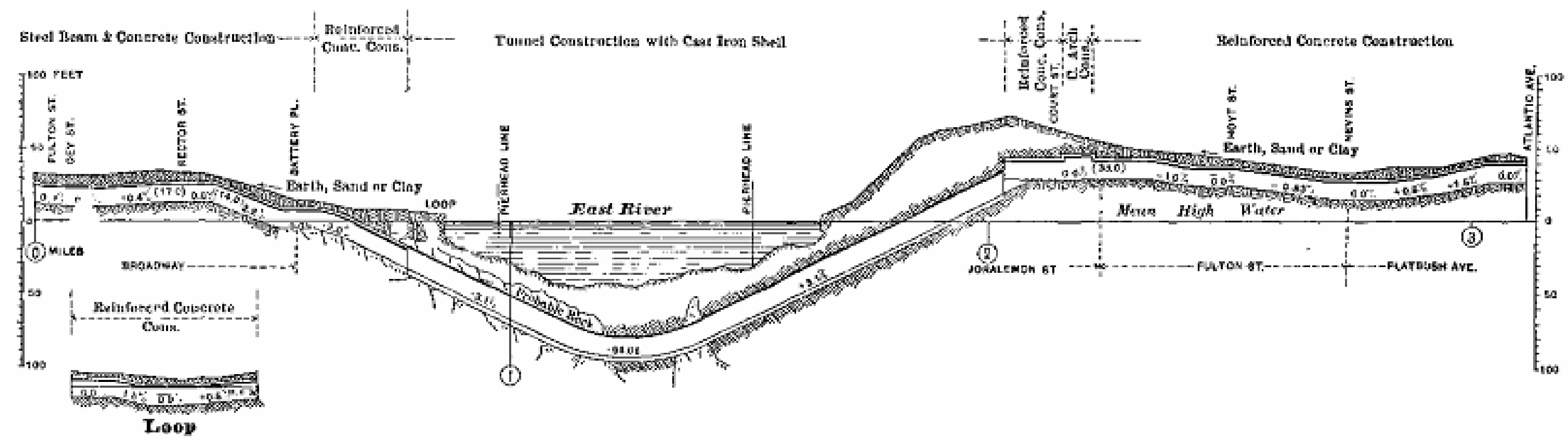
Left: caption: "Eleventh Avenue, Fort George – October 1904"

The Bronx Park (Eastern) Branch



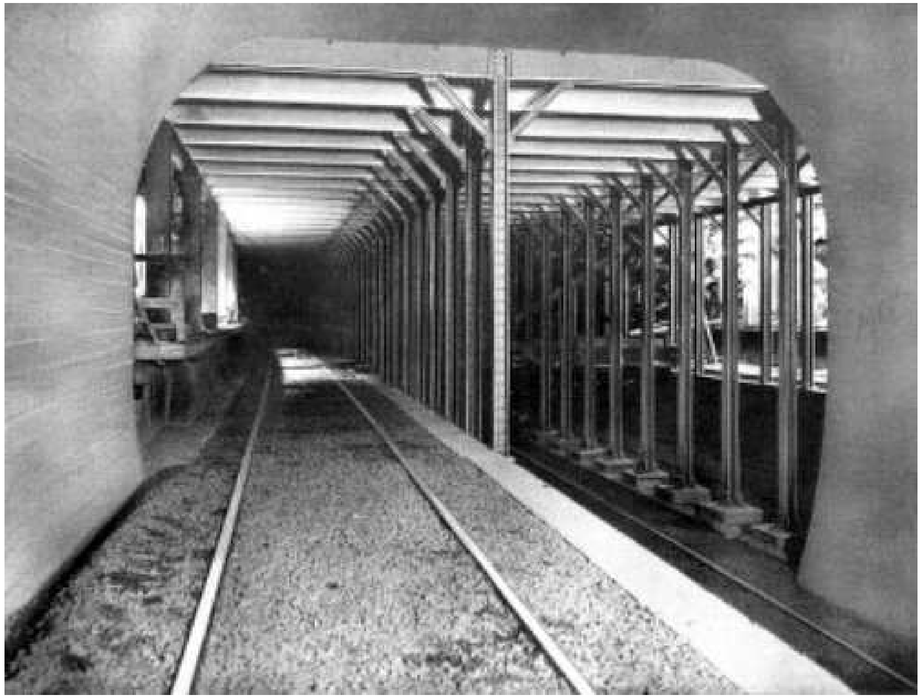
The stations on the "Bronx Park" or "Eastern Branch" were located at the following points: *110th Street, 116th Street, 125th Street, 135th Street, 145th Street* (spur line). Crossing the *Harlem River* into the *Bronx*, the stations were: *Mott Avenue, Melrose Avenue, Jackson Avenue, Prospect Avenue, Fox Street, Freeman Street, 174th Street, 177th Street* and *Boston Road* (near *Bronx Park*). There were two tracks to *Brook Avenue* and from that point to Bronx Park there were three tracks. On the *Lenox Avenue* spur to *148th Street* there were two tracks. There was a storage yard on the surface at the end of the *Lenox Avenue* spur, at 148th Street and a third on an elevated structure at Boston Road and *178th Street*. Also, there was a repair shop and inspection shed on the surface adjoining the spur at the *Harlem River* (from 148th to *150th Street/s.*)

The Brooklyn Extension



The stations in the *Borough of Brooklyn* on the "Brooklyn Extension" were located as follows: *Joralemon Street* (*Brooklyn Borough Hall*), *Hoyt Street, Nevins Street, Atlantic Avenue* (Brooklyn terminal of the *Long Island Railroad*). The Brooklyn Extension was a two-track line with a total length of 3.1 miles. The maximum grade was 3.1% (descending from the ends to the center of the *East River* tunnel). The minimum radius of curve was 1,200-feet.

Acceleration Grades



The total curvature of the “Y” was equal in length to 23% of the straight line and the least radius of curvature was 147-feet. The greatest grade was 3% and occurred on either side of the tunnel under the *Harlem River*. At each station there was a down grade of 2.1% (to assist in the acceleration of the cars when starting from a dead stop). In order to make time on roads running trains at frequent intervals it was necessary to bring the trains to their full speed very soon after departing a station. The electric traction equipment of the IRTC made quick acceleration possible while short “acceleration grades” at each station (in both directions) were of significant benefit. In order to obtain the quick acceleration in grade for local trains while at the same time maintain a level grade for the express service, the local/express track/s were constructed at different levels. The track was of standard construction with broken stone ballast, timber cross ties and 100-pound rails of the ASCE section. The cross ties were selected hard pine and all ties were fitted with tie plates. All curves were supplied with steel inside guard rails.

Above: local (left) and express (right) at different levels at *34th Street* and *Park Avenue* (looking south)

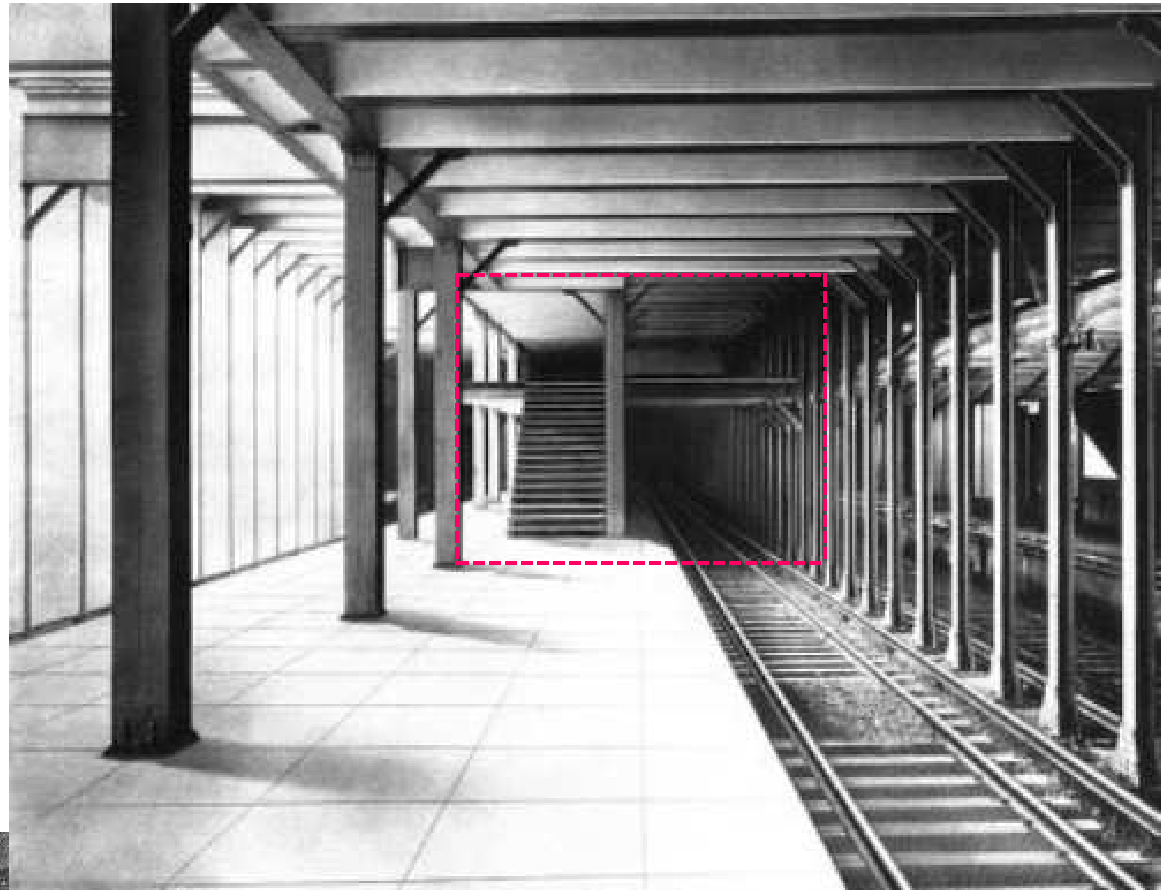
Stations

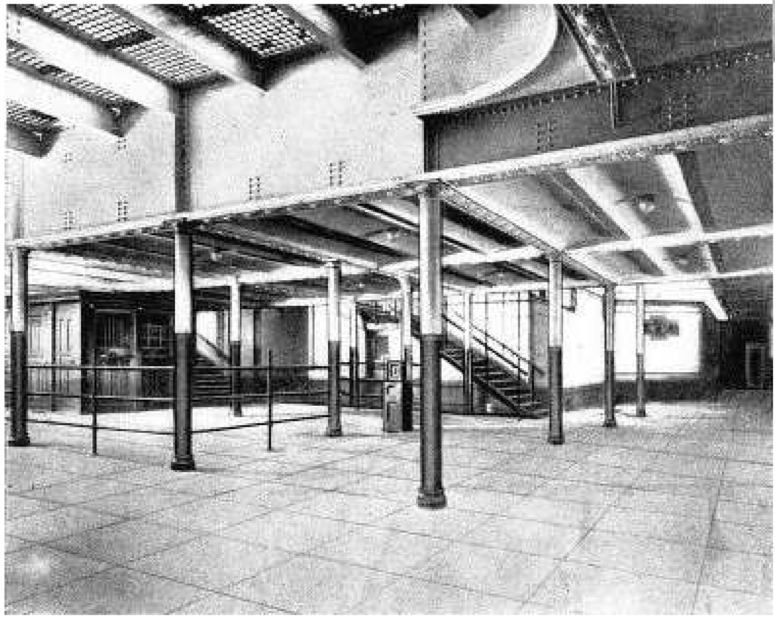
"In the new subway in New York crowding will be eliminated by the simple device of providing one stairway for entrance and one for exit, and by making the platforms large enough to accommodate several hundred persons at once. There will be broad staircases, of easy grade, ticket booths designed with reference to appearances as well its use, and the stations will have lofty vaulted ceilings well lighted by day through bulls-eye glass and at night by electric lamps…"

***Harper's Weekly*, January 31st 1903**

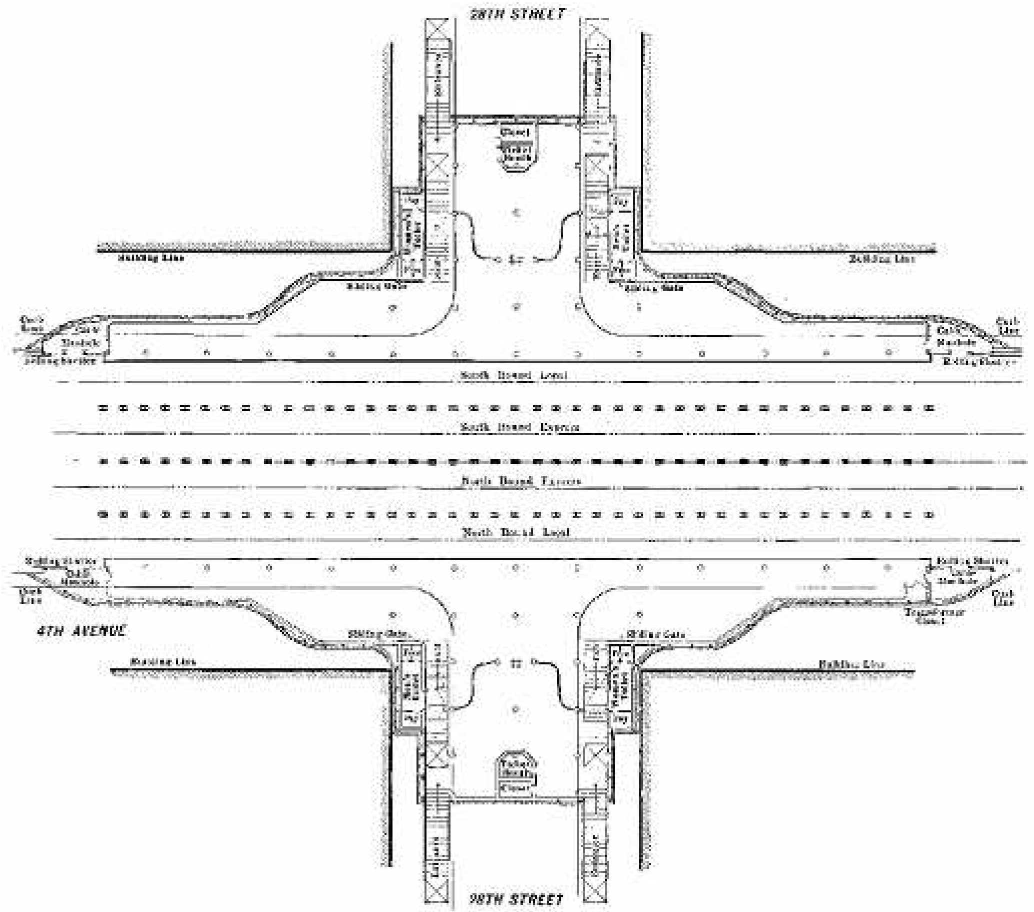
<u>Above L&R</u>: postcards of the interior of the *23rd Street* IRT Subway station

Of forty-eight stations on the IRT route, thirty-three were underground, eleven were on the viaduct portions of the line and three were partly on the surface and partly underground while one was partly on the surface and partly on a viaduct. The underground stations were at street intersections and, except in a few instances, occupied space under the cross street/s. The station plans were varied to suit the conditions of the different locations, the most important factor in planning them having been the amount of available space. The platforms were from 200 to 350-feet in length and about 16-feet in width (narrowing at the ends) while the center was larger or smaller, according to local conditions. As a general rule, the footprint of each station extended back about 50-feet from the edge of the platform. At all local stations (except at *110th Street* and *Lenox Avenue*) platforms were located on the outside of the tracks. At Lenox Avenue and 110th Street there was a single island platform for both uptown and downtown service. At express stations there were two island platforms between the express and local tracks; one for uptown and one for downtown service. In addition, there were the usual local platforms at *Brooklyn Bridge*, *14th Street* and *96th Street*. At the remaining express stations; *42nd Street* and *72d Street*, there were no local platforms outside of the tracks; local (a.k.a. “way”) and through trains used the island platforms.





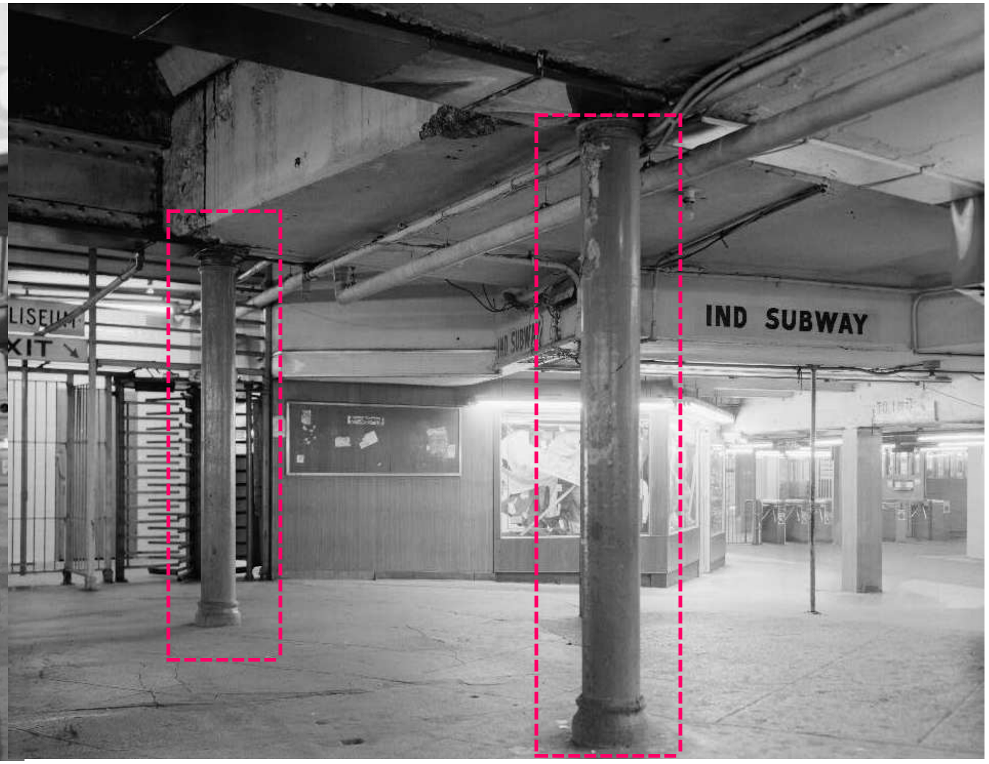
<u>Top Left</u>: *28^{th} Street* (local) IRT station
<u>Top Right</u>: caption: “Express Station at 14th Street, showing Island and Mezzanine platforms and stairs connecting them”
<u>Left</u>: *18^{th} Street* (local) IRT station



"…There are two classes of service, express and local; the former using the two inside tracks, and the latter the two outside tracks of the four-track road. Express trains which will run at a speed of about 25 miles an hour including stops, are made up of eight cars, of which five are motor cars. The local trains, which will have a speed of about 16 miles an hour, including stops, are made up of six cars, four of which are motor cars. The motor cars carry two 200-horse-power motors each, or 400 to the car, or 2,000 for the express trains. On tangents the expresses will attain a maximum speed of about 50 miles an hour…"

Left: caption: "Plan of 28th Street & Fourth Avenue Station"

<u>Above</u>: single island platform - *110th Street/Central Park North*

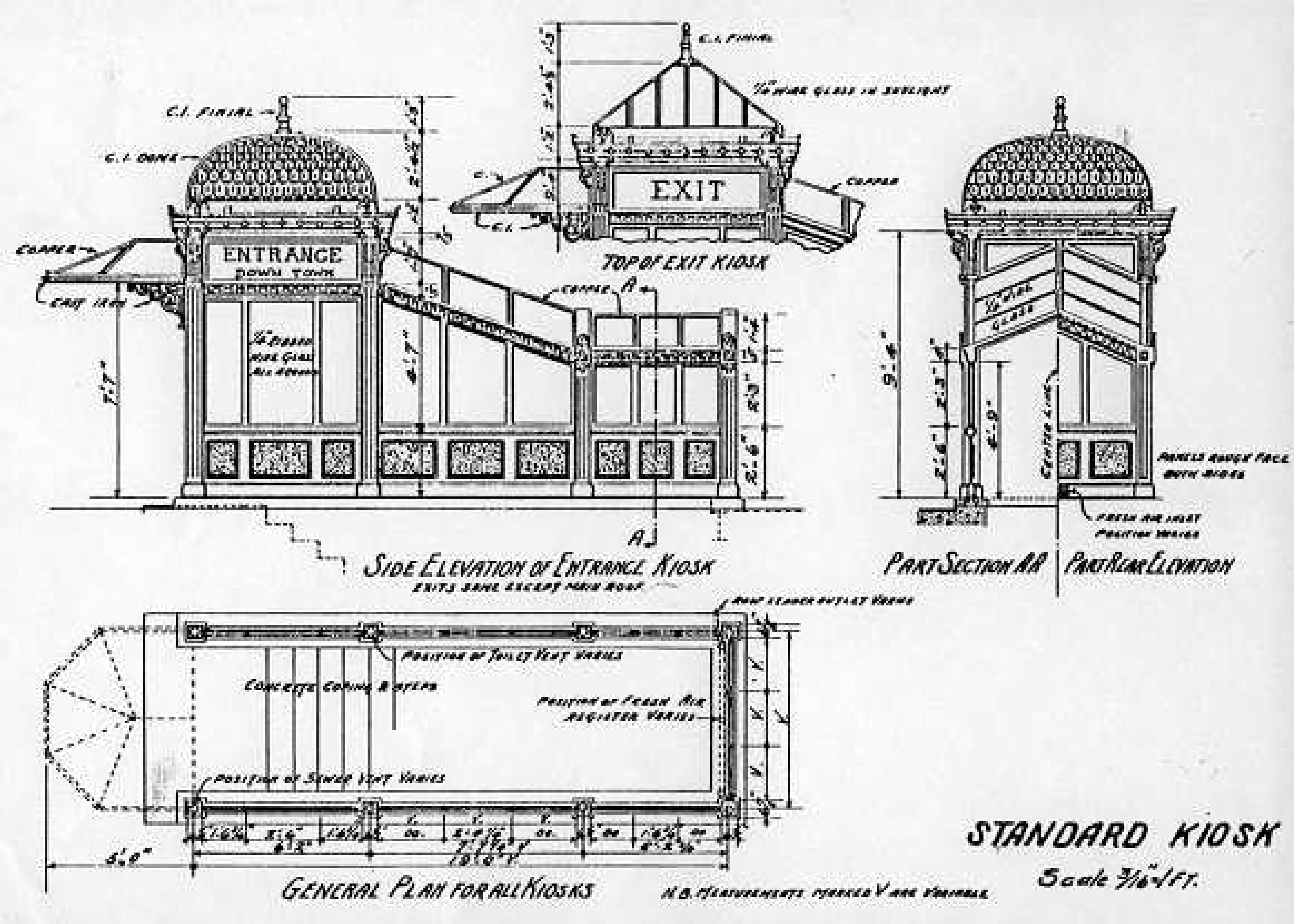


<u>Top Left</u>: *59th Street/Columbus Circle* - showing original uptown platform
<u>Top Right</u>: 59th Street/Columbus Circle - showing original cast-iron columns
<u>Left</u>: original cast-iron columns on *72nd Street* "island" platform

"…Where the tunnel is near the street level, there will be fewer stairs to climb than at Elevated stations, and where the street is not readily accessible by stairways, such as at the One Hundred and Twenty-fifth Street Viaduct, elevators will be provided…."

***Harper's Weekly*, January 31st 1903**

<u>Above</u>: *Bowling Green* Control House (left), built in 1905; *72nd Street* Control House (right), built in 1904. Important stations like these were distinguished with brick and stone structures (they are two of only three remaining). Both designed by *Heins & LaFarge*, the Control House at Bowling Green was located near the southern end of *Broadway*. Although the IRT Subway was, for the most part, modeled on the *London Underground*, the surface structures followed the styling of *Budapest, Hungary's* Subway which were based on exotic summer houses called "Kushks" (found in the gardens of ancient *Persia* and *Turkey*). The name was Americanized to "Kiosks." Although these Kiosks are now considered architectural treasures, they were scorned when built: *"A miserable monstrosity,"* wrote *The New York Times* in a 1904 editorial about the 72nd Street station.

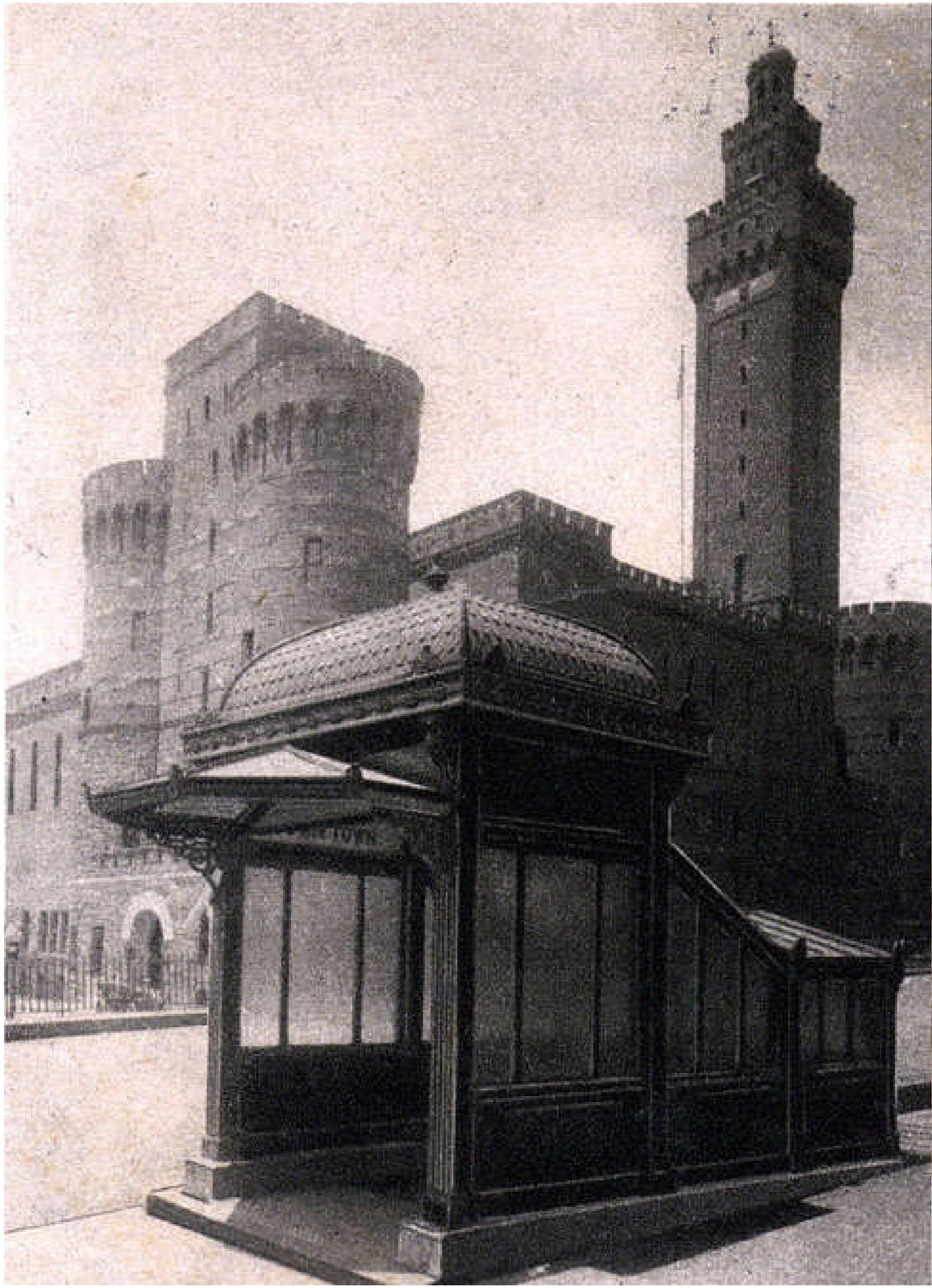


<u>Above</u>: caption: "Plan for IRT Subway Kiosk, New York City"

The Man from Montana

"…As we emerge upon the surface the Montana Man speaks again. 'You have given me the most interesting experience that a man can have in New York. Other cities have tall buildings, even great bridges, but no city has anything to compare with your subway. I have ridden in the Paris underground and in the famous London 'tuppenny tube,' but this is far superior to either, both in speed and in attractiveness. You New Yorkers may not realize the fact, but it, and the others of its kind that are sure to follow, will prove to be the most important influences in the city's development that have been evolved thus far in its history. Nothing human is perfect, and there is just one serious fault with this magnificent rapid transit line.' 'And that is?' 'These ugly exits and entrances stuck in the middle of the sidewalks. The entrances should be off the street, through the ground floors of buildings, as they are in the London system. But that can be remedied. As a whole, the subway is something of which not only New York but the whole country may feel proud.' 'Thank you,' I say, and I feel that at last I have succeeded in leaving a lasting impression of New York's greatness with the Man from Montana."

***Outlook Magazine,* November 1904**




104
EYE GLASSES


UNITED CIGAR S

The entrances to underground stations were enclosed at street level by Kiosks of cast-iron and wire-glass and varied in number from two to eight at a station. The stairways were of reinforced concrete. At *168th Street*, *181st Street* and *Mott Avenue*, where the platforms were from 90 to 100-feet below the surface, elevators were provided. Passengers entered the station without paying a fare. Train platforms were separated from the station by railings. At the more important stations, separate sets of entrances were provided for incoming and outgoing passengers; the stairs at the back of the station being used for entrances and those nearer the track being used for exits. At twenty of the underground stations it was possible to use vault lights extensively thus requiring very little artificial light. Any artificial light required was supplied by incandescent lamps embedded in the stations' ceilings. Provision was made for using the track circuit for lighting in an emergency if the regular lighting circuit failed. The station floors were made of poured concrete marked off in squares. At the junction of the floors and side walls, a cement sanitary cove was installed. The floors drained to catch-basins and hose bibs were provided for washing the floors.

Left: caption: "Kiosks at Columbus Circle"
Right: caption: "West side of Columbus Circle Station (60th Street) – illuminated by daylight coming through vault lights"

<u>Top Left</u>: uptown platform and control area - *79th Street*
<u>Top Right</u>: *125th Street* control area
<u>Left</u>: *116th Street/Columbia University* – downtown platform


14
14
14
14th St., Subwa on, New York.

"…For most of the way the road runs through a covered trench, its roof frequently touching the street surface. In very few cases will passengers have to walk more than fourteen feet down stairs from the street to the railroad platforms. At stations, the waiting rooms, tracks, and platforms will be roofed with thick glass at the street surface, so that sunlight will abound…The tunnel will be thirteen feet high inside, and its width will be fifty feet, except where there are side tracks, which will make it eighteen feet wider…"

***John B. McDonald,* 1902**

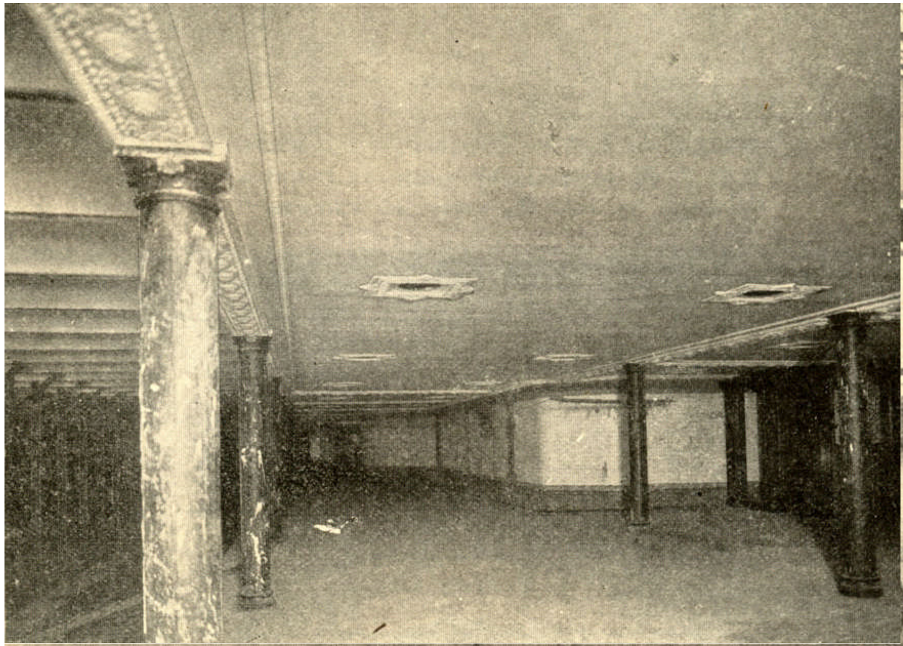
<u>Above</u>: North entrance, *72nd Street* station
<u>Left</u>: view of former location of vault lights (now ventilation grates) at *50th Street* IRT station

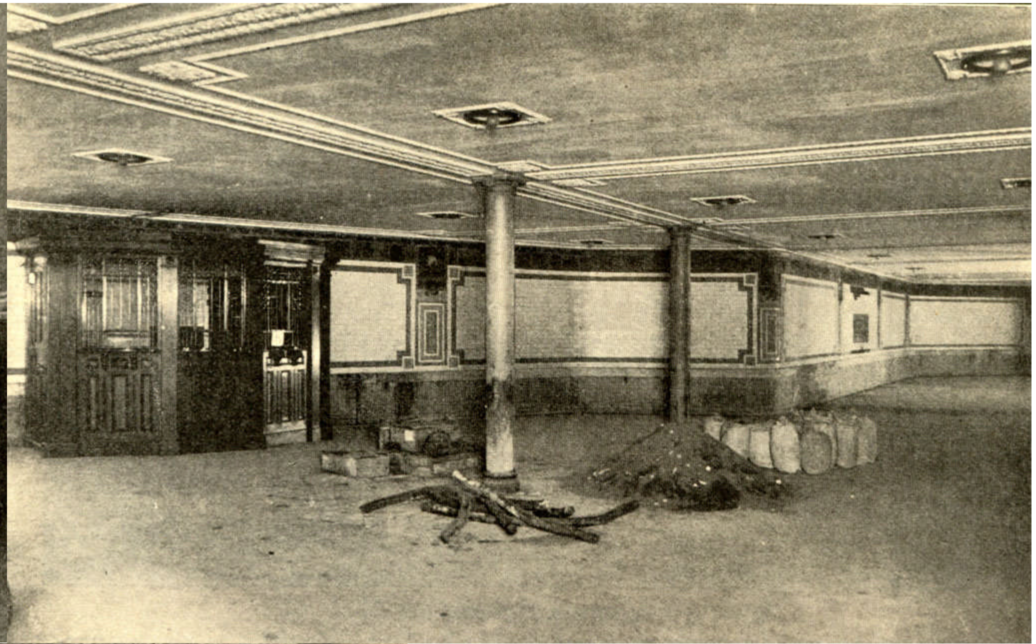
Architectural Treatment

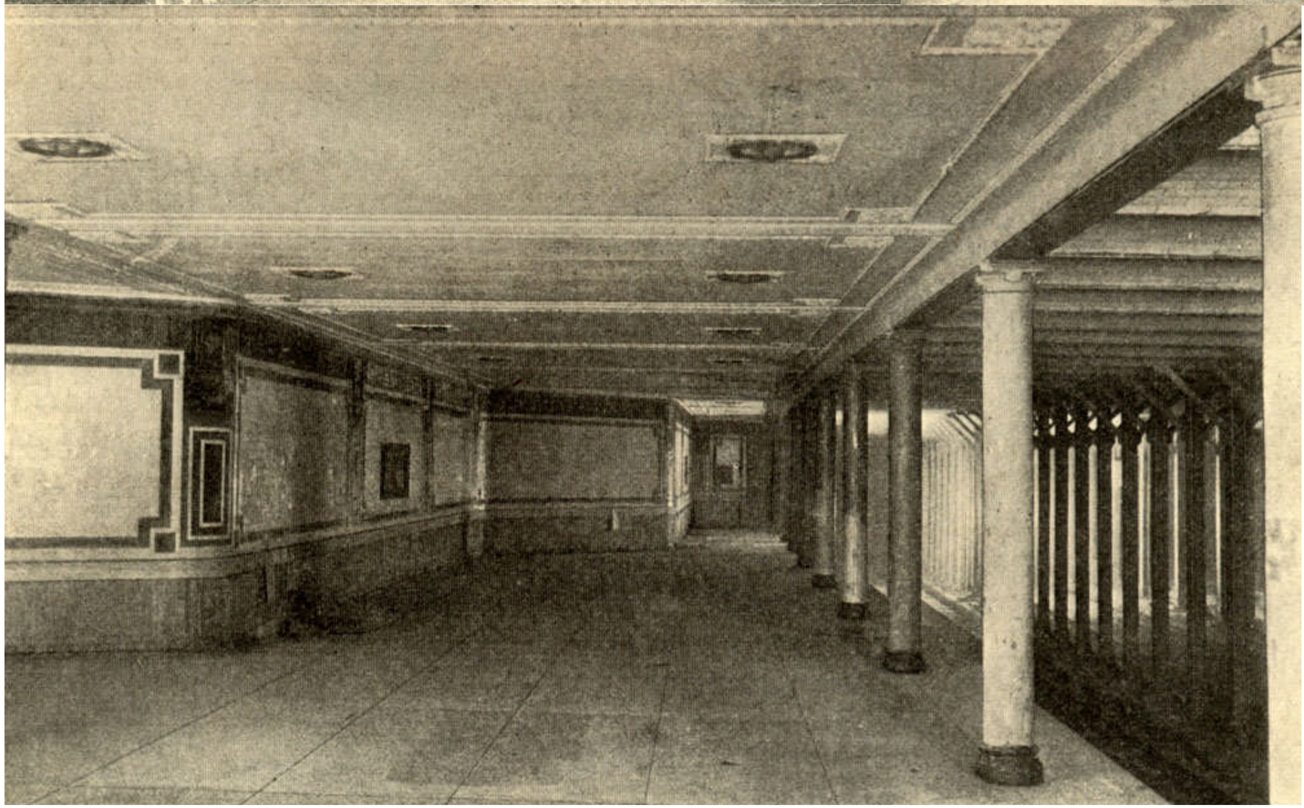
"All of these stations have been designed with great skill with a view to make them pleasing and attractive in appearance, and to afford the maximum of convenience to the passengers. The architectural treatment consists in the avoiding of flat barren walls, by furnishing them, where not roofed, with a fine cornice and ornamental railing, and where in tunnel, by dividing them into panels by means of pilasters with a cornice and molded base. These panels are covered with porcelain tiles, and the small arches in the station roofs are made with bricks of the same material. Porcelain was used instead of enameled brick, as it was feared the polished surface of the latter might be thrown off by frost…"

William Barclay Parsons

Two types of ceiling were used; flat (which covered the steel and concrete of the roof) and the other arched (between the roof beams and girders, the lower flanges of which were exposed (as pictured above). Both types had an air space between ceiling and roof which, together with the air space behind the inner side walls, allowed air to circulate and minimized condensation on the surface of both ceiling and walls. The ceilings were separated into panels by wide ornamental moldings and the panels were decorated with narrower moldings and rosettes.



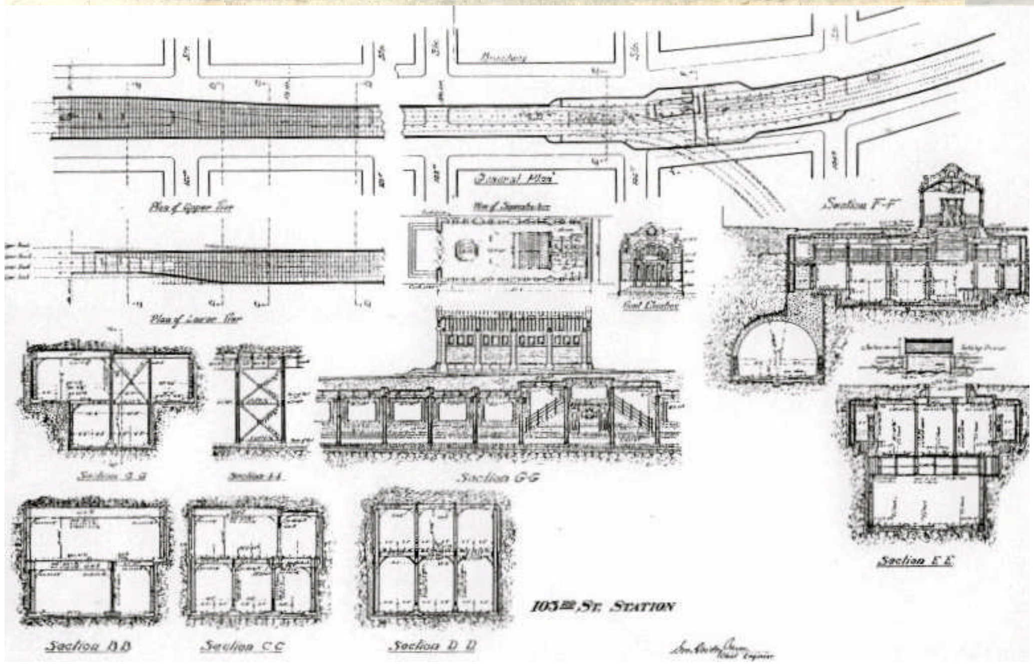




<u>Above & Left</u>: ***59th St./Columbus Circle*** **IRT Subway station**


50

The RTC contract of 1900 stated that *"…the railway and its equipment constitute a great public work. All parts of the structure where exposed to public sight shall therefore be designed, constructed, and maintained with a view to the beauty of their appearance, as well as to their efficiency…"* By calling for a resolution between art and utility, the contract would ensure that New York City's Subway would outdo its European counterparts. Since construction began long before they were appointed, architectural consultants *Heins & Lafarge* needed to work fast. They relied upon the model they knew best and brought several techniques they were already using at the *Bronx Zoo* to the Subway project. These included polychromed tile arches, vaulted ceilings and ornamental plaques. The challenge was to give each station a distinct character with appropriate decorations that would please as well as inform. Of course, the materials they planned to use had to be durable. Throughout the system, Heins & Lafarge used marble, brick, and ceramic or glass tile durable enough to withstand dampness and frequent scrubbing. They also used the ancient technique of mosaic and the relatively new one of glazed terra cotta. This latter technique was used to fashion a variety of ornaments: egg and dart moldings and key borders, scrolls, rosettes, leaves, garlands, cornucopias and wreaths. These patterns surrounded passengers with a feeling of the familiar, giving a sense of comfort and even luxury to what could have been an anxiety producing experience; traveling underground.



<u>Top Left</u>: caption: "Control (a.k.a. Station) House in the middle of Broadway, 103rd Street IRT Subway Station"

<u>Top Right</u>: caption: "104th street exit from the uptown platform, July 1912"

<u>Left</u>: caption: "Heins & LaFarge original plans, elevations and sections for the 103rd Street IRT Station"

"…All the ornamentation has been designed to help the passenger recognize his station without the necessity of listening for the announcement of the guard or reading the signs. Express stations at the City Hall, Fourteenth Street, Forty-second, Seventy-second, and Ninety-sixth streets naturally divide the local stations into groups. For each group a general scheme of decoration has been devised, and no two stations in a group are decorated in the same colors. For example, the ornamentation of all stations between the City Hall and Fourteenth Street will be characterized by long horizontal lines. The walls will be a white glass tile, the cornices of glazed terra-cotta, and the prevailing color of cornice and name panels will be, at the Worth Street station, dull green; at Canal, yellow; at Spring, white; at Bleecker, blue; and at Astor Place, bright green. Between Fourteenth and Forty-second streets, the decorations will be richer, and in panels instead of horizontal lines. Designs significant of the locality will be used wherever they can be appropriately. At Astor Place, beavers will appear in the designs; at Thirty-third Street, eagles, at Columbus Circle, Fifty-ninth Street, caravels; at One Hundred and Sixteenth Street, the blue and white of Columbia University. In other words, while no series of railway stations in the world will be so attractive to the eye as those of the Subway, there will be no meaningless ornamentation…"

***Harper's Weekly*, January 31st 1903**


23RD ST


28
TWENTY-EIGHTH
STREET
A Splendid Time is Guaranteed for All


50TH ST.
"BROADWAY'S MUSICAL KNOCKOUT!"
Grease
THE THREE BIGGEST HITS OF THE SUMMER!


50TH ST.
GOT HIS REVENGE… NOW IT'S
PETER SELLERS in
BLAKE EDWARDS'

Faience

For the IRT Subway, *Heins & Lafarge* also wanted more traditional decorative motifs such as garlands, wreaths, cornucopias, scrolls and rosettes to be executed in ceramic, mosaic, tile and terra cotta. As such, ceramics firms were brought in to produce the purely decorative signs and plaques. The two most prominent firms were the *Grueby Faience Company* of *Boston* and *Rookwood Pottery* of *Cincinnati*. Originally just producers of artistic tiles and pottery, both firms began turning out architectural faience work by the turn of the century. "Faience" is an opaque, glazed ceramic which is fired twice (as opposed to single-fired terra cotta) and therefore achieves a greater range of colors. The *Grueby Faience Company* was founded in 1894 by *William H. Grueby*. This company specialized in architectural tiles, brick and terra cotta. Grueby's work won international acclaim earning medals at the 1900 *International Exposition* in *Paris*, the 1901 *Pan-American Exposition* in *Buffalo* and the 1904 *Louisiana Purchase Exposition* in *St. Louis*. They were renowned for the matte green glaze which can be found in the *50th Street* station (above). The company, which became even better known for its art pottery, was bought out by the *C. Pardee Works* in *Perth Amboy, New Jersey* in 1917. It closed completely in 1938. The Grueby Faience Company produced many of the larger and more distinctive plaques: the ship (Caravel) at *Columbus Circle*; the eagle at *33rd Street* (above); the beaver at *Astor Place* as well as numerous decorative name and number plaques at *Brooklyn Bridge, Bleeker Street, 14th, 18th, 42nd, 50th, 103rd* (above)*, 110th* (above) and *116th Street/s*.

Above: ceramic plaque depicting the *Brooklyn Bridge*

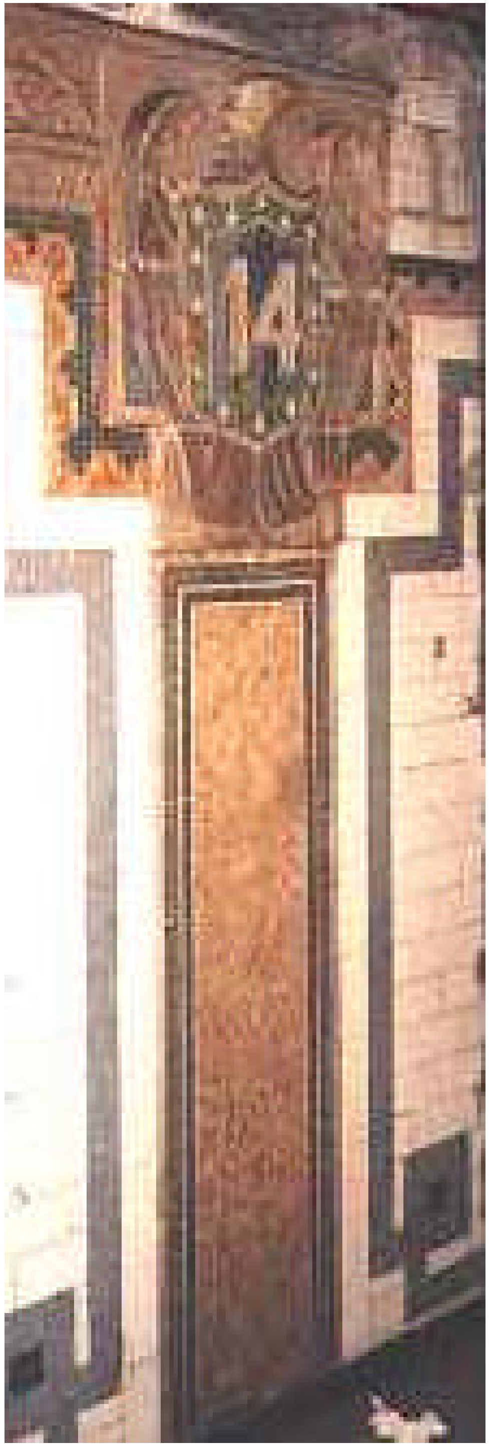
Left: *Columbus Circle* was the first station ready for tile so the *Grueby Faience Company* tested its various types here. This frame and cornice was very elaborate; rosettes joined by nautical line and garlands of fruit tied with flowing ribbons. The famous matte green Grueby glaze (which can be seen on the company's vases at the *Metropolitan Museum of Art*) was the dominate glaze used at the *Astor Place*, *50th*, *59th* (Columbus Circle), *110th* and *116th Street* station/s.

Maria Longworth Nichols; daughter of a wealthy ***Cincinnati*** patron, started ***Rookwood Pottery*** in 1880. Examples of the pottery it produced were awarded gold medals at the ***Universital Exposition*** in ***Paris*** in 1889. In 1902, the company formed an architectural department and received a large order for ornaments to be used in the IRT Subway stations. Rookwood Pottery produced the decorative faience for the ***23rd, 79th, 86th*** and ***91st Street*** station/s as well as large plaques at ***Wall*** and ***Fulton Street/s***. ***Eugene Atwood***, who had been a partner with ***William Greuby*** in ***Boston***, formed the ***Hartford Faience Company*** in 1894. They produced a wide range of architectural products, many of which were used in ***New York City*** buildings, until about 1913. Thereafter, the company made ceramic electrical fixtures. Fine examples of their ornamental plaques can be seen at the ***South Ferry*** and ***Borough Hall Brooklyn*** station/s.

Above: plaque at South Ferry station by the Hartford Faience Company. Faience plaques were made in plaster molds which allowed them to be hollow blocks with open backs. Average blocks were roughly four-inches deep and were set into the structure of the wall. Large pieces, which were extremely heavy, often required metal straps for additional anchoring.

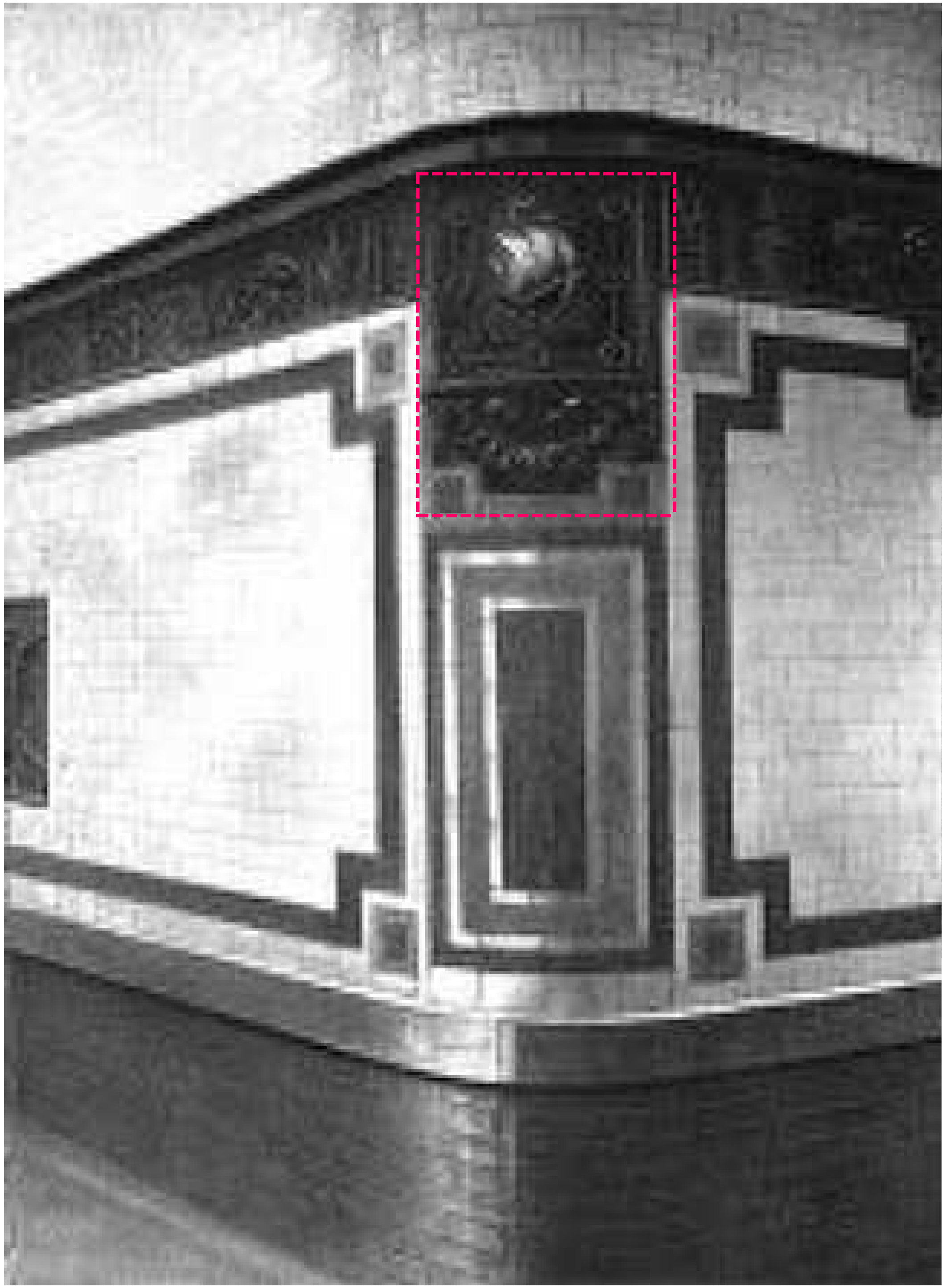
The bases of walls were buff Norman brick with glass or glazed tile above. Above the tile was a faience cornice. Ceramic mosaic was used for decorative panels, friezes, pilasters and name-tablets. A different decorative treatment was used at each station including a distinctive color scheme. At some stations, the number of the intersecting street or initial letter of the street name was shown on conspicuous plaques, at other stations the number or letter was in the panel. Some stations featured artistic emblems in the scheme of decoration as at *Astor Place*, the beaver (left); at *Columbus Circle*, Columbus' Caravel and at *116th Street*, the seal of *Columbia University*. The walls and ceilings above the cornice were finished in white Keene cement.

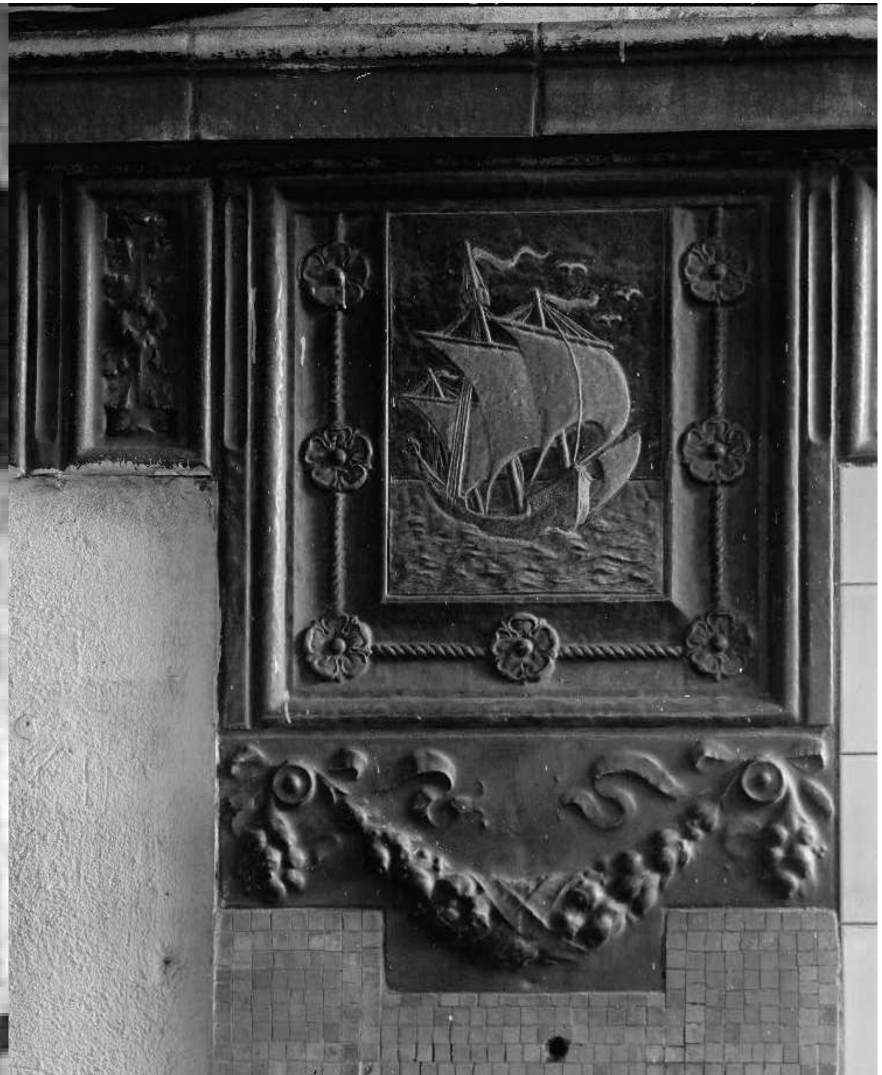
Above: wall treatment showing mosaic name tablet and faience cornice, *Times Square/42nd Street* station.



"…'Each station has a color scheme different from the others,' he announces, 'and each has its individual decorations. They are all very attractive, too. I should not call these stations beautiful, but they are artistically decorated.' 'The variation in color and style of decorations,' I explain, 'serves primarily a utilitarian purpose. It helps the passenger to distinguish his station. If a man is accustomed to using regularly a certain station in which the color scheme is green and white, he will soon learn to identify it by this combination of colors, even if his eye does not happen to catch the large station sign as he glances through the window. In addition, the various stations have each an appropriate design worked into the frieze along the wall. Here we are at Columbus Circle, and you see the design represents one of the caravels in which the great discoverer voyaged to America. Along the frieze, too, the numbers indicating the street appear every few feet. Watch for the next station and you will see a whole row of 50's along the wall, indicating Fiftieth Street. The guards call out the stations also, so that one should make no mistake in one's station.'…"

***Outlook Magazine*, November 1904**





<u>Above & Left</u>: faience plaque of Columbus' Caravel (*Columbus Circle*) by the *Grueby Faience Co*.

<u>Above</u>: *116th Street* (down-town platform)
<u>Left</u>: faience plaque of the seal of *Columbia University* (116th Street)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Foul Play




Ticket booths were of oak with bronze window grills and fittings. Passengers paid for an IRT Subway ride with a ticket. Turnstiles were introduced in the 1920s and fare payment methods evolved through coins and tokens to *MetroCard*.

Above L&R: caption: "City Hall Station Ticket Office, 1904"

Left Top: caption: "Automatic Change-Making Machine In Seventy-Seventh Street Station of Interborough Rapid Transit Subway, New York" (ca. 1924)

Left Bottom: contemporary MetroCard turnstile

There were toilets in every station (except at the *City Hall* loop). Each toilet had free closet/s and a pay closet which was furnished with a basin, mirror, soap dish and towel rack. The fixtures were porcelain finished in dull nickel. The woodwork of the rooms was oak; the walls were red slate wainscot and Keene cement.

Above: uptown control area with original ticket booth – *50th Street*

Left: *110th Street/Central Park North* – platform control area (turnstiles)

Guastavino

When looking for firms to assist with their elaborate program of design and decoration, ***Heins & Lafarge*** relied on their previous experience with the firm they had used for the ***Bronx Zoo*** - the ***Guastavino Fireproof Construction Company***. For the zoo, they had used Guastavino's system of structural arches and vaulted ceilings, polychrome tiles and sculpted terra cotta ornaments. Guastavino tiles were a fireproof, laminated tile used for wide arches that created a unique vaulted spatial effect. The major example of their use in the IRT Subway is the original ***City Hall*** station. Its matte ceiling tiles contrast with the green and brown glazed tiles at the edges of the vaults. Blue and white glazed name plaques provided a handsome form of identification for the station. One reporter described it as: ***"a cool little vaulted city of cream and blue earthenware like a German beer stein."*** The Guastavinos (***Rafael Guastavino, Sr***., 1842-1908 and ***Rafael Guastavino, Jr***., 1872-1950) specialized in constructing self-supporting tile arches that were light, strong, fireproof and economical. Their beautiful thin-shell ceiling tiles grace numerous buildings including the ***Municipal Building***, the ***Cathedral of St. John the Divine***, ***St. Paul's Chapel*** at ***Columbia University***, the ***Oyster Bar*** at ***Grand Central Terminal***, the ***Registry Room*** at ***Ellis Island*** as well as the ***Elephant House*** of the Bronx Zoo.

Left: the Guastavino tile ceiling in the Registry Room at Ellis Island

<u>Above</u>: the Guastavino vaults of *City Hall* station
<u>Left</u>: the Guastavino tiles were typically set in a herringbone pattern with fast-setting mortar to create light-weight vaults. These arches at the Bronx Zoo's *Elephant House* are both structural and decorative.

Not One Whiff

"…The air in the tunnel will be as pure as it is in the lowest story of any house built under the best hygienic regulations. There will not be one whiff of what is known as cellar air, nor will there be steam, smoke, or cinders…"

***John B. McDonald,* 1902**

RE: soil, vent and water pipes were run in wall spaces for accessibility. Rooms were ventilated through the hollow columns of the Kiosks and each was provided with an electric fan and heater.

“…‘Another thing that surprises me,’ says the Westerner, ‘is the dryness and good ventilation and the amount of natural light at all the stations. I have been accustomed to associate the word tunnel with a damp, dark, stuffy hole.’ ‘This really is not a tunnel,’ I reply. ‘It is a subway, and the fact that it was cut from the surface, while it caused New Yorkers much inconvenience during the process of building, enables the stations to be supplied with daylight through the glass discs that you observe forming a large section of the roof. Proximity to the surface allows fresh air to come in at every station, too, and this is kept in circulation by the movement of the trains, without any artificial system of ventilation. Dryness was assured in the construction. We really are riding in a long, rectangular, waterproof box, the sides of which are composed of layers of concrete, with heavy felt between, so that not a drop of moisture can get through.’…”

Outlook Magazine, **November 1904**

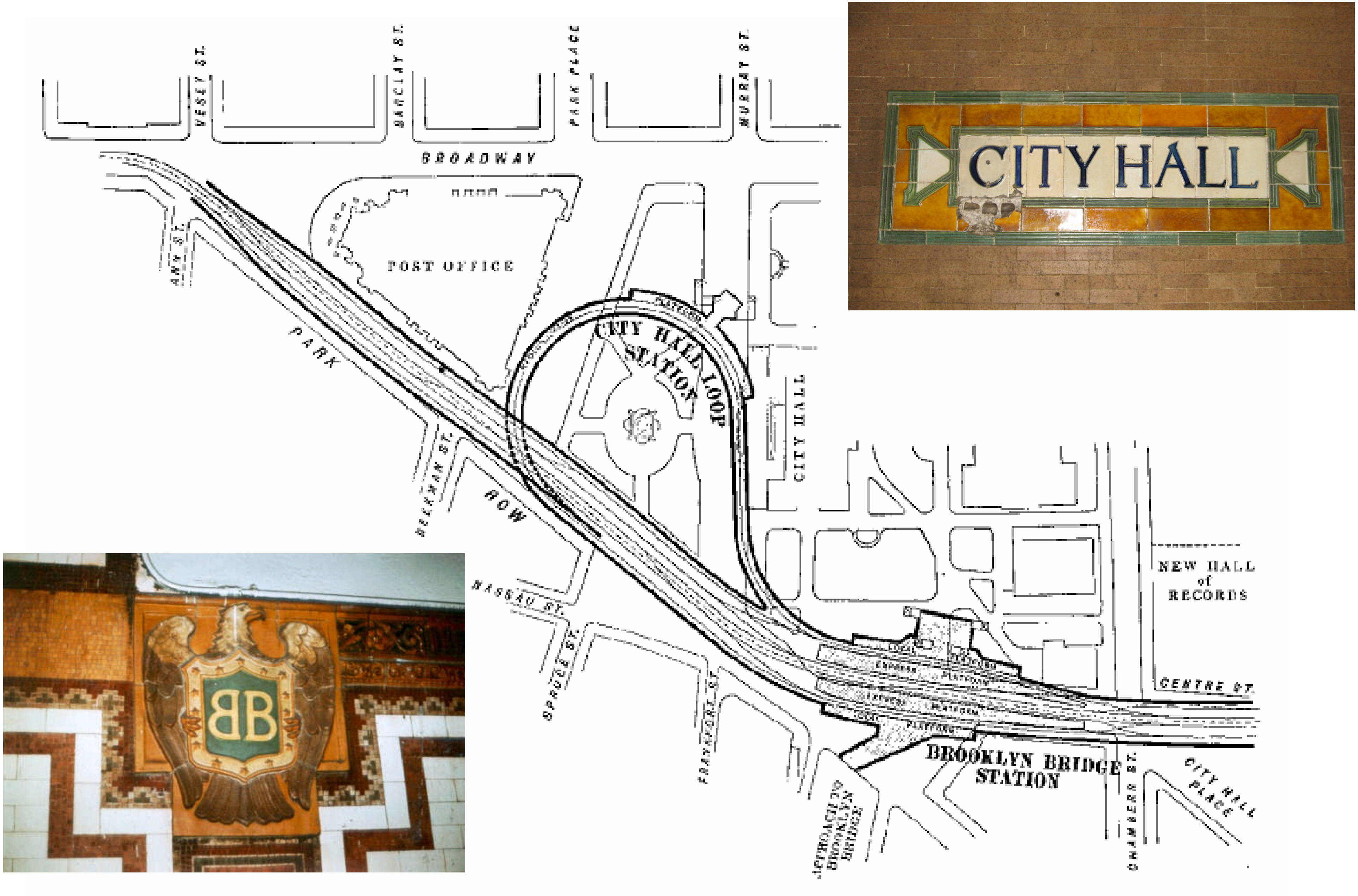
"…Repeated experiments have convinced the architects and engineers that the moisture and drip familiar to explorers of caves and tunnels can be avoided in the Subway stations by building air-chambers behind walls and ceilings. Accordingly, this method of construction has been adopted, and the underground will be damp-proof. The tunnel will be cooler in summer and warmer in winter than the upper air…"

***Harper's Weekly*, January 31st 1903**

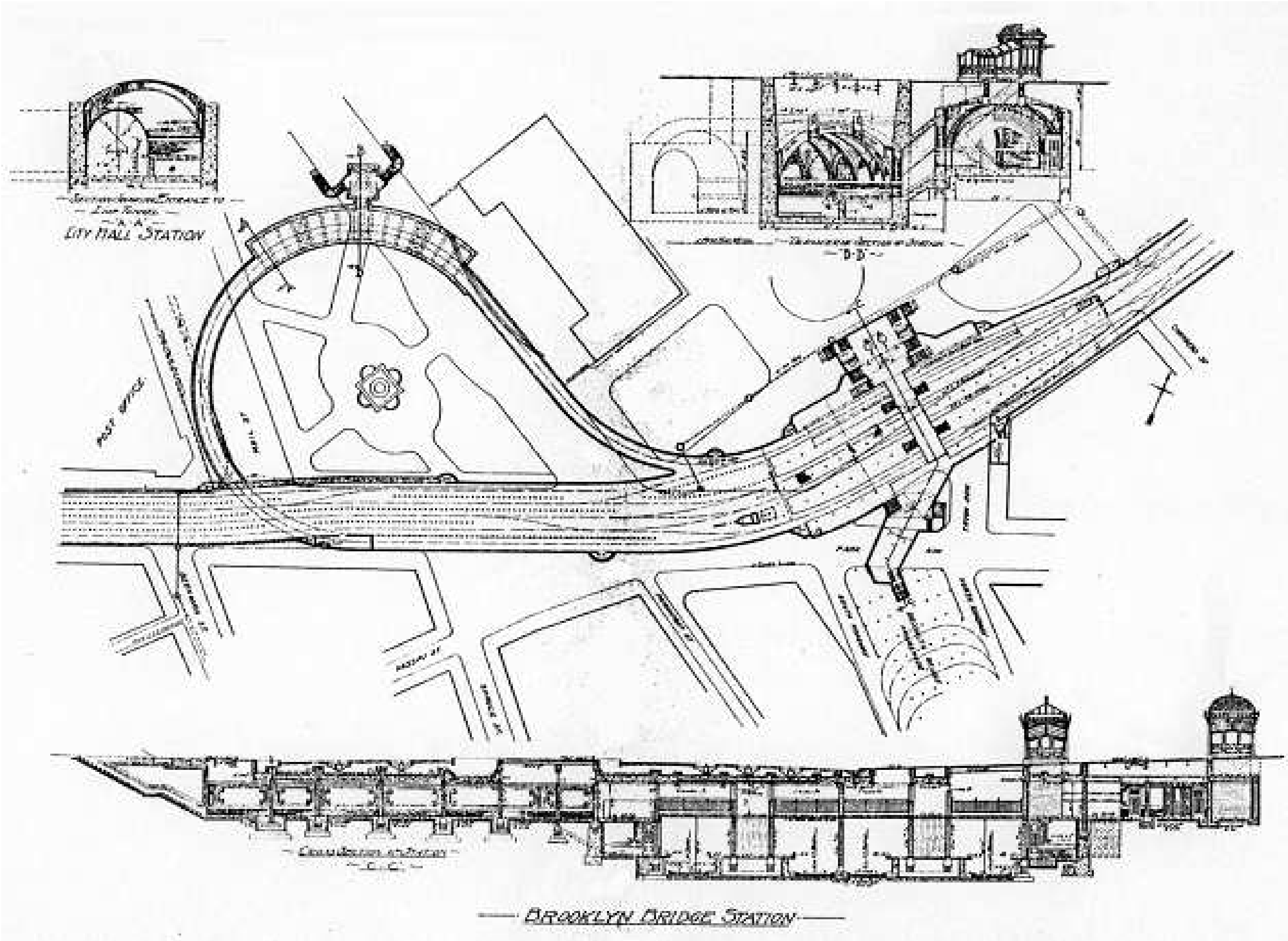
City Hall & Brooklyn Bridge

"…Although the City Hall station is intended to be rather the show station of the line, with its symphonic curves of roof and platforms and track, 'not a straight line in it,' as one admirer has observed, the main terminus and downtown station is a stone's throw away, over by the old Hall of Records and in front of the entrance to the Brooklyn Bridge. Both local and express trains will run to and from this station, and down its stairways late in the afternoon and early in the evening will pour part of the thousands who block the Third and Sixth Avenue L trains and the surface lines on their way uptown and to Harlem and the Bronx. Eventually the four-track route will extend straight on down to South Ferry and the end of the island, and thence by tunnel to Brooklyn, but at present the southern terminus is the City Hall. Curving out to the right from the four-track line, under the mayor's office in the City Hall, under the Post Office and some of the buildings of Newspaper Row, and thence back to the up-town track, is a single-track loop which is one of the most interesting engineering devices of the subway. This loop is designed to receive the downtown trains as fast as they come in from the north, and to bring them around to the up-town tracks without the delay of switching. When the line is completed through to South Ferry, a train may be run off the main track and around the loop, or it may be continued straight on, and as the loop is made to pass beneath the down-town track as it curves around, a grade-crossing is avoided and one of the more important tasks of constructive engineering which the subway presented is solved…"

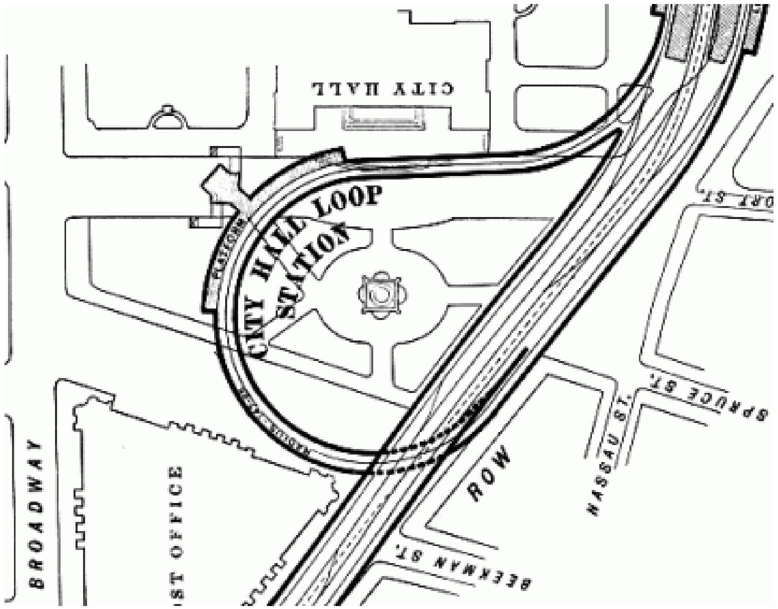
***Century Magazine*, October 1902**

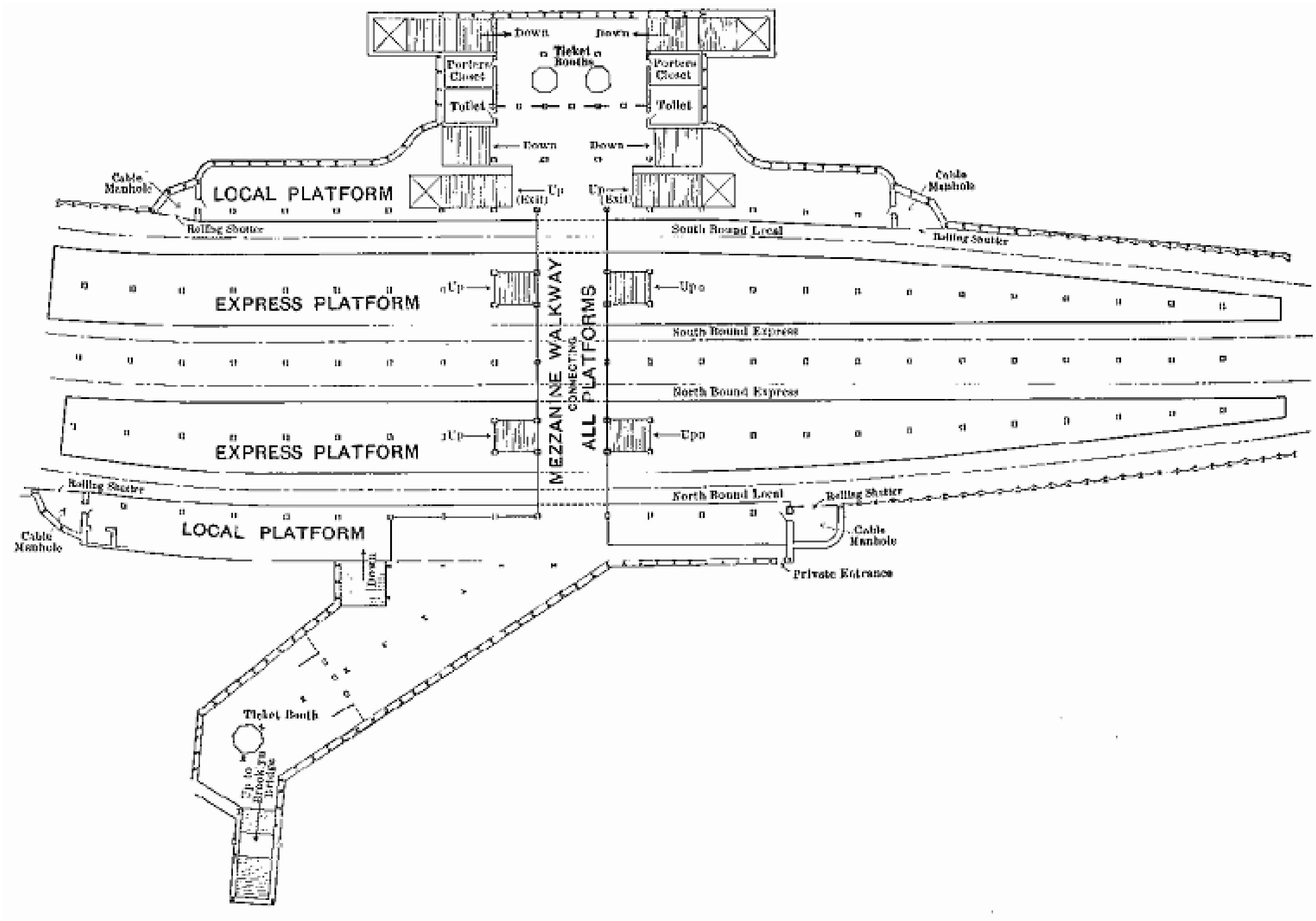


<u>Above</u>: caption: "Plan of Brooklyn Bridge Station and City Hall Loop"

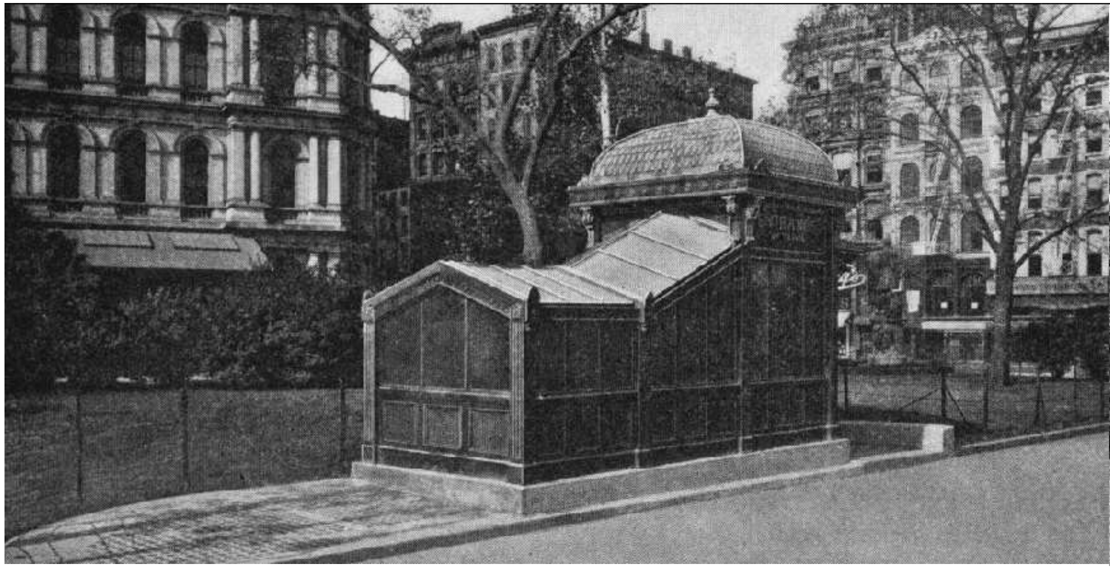

CITY HALL STATION
BROOKLYN BRIDGE STATION

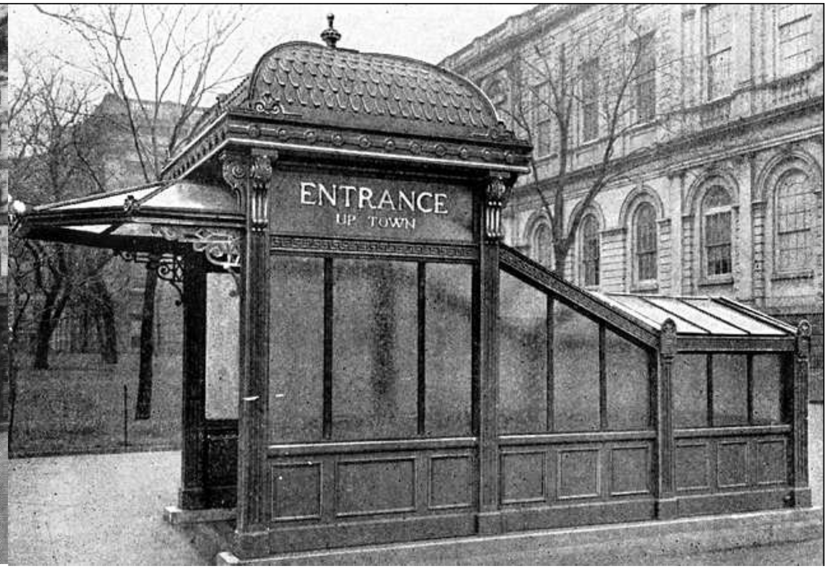

Subway Station under City Hall, New York


CITY HALL
CITY HALL LOOP STATION
BROADWAY
ROW
NASSAU ST.
SPRUCE ST.
BEEKMAN ST.



<u>Above</u>: caption: "Plan of Brooklyn Bridge Station"





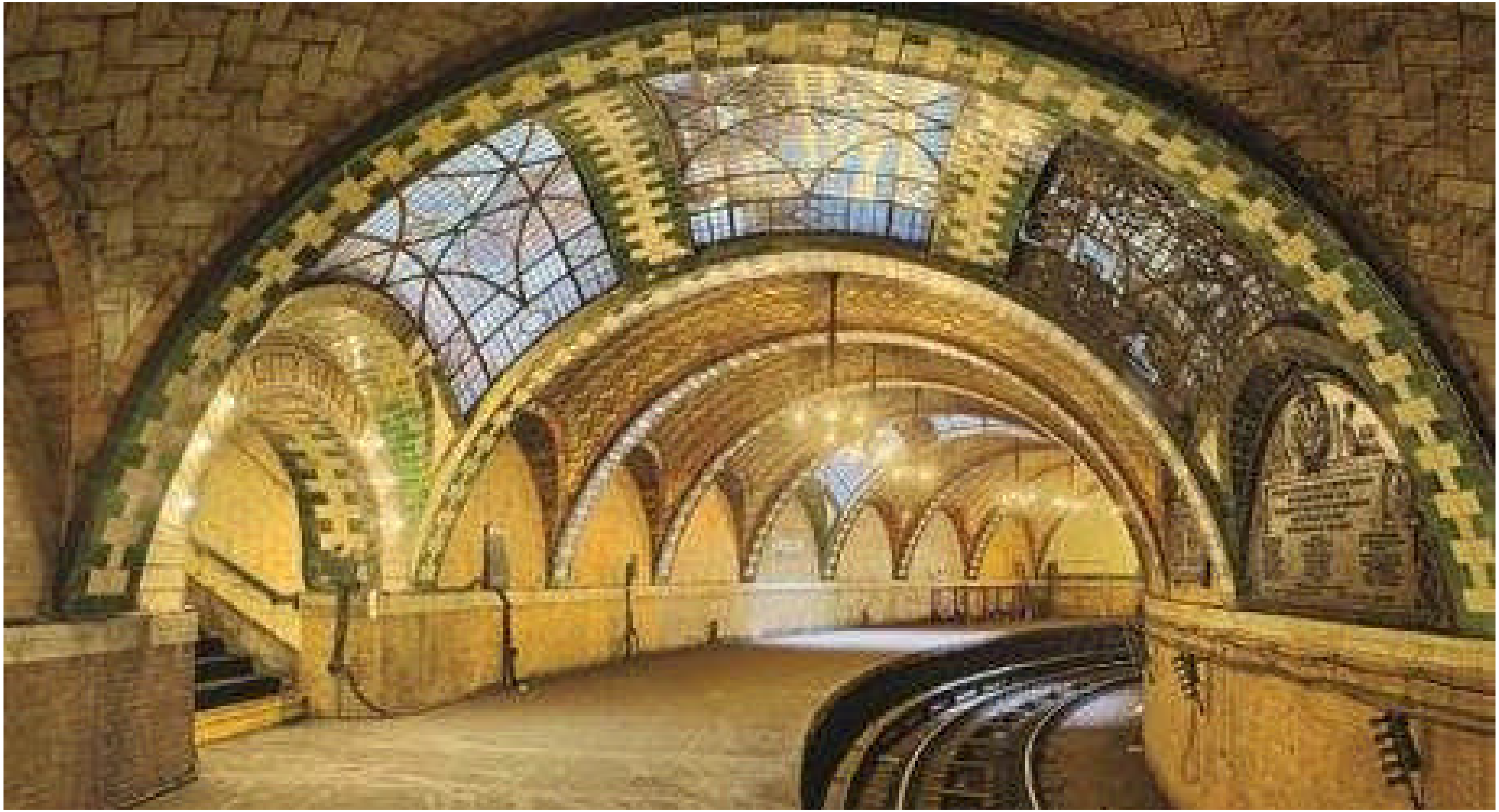
"…We descend, cross the street, are swept into the vortex, go down a short flight of steps, and find ourselves, with some hundreds of others, on a broad platform extending along one side of a subterranean vault. It is a very clean, dry, and brilliantly lighted vault. The arch of the roof above us and above the track that curves past us alongside the platform is smooth and spotless in white paint. The wall behind the platform on which we stand glistens in the glory of shining white panels, and bears a large sign, 'City Hall.'…"

***Outlook Magazine,* November 1904**

<u>Left</u>: caption: "Entrance to Subway, City Hall Park. Post Office Shown at the Left"

<u>Right</u>: caption: "Entrance to Subway, City Hall Park. City Hall at right"


City Hall, New-York.



An example of the care used to obtain artistic effects can be seen clearly at *City Hall* station (above). The line at this point was through an arched tunnel. In order to secure consistency in treatment, the roof of the station was continued by a larger arch of special design.

At the *168th Street, 181st Street* (above) and at *Mott Avenue* station/s, where the Subway is deep beneath the surface, unadorned arches were built over the stations and tracks with spans of fifty-feet.


CITY HALL


CITY HALL


CITY HALL


City Hall Subway Station, New York

The *City Hall* IRT Subway station was the system's showpiece and one of the most written about stations. It was closed in 1945. The platform was very short and tightly curved. Thus, when longer trains were introduced, it was considered too dangerous to open the center doors at the station's platform. The station is now an annex to the NYC *Transit Museum.*

“We have used a very limited number of different materials, rather few patterns and not many colors. These have been combined and recombined in varying arrangements, so as to produce a pretty considerable appearance of diversity, and all this has been for the distinct and proper purpose of aiding the traveler in the rapid and easy identification of his whereabouts.”

RE: excerpt from a report to RTC Chief Engineer W.B. Parsons in which *Heins & Lafarge* modestly summarized their accomplishments in their efforts to provide aesthetically functional decoration to the IRT Subway

Part 3

A Gigantic Task

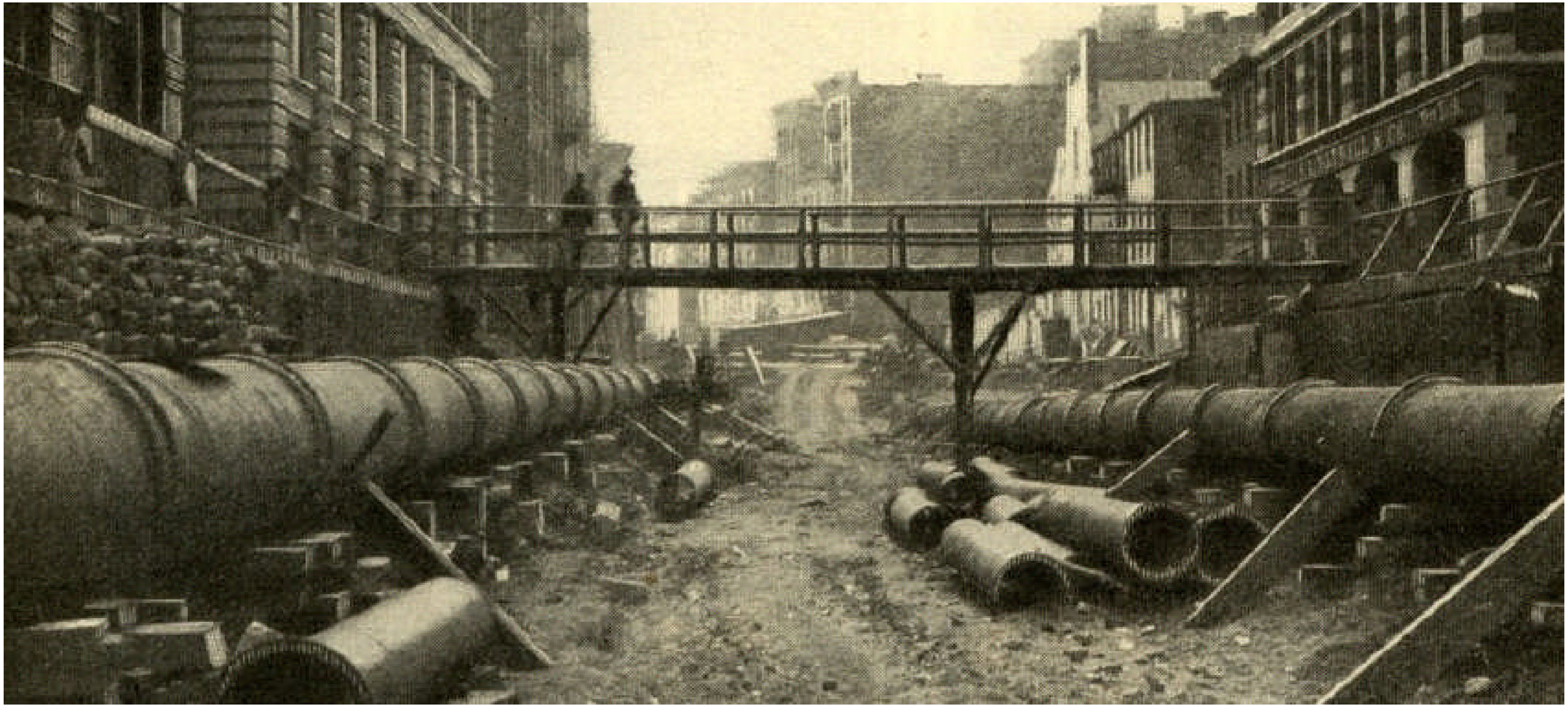
“To build and equip New York’s underground rapid transit railroad is truly a gigantic task. It is beset by almost countless complications. The problems growing out of it include many new ones, of much apparent difficulty, requiring the most expert skill and the highest practical judgment in their solving. Yet so far as the work has progressed there has been no obstacle that has not been foreseen, no task whose performance has not been thought out before the labor of digging and tunneling was begun. Nothing has been left to chance. The engineers of the Rapid Transit Commission and of the contractor have anticipated the methods and calculated the cost of every step that has been taken and that will be taken, to the day when trains begin to run on the road…As an engineering task, the building of the new road is practically without precedent. A great trench has to be carried through the heart of the most crowded city in the world without disturbing that city’s traffic. It has to be led through a bewildering assortment of pipes that carry light, heat, water, power, and electric and pneumatic communication to all parts of New York. To do the work without disturbing the every day business of the people is the problem…”

***John B. McDonald*, 1902**

A Surgical Engineering Feat

"…Imagine a surgeon who has to direct a probe from the neck of a patient all the way to each heel. He must carry out the exploration thoroughly. He must not hurt a single nerve or break the wall of any vein or artery. Nerves, tendons, veins, and arteries must all be avoided, or pushed aside and protected, wherever the probe encounters them. Above all, the tranquility of the patient must not be upset. There you have a fair likeness of what had to be done in digging the rapid transit tunnel…"

***John B. McDonald,* 1902**



"…Having determined the route, the board's engineers, under the direction of their chief, William Barclay Parsons made a series of borings over the entire route to determine the precise nature of the ground in which the work was to be carried on. These borings went twenty-five feet below the surface, and they were only twenty feet apart - nearly six thousand of them altogether. Minute examinations of the city maps and records gave the exact location of every water pipe, gas main, sewer, pneumatic tube and wire conduit, every street car track, elevated railroad foundation, and building foundation that would be encountered on the route. The plan of the four track road, with stations a quarter of a mile apart, every sixth station being of double size to accommodate express traffic, was carefully worked out. It was determined that the four tracks should not be placed in pairs, one above the other, but that they should lie side by side in a broad, low tunnel. No motive power causing combustion in the tunnel should be used..."

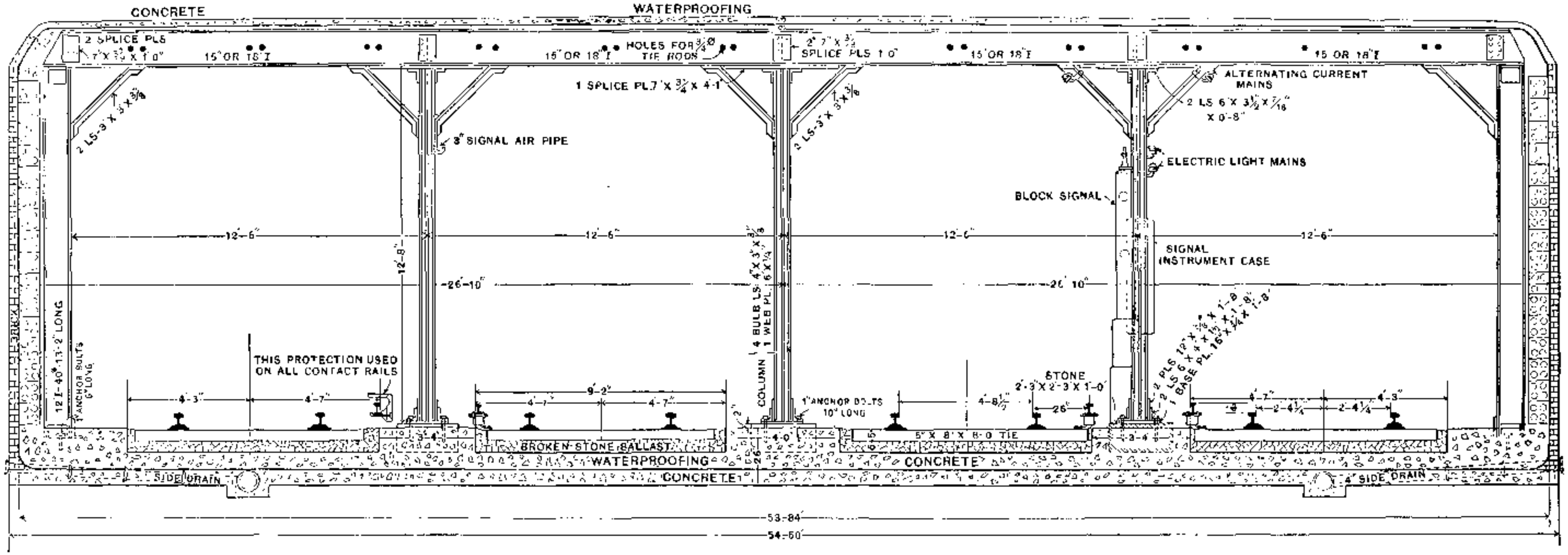
***John B. McDonald,* 1902**

<u>Above</u>: caption: "Preliminary work for the tunnel on Elm Street, one of the many points at which great care was necessary in excavating along the Croton water pipes"

Five types of construction were employed in building the IRT Subway:

1) **The typical subway near the surface with flat roof and I-beams for the roof and sides, supported between tracks with steel bulb-angle columns used on about 10.6 miles or 52% of the route;**
2) **Flat roof typical subway of reinforced concrete construction supported between the tracks by steel bulb-angle columns, used for a short distance on *Lenox Avenue* and on the *Brooklyn* portion of the *Brooklyn Extension*, also on the *Battery Park Loop*;**
3) **Concrete lined tunnel used on about 4.6 miles or 23% of the route, of which 4.2% was concrete lined open cut work and the remainder was rock tunnel work;**
4) **Elevated railway on steel viaduct used on about five miles or +24% of the road;**
5) **Cast-iron tubes used under the *Harlem* and *East River/s*.**

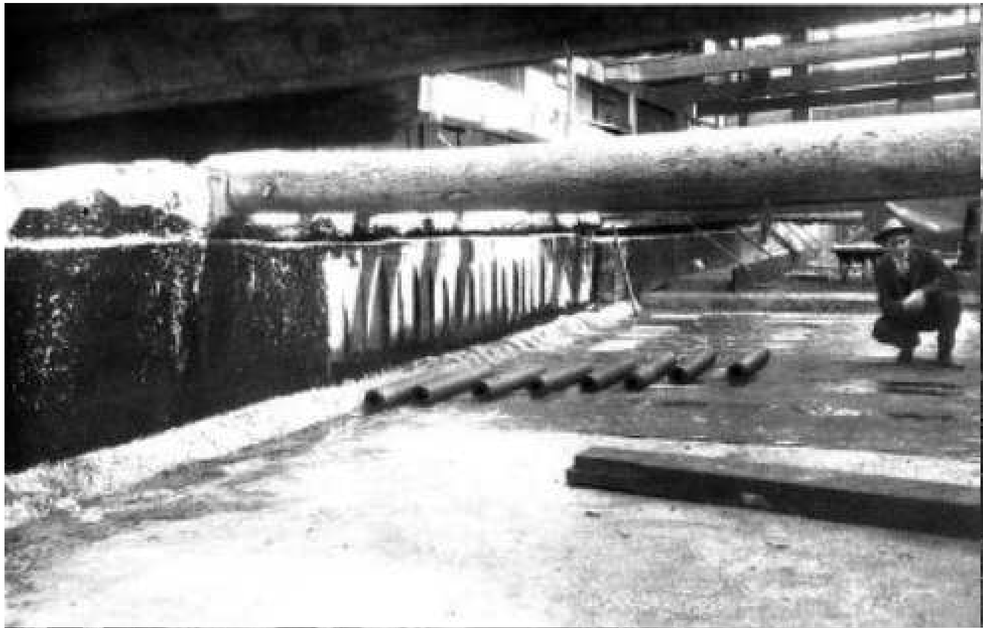
1) Flat Roof I-Beam Construction



The general character of the flat roof I-beam construction included the bottom made of concrete. The side walls had I-beam columns spaced five-feet apart between which were vertical concrete arches, the steel acting as a support for the masonry and allowing the thickness of the walls to be materially reduced from that necessary were nothing but concrete used. The tops of the wall columns were connected by roof beams which were supported by rows of steel columns between the tracks; built on concrete and cut stone bases forming part of the floor system. Concrete arches between the roof beams completed the top of the Subway. Such a structure was not impervious to moisture thus, a course of two to eight thicknesses of felt, each washed with hot asphalt, was laid behind the side walls, under the floor and over the roof. In addition to this precaution against dampness, in three sections of the Subway (on *Elm Street* between *Pearl* and *Grand Street/s*, on the approaches to the *Harlem River Tunnel* and on the *Battery Park Loop*) the felt waterproofing was made more effective by one or two courses of hard-burned brick laid in hot asphalt, similar to the method used in constructing the linings of reservoirs.

Above: caption: "Typical Section of Four Track Subway"

<u>Above</u>: caption: "Finishing Concrete Side-Arches of Subway"



<u>Top Left</u>: caption: "Laying sheet waterproofing in bottom"
<u>Top Right</u>: caption: "Special brick and asphalt waterproofing"
<u>Left</u>: caption: "Water-proofing Floor and Wall of Subway - Elm Street"

<u>Top Left</u>: caption: "Four-Track Steel Work in place between Reade and Duane Streets"
<u>Top Right</u>: caption: "Four-Track Subway – Showing Cross-Over South of 18th Street Station"
<u>Left</u>: caption: "Four-Track Structure complete between Bleecker and Houston Streets"

“…The general plan of street excavation is to make an opening four hundred feet long and one half the width of the street at a time. The tunnel is built along that section, the pipes and electric subways are replaced, and the street surface is restored. Then, as the pavement is relaid, new excavation is pushed forward. Meantime, work on the opposite half of the street, hitherto unopened, is carried on. The trench dug is usually about twenty feet deep. On the bottom of the excavation is spread a solid floor of concrete. At intervals of five feet along this floor, frames of steel beams are erected, securely riveted together, and running transversely to the street. These frames are the ribs of the tunnel. They carry the load of the street above, and they sustain the thrust of the earth on either side. Between the frames there is built a concrete wall and roof thick enough to embed the steel skeleton and preserve it from rust or decay. Alternate layers of asphalt and roofing felt will be spread on the outside of the structure, so as to make it absolutely waterproof…”

John B. McDonald, **1902**

Top Left: caption: "Upper Broadway During Construction of Subway"
Top Right: caption: "Construction of Subway on one side of Fourth Avenue"
Left: caption: "View of 4th Avenue at 17th Street during construction of the IRT Subway, November 1902"

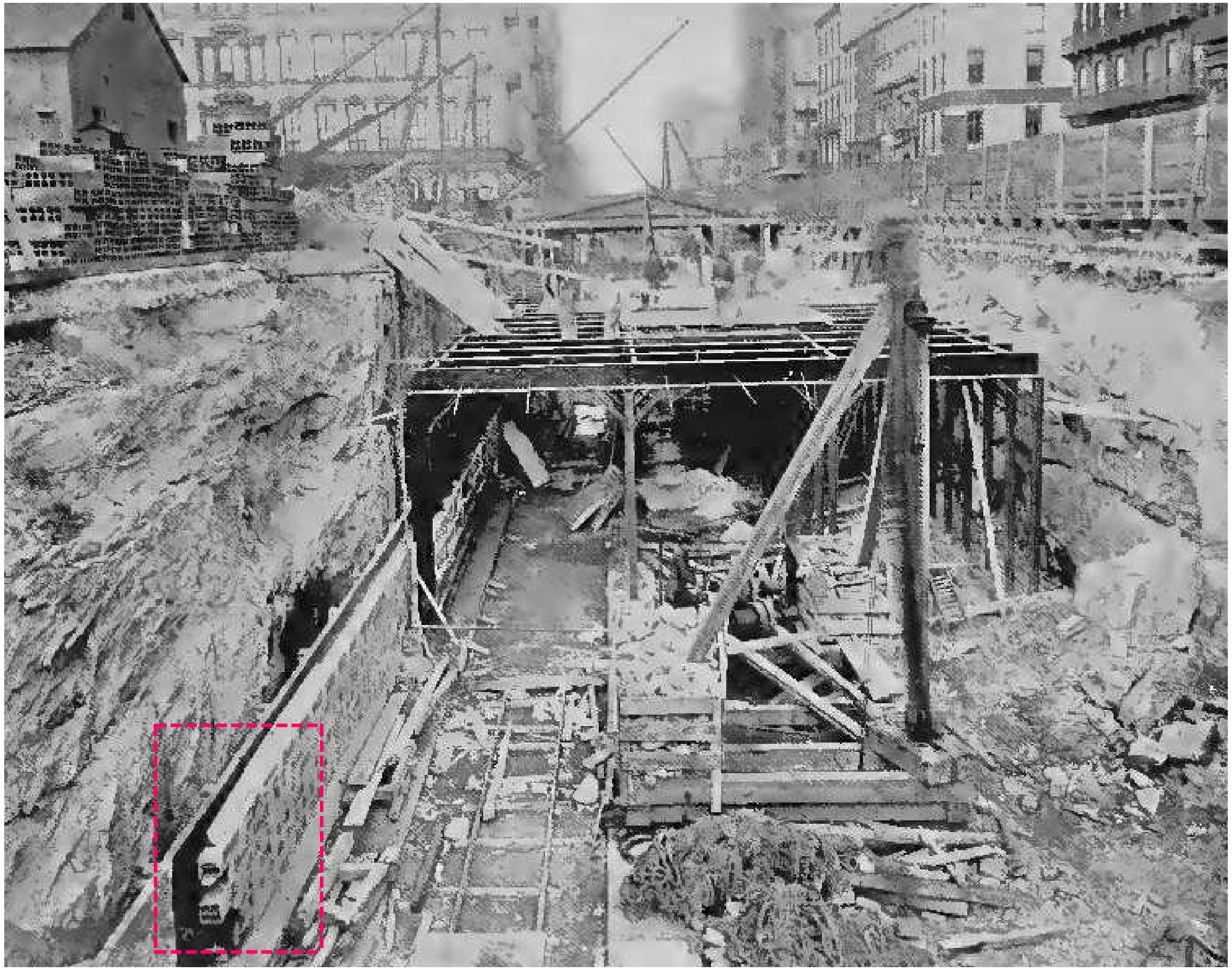
Well-timbered shafts about eight by ten-feet were sunk along one curb line and tunnels driven from them toward the other side of the street, stopping about 3.5-feet beyond its center line. A bed of concrete was laid on the bottom of each tunnel and, when it had set, a heavy vertical trestle was built on it. In this way trestles were built half across the street, strong enough to carry all the street cars and traffic on that half of the roadway. Cableways to handle the dirt were erected near the curb line spanning a number of these trestles and then the earth between them was excavated from the curb to within a few feet of the nearest electric car track. The horse-car tracks were removed. Between the electric tracks a trench was dug until its bottom was level with the tops of the trestles, about three-feet below the surface, as a general rule. A pair of heavy steel beams was then laid in this trench on the trestles. Between these beams and the curb line a second pair of beams were placed. In this way the equivalent of a bridge was put up, the trestles acting as piers and the beams as girders. The central portion of the roadway was then undermined and supported by timbering suspended from the steel beams. The various gas and water pipes were hung from timbers at the surface of the ground. About four sections, or 150-feet, of the Subway were built at a time in this manner. When the work was completed along one side of the street it was repeated in the same manner on the other side. This method of construction was subsequently modified so as to permit work on both sides of the street simultaneously. The manner in which the central part of the roadway was supported remained the same and all of the traffic was diverted to this strip.[183]

Above: caption: “Excavating trench along Broadway”
Left: caption: “Cutting the trench along Broadway, at Fifty-fifth street - here some of the street pipes are supported on a temporary wooden framework while the tunnel is built”

In front of the waterproofing, immediately behind the steel columns, were the system of terra-cotta ducts in which the electric cables were placed. The cables could be reached by means of manholes every 200 to 450-feet, which opened into the subway and also into the street. The number of these ducts ranged from 32 to 128 and were connected with the main power station at *59th Street* and the *Hudson River.*

Left: caption: "Ducts in side-walls – eight only of the sixteen layers are shown"

Right: caption: "Waterproofing roof of Subway — Elm Street"



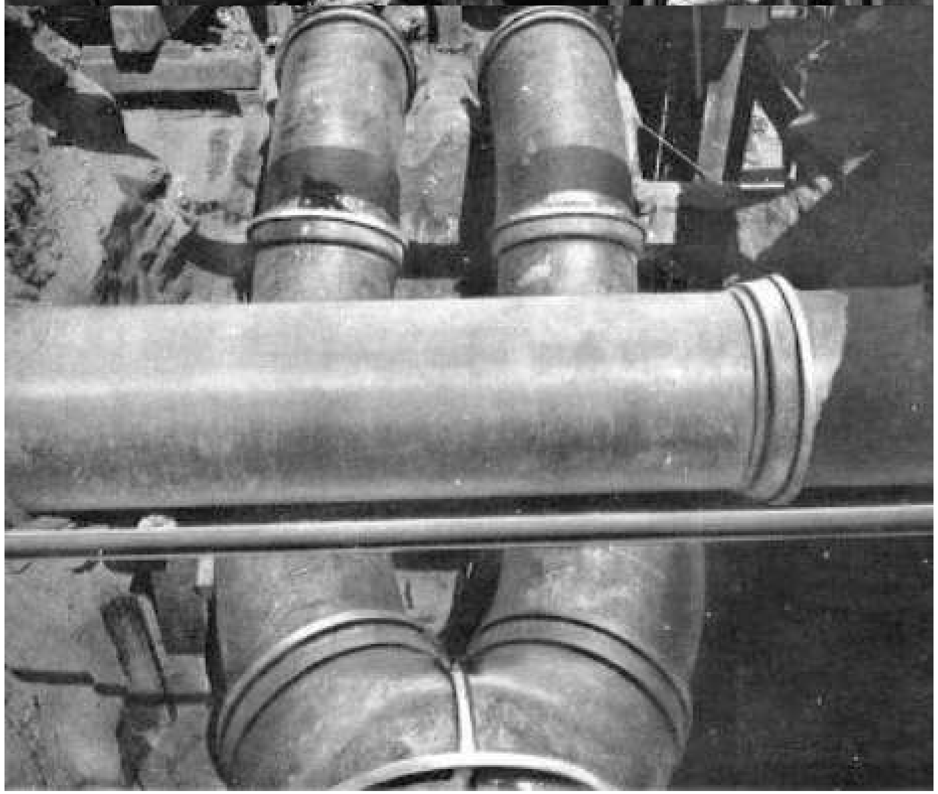
Calamity

"…Of the explosion of blasting-powder at Forty-first street by which eight were killed and hundreds endangered, about the only thing that can be said is that it might easily have been vastly more horrible. The carrying away of the subway roof, however, and the consequent fall of the fronts of several of the brownstone houses on the avenue just above Thirty-seventh street…The tunnel here burrows under the existing subway used by the Fourth Avenue surface-cars, and its floor is about sixty feet below the surface. It had been carried about half-way between Thirty-seventh and Thirty-eighth streets, at what was thought to be a safe distance from the stoop-line of the row of houses above. But the rock, apparently as solid as Gibraltar, lay in slanting strata, and one day, almost without warning, a huge section of one of these slanting strata simply slid diagonally from the easterly roof as a card slips out of a loosely shuffled pack. Every workman on the section was rushed to the spot in the hope that the damage could be repaired before it became apparent on the surface; but before the break could be properly shored, the areaways and front steps of the houses came tumbling down into the chasm. Parts of the front walls soon followed, and the crowd of idlers and nurse-maids and delivery-boys who gathered a few minutes after the first cave-in enjoyed the delectable experience of gazing into the very heart of each house, just as you look at an interior on the stage. One gentleman was in his bath-tub at the time. His valet burst into the room. 'Quick! quick! You must get out of here, Sir!' cried that worthy. 'There's been an earthquake, Sir, and the house is falling in!' 'Indeed!' observed the gentleman with interest, and he finished his bath…"

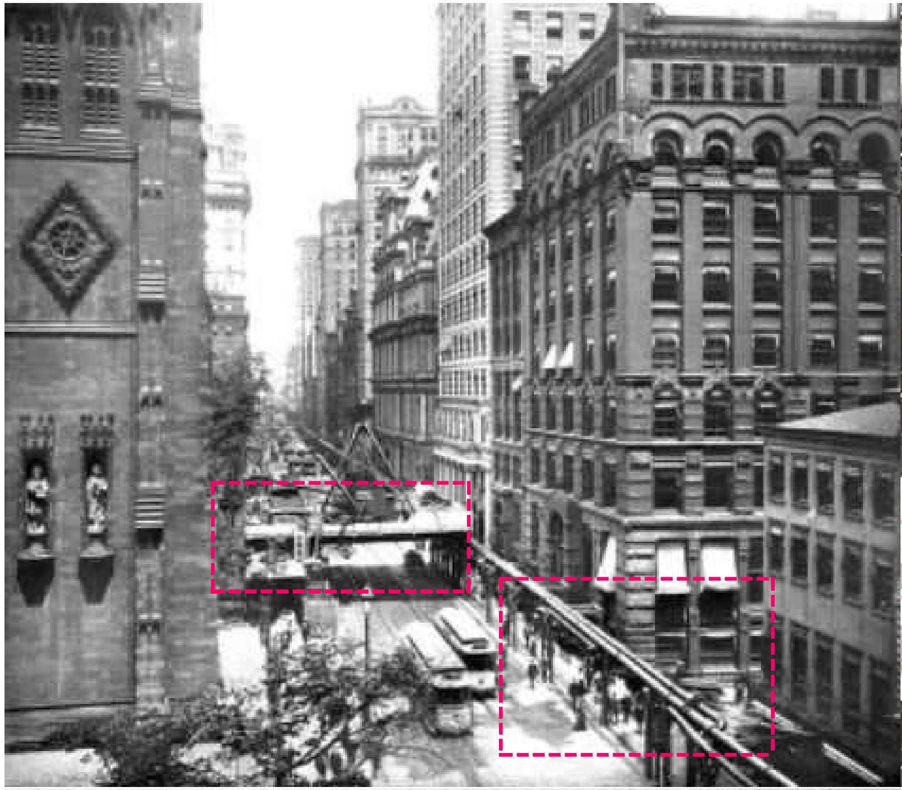
***Century Magazine,* October 1902**

The Underground Tangle of Pipes

The natural difficulties of the route were increased by the network of sewers, water and gas mains, steam pipes, pneumatic tubes, electric conduits and their accessories which filled the spaces below the streets and on the surface; railways and their infrastructure. In some places, the columns of the elevated railway had to be shored up temporarily and in other places the Subway passed close to the foundations of buildings, where delicate construction was needed to ensure the safety of both Subway and structure/s. Since the Subway was close to the surface along a considerable part of its route, its construction involved the reconstruction of all the underground pipes and ducts in many places as well as the removal of projecting vaults and/or buildings and, in some cases, the underpinning of their walls.



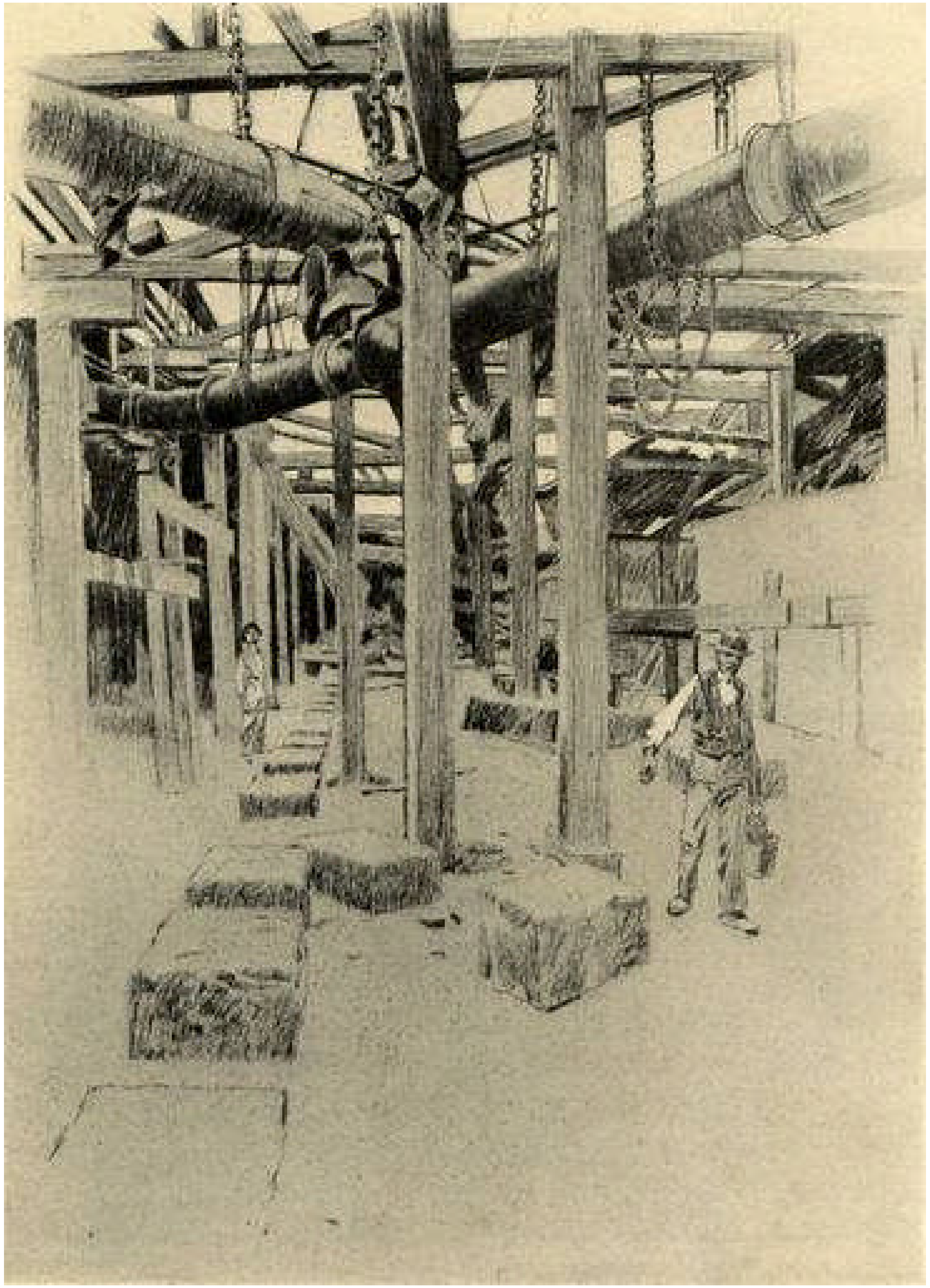
Top Left: caption: “Large gas and water pipes, relaid behind each side-wall on Elm Street”
Top Right: caption: “Subdivision of 36-inch and 30-inch gas mains over roof of Subway – 66th Street and Broadway”
Left: caption: “Difficult pipe work – Broadway and 70th Street”



<u>Top Left</u>: caption: “Looking up Broadway from Trinity Church – showing working platform and gas mains temporarily supported overhead”

<u>Top Right</u>: caption: “IRT Subway construction on Broadway”

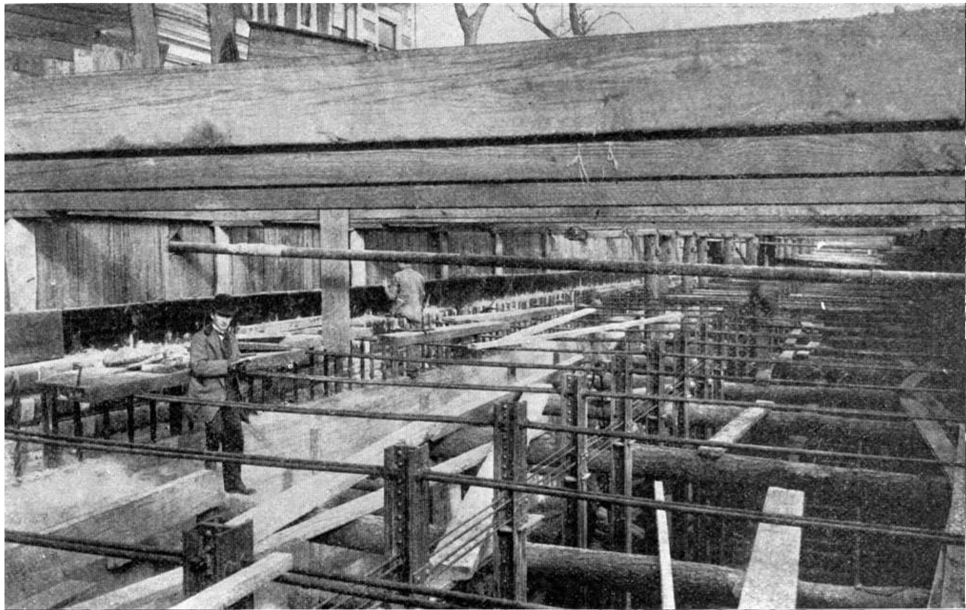
<u>Left</u>: caption: “IRT Subway construction, 103rd Street and Broadway”

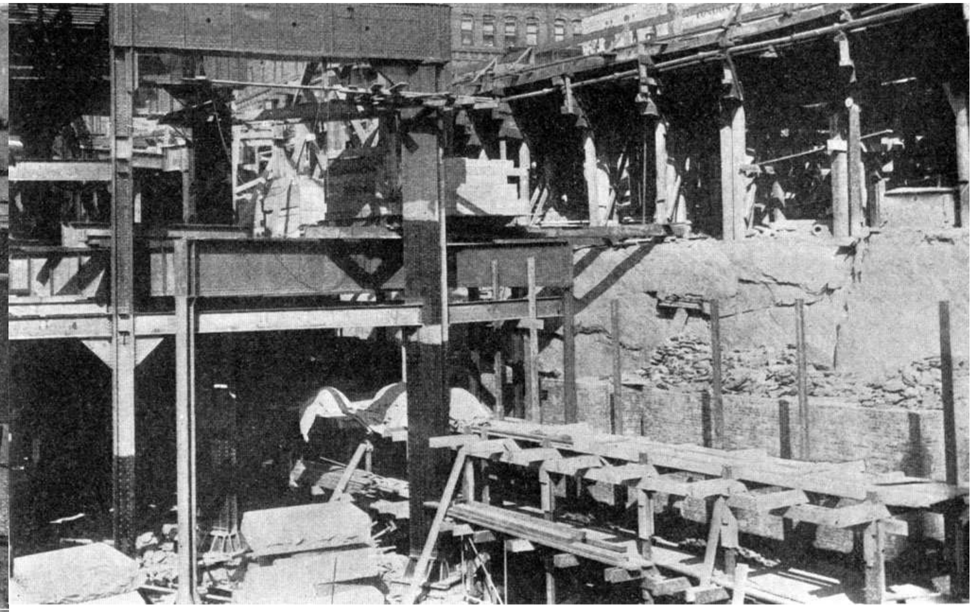


"…The streets of New York have not been blocked at any place by the work of excavation for the tunnel. Of course some of them have been narrowed to half their normal width at several points, but there has been little or no obstruction of traffic. The route selected is not a pipe thoroughfare throughout, but important pipes run parallel with the road for at least two thirds of the way. Wherever pipe crossings are encountered, the underground structures have been readjusted; but troublesome as this work is, it has been done without any serious blocking of the streets…"

***John B. McDonald,* 1902**

Left: caption: "The water-pipes in service under heavy pressure are temporarily suspended from beams at the street level. After the subway is completed, masonry piers will be built on its roof to support them."





<u>Top Left</u>: caption: “Lenox Avenue and 141st Street”
<u>Top Right</u>: caption: “Broadway and 42nd Street”
<u>Left</u>: caption: “Cut and Cover construction, NY Subway, 1902”

At *125th Street* and *Lenox Avenue,* one of the most complicated networks of subsurface structures was encountered. Street surface electric lines with their conduits intersected. On the south-side of 125th Street were a 48-inch and a 6-inch water main, one 12-inch and two 10-inch gas pipes and a bank of electric light and power ducts. On the north-side were a 20-inch water main, one 6-inch, one 10-inch and one 12-inch gas pipe and two banks of electric ducts. The headroom between the subway roof and the surface of the street was 4.75-feet. It was necessary to relocate the yokes of the street railway tracks on Lenox Avenue in order to bring them directly over the tunnel roof-beams. Between the lower flanges of the roof-beams for four bents were laid heavy steel plates well stiffened and in these troughs were laid four 20-inch pipes which carried the water of the 48-inch main. Special castings were necessary to make the connections at each end. The smaller pipes and ducts were rearranged and carried over the roof or laid in troughs composed of 3-inch I-beams laid on the lower flanges of the roof-beams. In addition to all the transverse pipes, there were numerous pipes and duct lines to be relaid and rebuilt parallel to the Subway and around the station. The change was accomplished without stopping or delaying the street cars and the water mains were shut off for only a few hours.

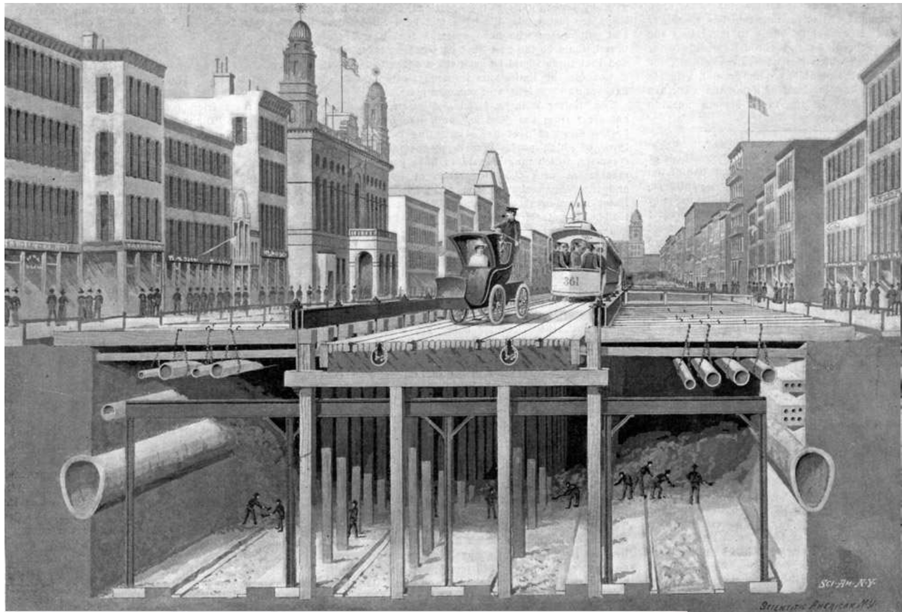
Left: caption: "Small water mains between street and surface and Subway roof, substituted for one large main – 125th Street and Lenox Avenue"

Right: caption: "Special riveted rectangular water pipe, over roof of Subway at 126th Street and Lenox Avenue"

"…A typical tangled puzzle of this kind is at Twenty Third Street and Fourth Avenue, where there is to be a large rapid transit station, and where surface car lines run along both avenue and street. Besides the obstacle their underground mechanism creates, gas, water, and sewer mains were encountered, in addition to pneumatic tubes through which mail is propelled, conduits for telegraph, telephone, high tension and low tension electric currents, and a few minor obstructions. These pipes, tubes, and conduits were piled upon one another like a lot of jackstraws…"

***John B. McDonald,* 1902**

RE: on *Fourth Avenue*, north of *Union Square* to *33rd Street*, there were two electric conduit railway tracks in the center of the roadway and a horse-car track near each curb for part of the distance. The two electric car tracks were used for traffic which could not be disturbed. These conditions rendered it impracticable to disturb the center of the roadway.



"…At such a point every pipe and conduit is charted and marked. As soon as the traction company has changed its motive power on the Lexington Avenue line, which is to be done this spring, the deep, broad cable pits will be abandoned, and we shall be at liberty to proceed. We shall take up, move aside, and relay each pipe, tube, or conduit. They will be replaced in an orderly arrangement just below the street pavement and alongside the rapid transit tunnel. Thus put down, the various pipes will form a pile nearly six feet in depth…"

John B. McDonald

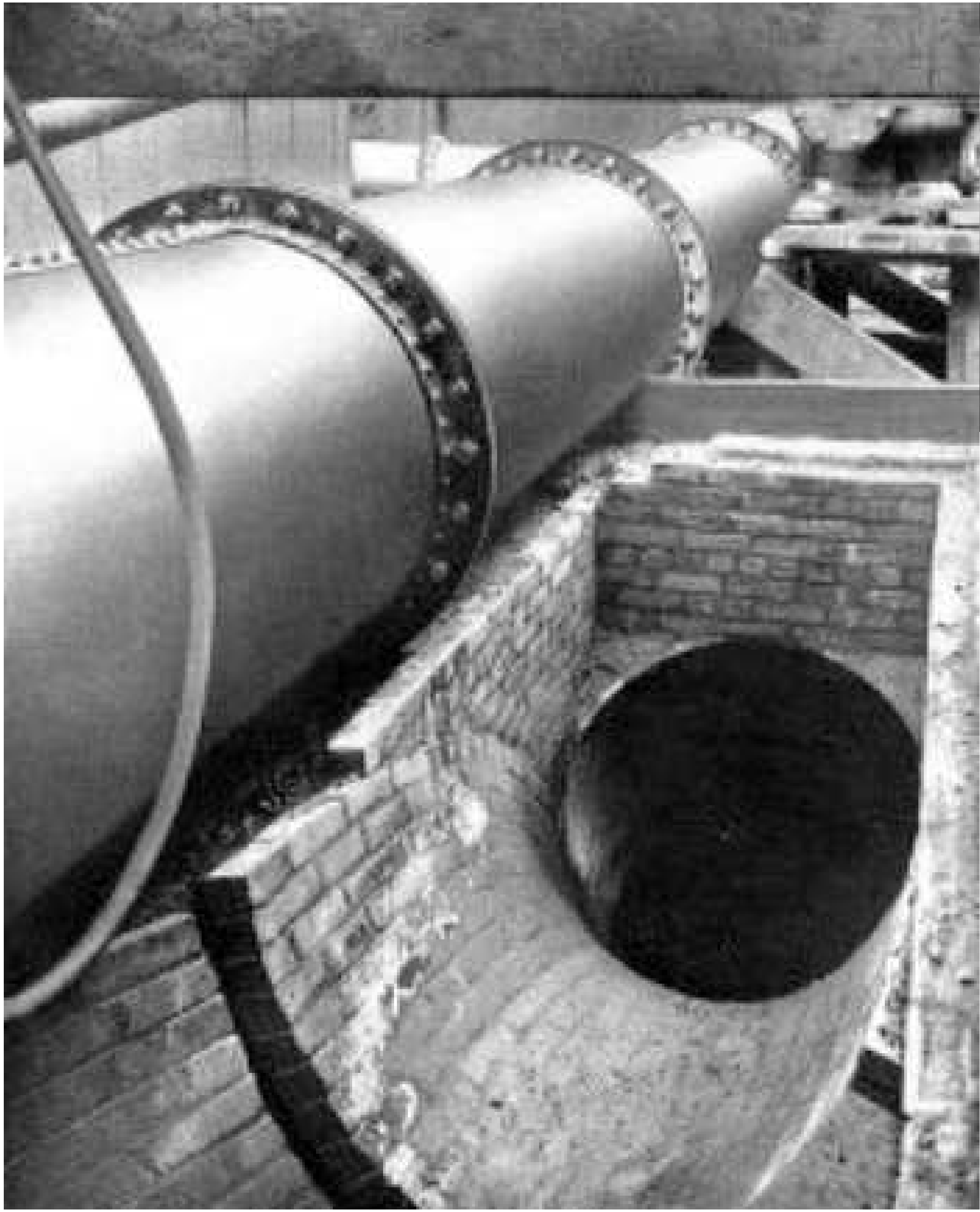
<u>Top Left</u>: caption: "Typical Cross-Section of Subway on Fourth Avenue, Showing Method of Supporting Trolley Tracks and Gas and Water Mains During Construction." ***Scientific American*****, September 1902**

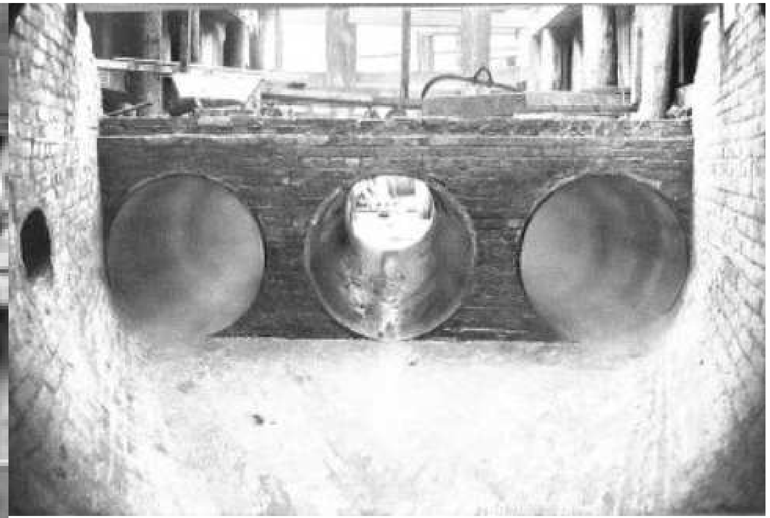
<u>Top Right</u>: caption: "Derrick with Stiff Leg spanning Surface Railway Track — Section 3"

<u>Left</u>: caption: "Forty-second Street during construction of the subway system"

Sewer Diversion

The typical Subway near the surface was used for about one-half of the route. Since the sewers were at a depth interfering with construction, it meant that the sewers along that half had to be reconstructed. Thus, nearly as many main sewers had to be reconstructed off the route of the Subway as on the route; 7.21 miles of main sewers along the route were reconstructed and 5.13 miles of main sewers off the route. The reason why so many main sewers on streets away from the Subway had to be rebuilt was due to the fact that from *42nd Street* south there was a natural ridge and before the construction of the Subway, sewers drained to the *East River* and/or to the *Hudson River* from the ridge. The route was so near to the dividing line that the only way to care for the sewers was, in many instances, to build entirely new outfall sewers.





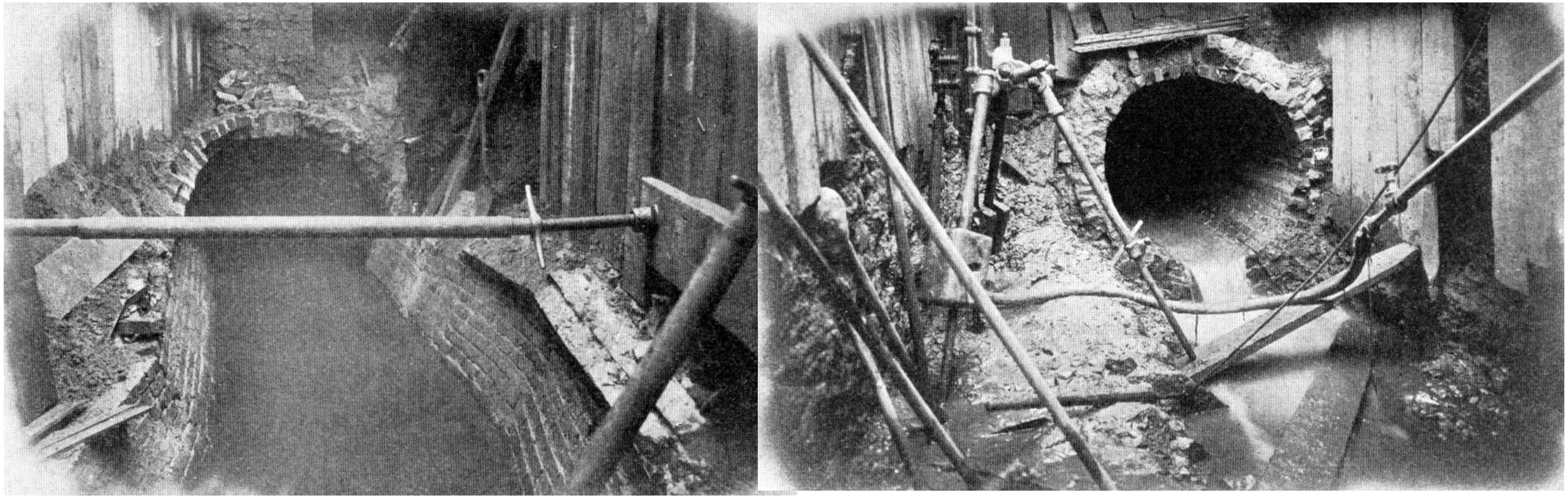
At *110th Street* and *Lenox Avenue,* a 6.5-foot circular brick sewer intersected the line of the subway at a level which necessitated its removal or subdivision. The latter was adopted and three 42-inch cast-iron pipes were passed under the Subway. At *149th Street* and *Railroad Avenue,* a sewer had to be lowered below tide level in order to cross under the Subway. To do this, two permanent inverted siphons were built of 48-inch cast-iron pipe. Two were built in order that one might be used, while the other could be shut off for maintenance. This was the only instance where siphons were used.

Above: caption: "Three pipes substituted for large brick sewer at 110th Street and Lenox Avenue"

Left: caption: "Sewer siphon at 149th Street and Railroad Avenue"

A notable example of sewer diversion was at *Canal Street* where the flow of the sewer was carried into the *East River* instead of the *Hudson River* permitting the sewer to be bulk-headed on the west-side and continued in use. On the east-side a new main sewer was constructed to empty into the East River. The new east-side sewer was built off the route of the Subway for over a mile. An interesting feature in the construction was the work at *Chatham Square*, where a 6.5-foot circular brick conduit was built. The confluence at this point of numerous electric surface car lines, elevated railroad pillars and voluminous vehicular street traffic made it imperative that the surface of the street not be disturbed thus the sewer was built by tunneling. This tunneling was through very fine running sand and the section to be excavated was small. To meet these conditions, a novel method of construction was used. Interlocked "poling boards" were employed to support the roof and were driven by lever jacks (similar in manner to the method used in the shield system of tunneling). The forward ends of the poling boards were supported by a cantilever beam. The sides and front of the excavation were supported by lagging boards laid flat against and over strips of canvas which were rolled down as the excavation progressed. The sewer was completed and lined in lengths of from one-foot to 4.5-feet and at the maximum rate of work about twelve-feet of sewer were finished per week.

Left: caption: "Special construction of 6.5-foot sewer, under Chatham Square"

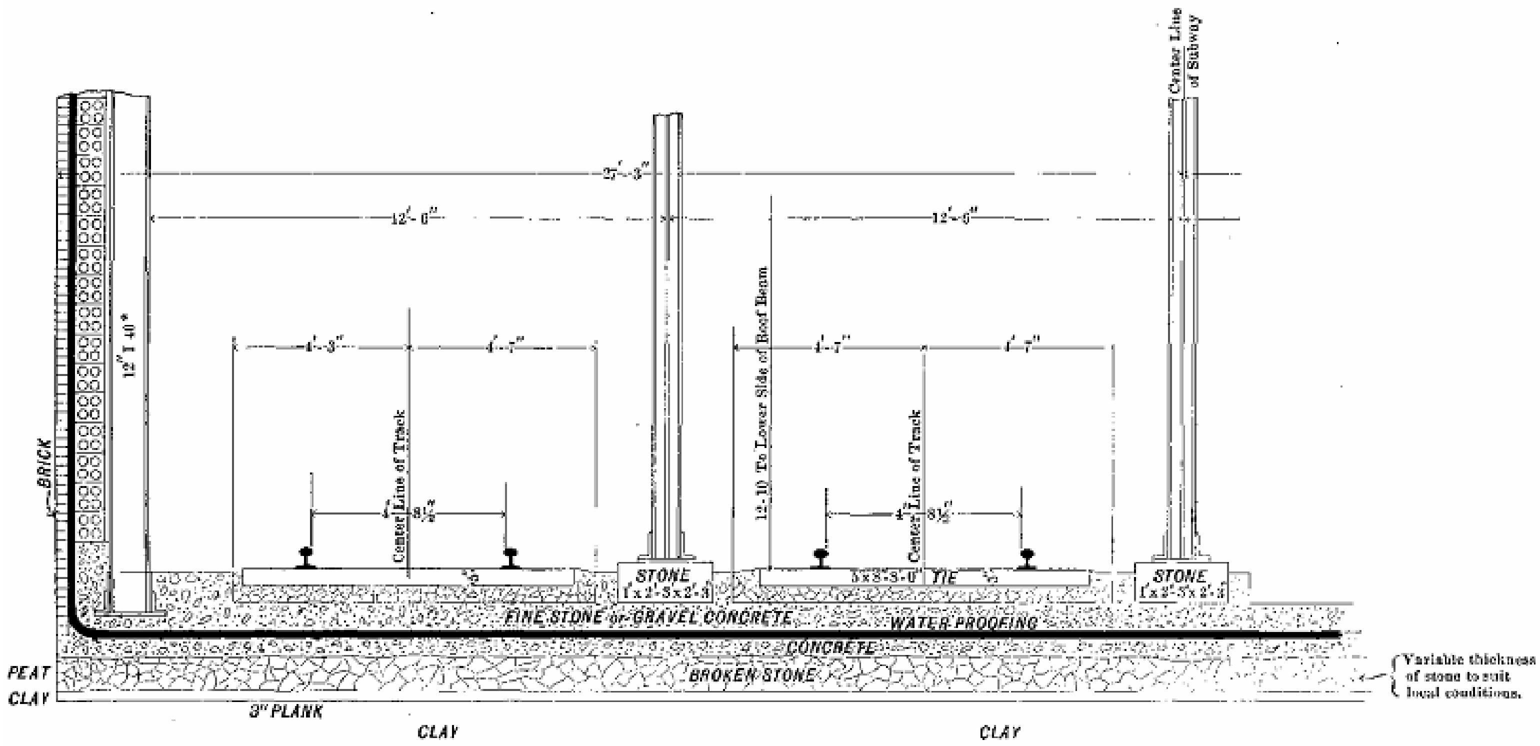


"…There were some special problems to be solved at certain points. The road crossed one or two sewers in places where, owing to the low elevation of the ground, it was not possible to carry them down beneath the railway bed. At Canal Street there was a sewer nine feet wide and six feet high, which drained an area of one hundred and twenty one acres lying east of the road, and ran across Broadway to the Hudson River. In this case a new channel, six feet in diameter, was built from the East River up James, Mulberry, and Center Streets to Canal Street, so that now the drainage of that district will be conveyed eastward instead of to the west…"

***John B. McDonald,* 1902**

Left: *Bleecker Street* sewer

Right: *157th Street* sewer



The work was all done by open excavation; the so-called "cut and cover" system, but the conditions varied widely along different parts of the line, and different means were adopted to overcome local difficulties. The distance of the rock surface below the street level had a marked influence on the manner in which the excavation of the open trenches could be made. In some places the rock rose nearly to the pavement, as between *14th* and *18th Street/s*. At other places the Subway was located in water-bearing loam and sand, as in the stretch between *Pearl* and *Grand Street/s*, where it was necessary to employ a special design for the bottom. This part of the route included the former site of the ancient *Collect Pond*, familiar in the early history of *New York City* and the excavation was through "made ground" (the pond was filled-in for building purposes after it was abandoned for supplying water to the city). The excavations through adjacent *Canal Street* were also through made ground, that street having been at one time (as its name implies) a canal.

Above: caption: "Section of Subway at Pearl Street"

Drainage

The application of waterproofing to the exterior surfaces of the shell of the Subway tunnel, which was applied to the masonry without a break along the entire route, made it unnecessary to provide an extensive system of drains, sump pits etc. for the collection and removal of water from the interior of the tunnel. However, at each depression or point where water could collect from any cause, such as by leakage through a cable manhole cover or by the breaking of an adjacent water pipe or the like, a sump pit or drain was provided for carrying the water away from the interior of the tunnel. For all locations where such drains or sump pits were located above the line of the adjacent sewer, the carrying of the water away was easily accomplished by employing a drain pipe in connection with suitable traps and valves. However, in other cases where it was necessary to elevate the water, the problem was of a different nature. In such cases, whenever possible, at each depression where water was liable to collect a well or sump pit was constructed just outside the shell of the tunnel. The bottom of the well was placed lower than the floor of the tunnel, so that the water would flow into the well through a drain connecting to the tunnel. Each well was provided with a pump. In the case of these wells and in other locations where it was necessary to maintain pumps, it was not possible to employ a uniform design of pumping equipment since various locations offered different conditions. An electric pump was employed in only two cases (compressed-air was considered more reliable at the time).

The several tunnel depressions where it was necessary to maintain a pumping plant were as follows:

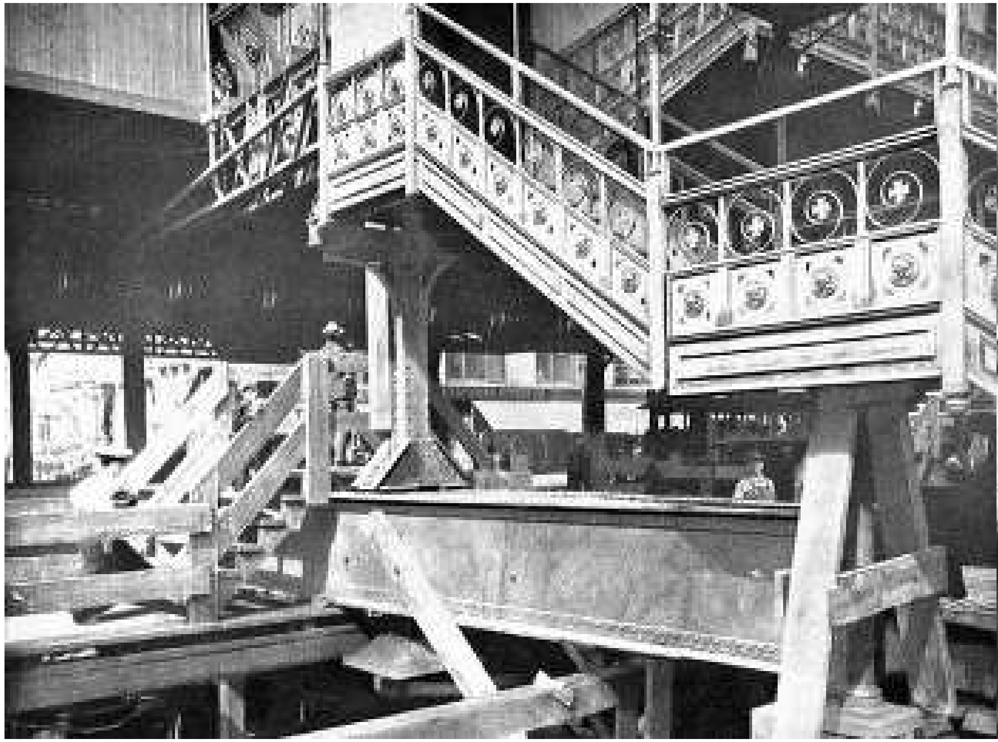
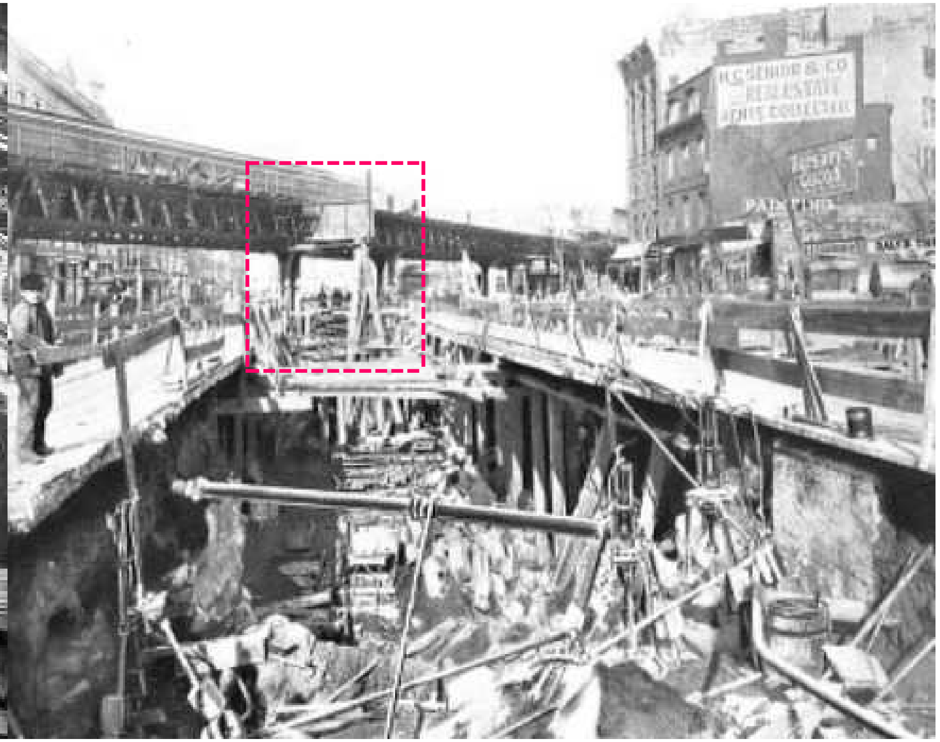
- **No. 1—Sump at the lowest point on City Hall Loop;**
- **No. 2—Sump at intersection of Elm and White Street/s;**
- **No. 3—Sump at 38th Street in the Murray Hill Tunnel;**
- **No. 4—Sump at intersection of 46th Street and Broadway;**
- **No. 5—Sump at intersection of 116th Street and Lenox Avenue;**
- **No. 6—Sump at intersection of 142nd Street and Lenox Avenue;**
- **No. 7—Sump at intersection of 147th Street and Lenox Avenue;**
- **No. 8—Sump at about 144th Street in the Harlem River Approach;**
- **No. 9—Sump at the center of the Harlem River Tunnel;**
- **No. 10—Sump at intersection of Gerard Avenue and 149th Street**

In addition to the above mentioned sump pits where pumping plants were maintained, it was necessary to maintain pumping plants at the following points:

- **Location No. 1—At the cable tunnel constructed under the Subway at 23rd Street and Fourth Avenue;**
- **Location No. 2—At the sub-subway at 42nd Street and Broadway;**
- **Location No. 3—At the portal of the Lenox Avenue extension at 148th Street;**
- **Location No. 4—At the southerly end of the Harlem River Tunnel;**
- **Location No. 5—At the northerly end of the Harlem River Tunnel;**
- **Location No. 6—At the portal at Bergen Avenue and 149th Street;**

The air supply to the air-operated pumps was independent of the compressed air line which supplied air to the switch and signal system, but breakdown connections were made between the two systems so that either system could assist the other out in case of emergency. A special air-compressor plant was located at the *148th Street* repair shop and another plant within the Subway at *41st Street* for supplying air to the pumps within the immediate locality of each compressor plant. For the more remote pumps, air was supplied by small air-compressors located within passenger stations. In one case, for the No. 2 sump, air was taken from the switch and signal air-compressor plant located at the No. 11 sub-station.

Underpinning

In a number of places it was necessary to underpin the columns of the elevated railways and a variety of methods were adopted. A typical example of the difficulties involved was to be found at the ***Manhattan Railway*** elevated station at ***Sixth Avenue*** and ***42nd Street*** **(left). The stairways of this station were directly over the open excavation for the subway in the 42nd Street thoroughfare and were used by a large number of people. The work was done in the same manner at each of the four corners. Two narrow pits about forty-feet apart were first sunk and their bottoms covered with concrete at the elevation of the floor of the Subway. A trestle was built in each pit and on these were placed a pair of three-foot plate girders; one on each side of the elevated column which was midway between the trestles. The column was then riveted to the girders and was thus held independent of its original foundations. Other pits were then sunk under the stairway and trestles built in them to support it. When this work was completed it was possible to carry out the remaining excavation without interfering with the elevated railway traffic. Also, at** ***64th Street*** **and** ***Broadway*** **(right), the whole elevated railway had to be supported during construction. A temporary wooden bent was used to carry the elevated structure. The elevated columns were removed until the subway structure was completed and then re-installed.**

"…Throughout most of the sections below One Hundred and Fourth Street, the tunnel digging has involved a tremendous amount of delicate cutting away of earth. A slip of pickax or shovel might do great damage to any of the pipes which fill the space close under the surface. Thus far no accident of this kind has occurred. The men ply their tools as delicately as if they were scalpels. The pipes under and around which so much digging is done are supported in their proper positions by immense chains, which are swung from gigantic wooden girders and adjusted with scrupulous care. Similar girders are used to support street car tracks wherever the tunnel excavation is done from the surface. Owing to the great care that has been taken, no accident has occurred in these branches of the work…"

***John B. McDonald,* 1902**

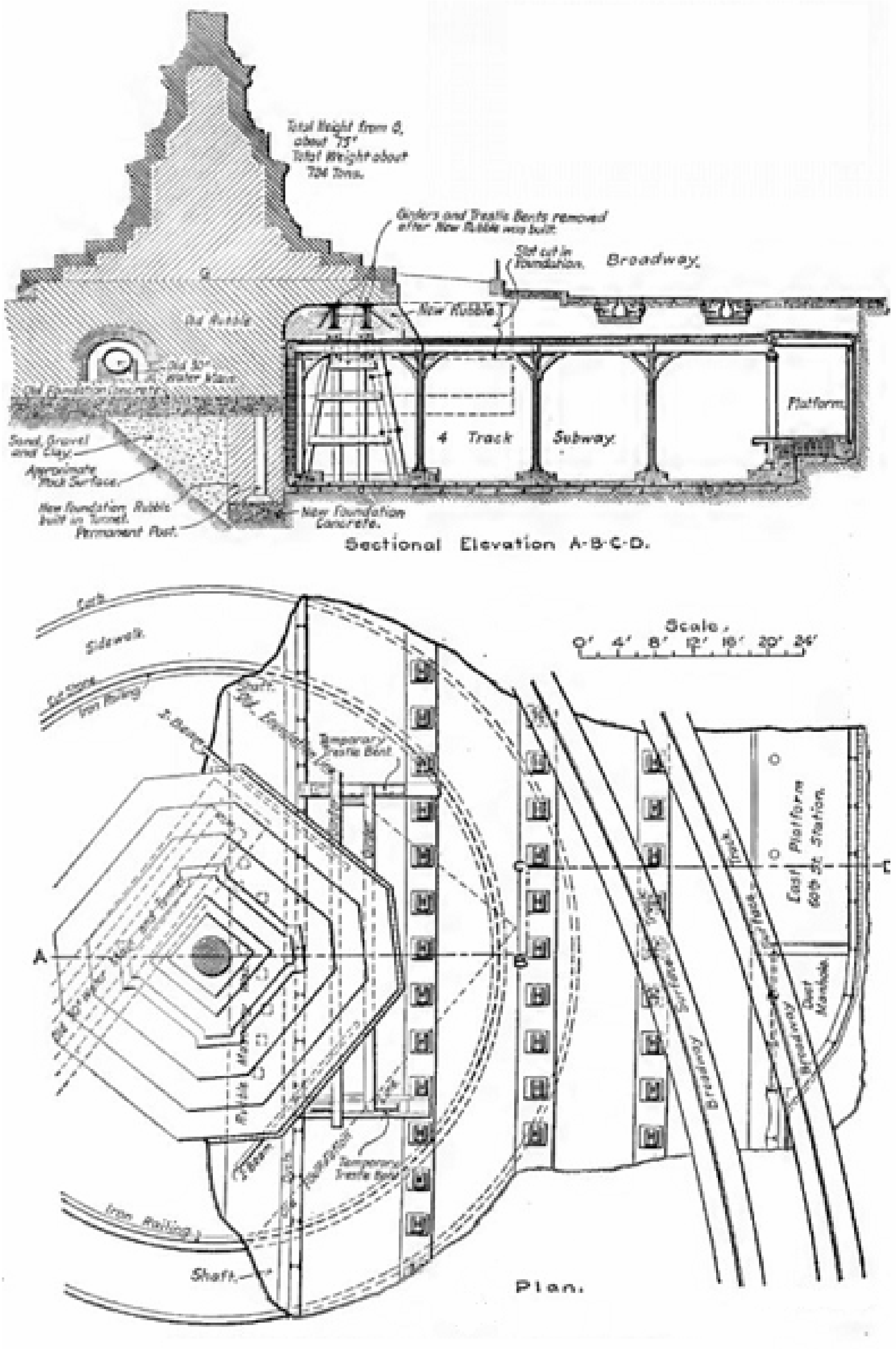
Left: caption: "Excavation for Subway in progress under Metropolitan Street Railway Tracks"

Right: caption: "Surface railway tracks supported over excavation on upper Broadway"

Under The Columbus Monument

"…In the Circle, just below this station, rises the tall column on the top of which stands the statue of Cristoforo Colombo, given to New York by its residents of Italian birth. The subway passes directly under this column, and the difficulties and delicacies of the task of shoring up this monument while the excavation was going on were not lightened by the fact that the foundation of the column rested partly on rock and partly on sand…"

***Century Magazine,* October 1902**

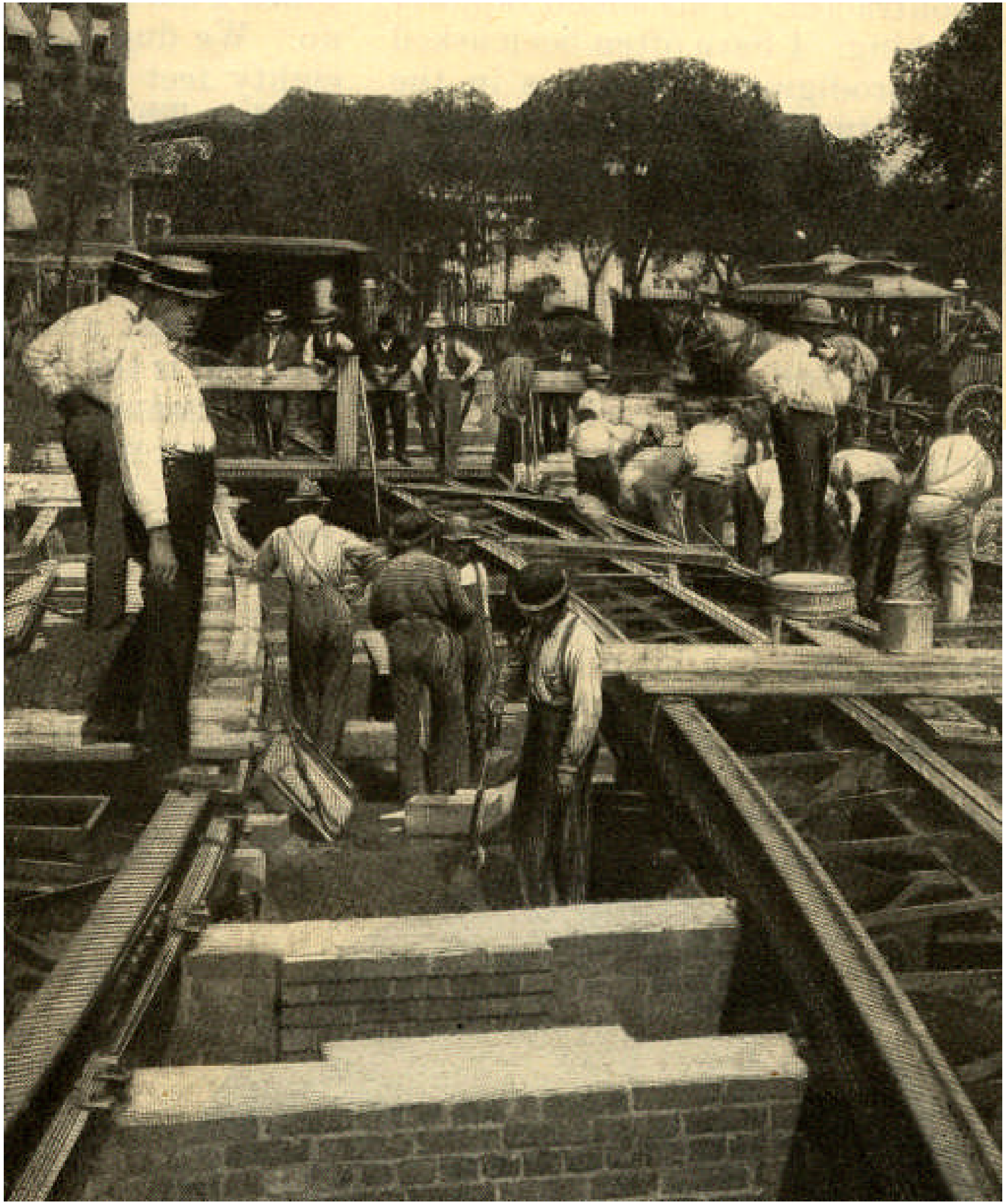


"Near where the subway swings around the southwest corner of Central Park it passes through and under the foundations of the Columbus monument. The slender stone shaft, surmounted by its heroic statue, is seated on a molded pedestal with extended base, which altogether rises seventy-five feet above the street and weighs nearly a million and a half pounds. It has a masonry foundation forty-five feet square and fourteen feet deep, which was built partly on rock, but mostly on earth. Its east corner overhangs the subway nearly forty feet, and the position of the latter is so near the surface of the ground that its walls and roof cut a wide and deep section out of the masonry. This made it necessary to support the monument so that its tall shaft should neither lean nor settle a hair's-breadth, nor the thin, accurately fitted pedestal stones be cracked, or their polished joints open, under the great strains developed when the masonry was cut out to a mere shell and the support removed from under a third of its base and almost up to the center, reducing its stability to a slender margin..."

***Century Magazine,* October 1902**

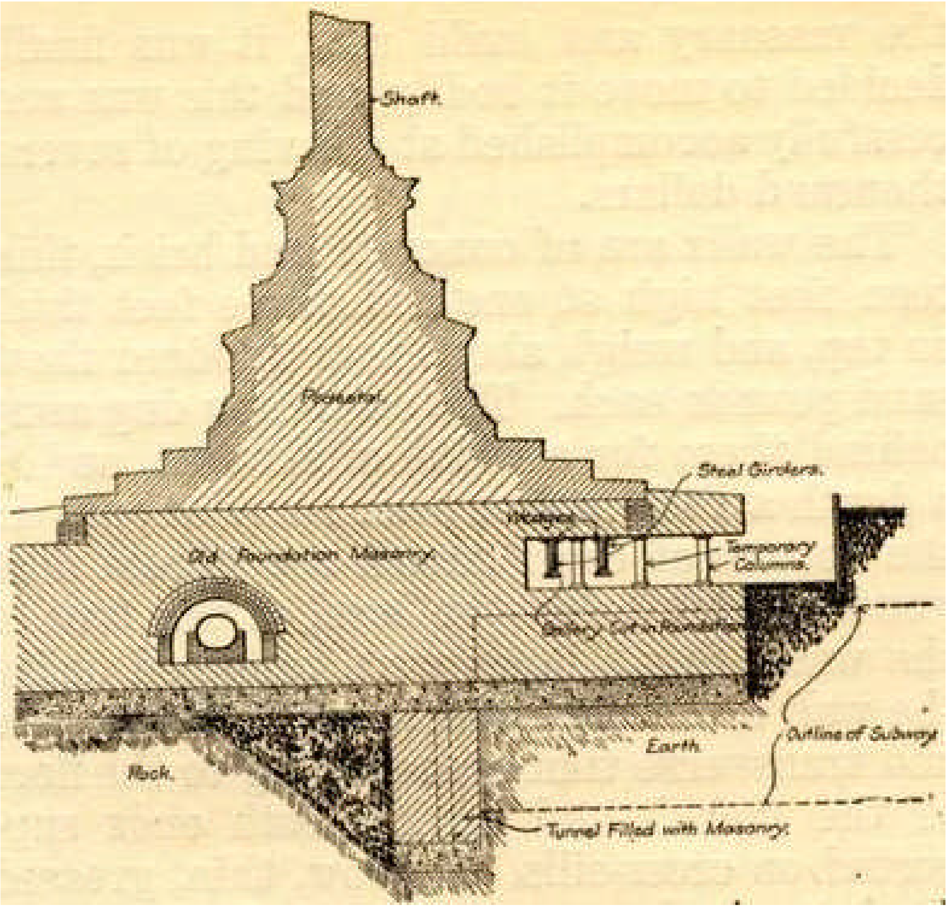
<u>Left</u>: caption: "Underpinning the Columbus Monument, New York – July 27th 1901"

A feature of the construction which attracted considerable public attention while it was in progress was the underpinning of a part of the *Columbus Monument* near the southwest entrance to *Central Park*. This handsome memorial column had a stone shaft rising about 75-feet above street level and weighed about 700-tons. Its rubble masonry foundation was 45-feet square and rested on a two-foot course of concrete. The Subway passed under its east-side within three-feet of its center, thus cutting out about three-tenths of the original support. At this place the footing was on dry sand of considerable depth, but on the other side of the monument rock rose within three-feet of the surface. The steep slope of the rock surface toward the Subway necessitated particular care in underpinning the footings. The work was done by first driving a tunnel six-feet wide and seven-feet high under the monument just outside the wall line of the Subway. The tunnel was given a two-foot bottom of concrete as a support for a row of wood posts a foot square, which were put in every five-feet to carry the footing above. When these posts were securely wedged in place the tunnel was filled with rubble masonry. This wall was strong enough to carry the weight of the portion of the monument over the Subway, but the monument had to be supported to prevent its breaking off when undermined. Thus, to support it a small tunnel was driven through the rubble masonry foundation just below the street level and a pair of plate girders run through it. A trestle bent was then built under each end of the girders in the finished excavation for the subway. The girders were wedged up against the top of the tunnel in the masonry and the excavation was carried out under the monument without any damage to the structure.



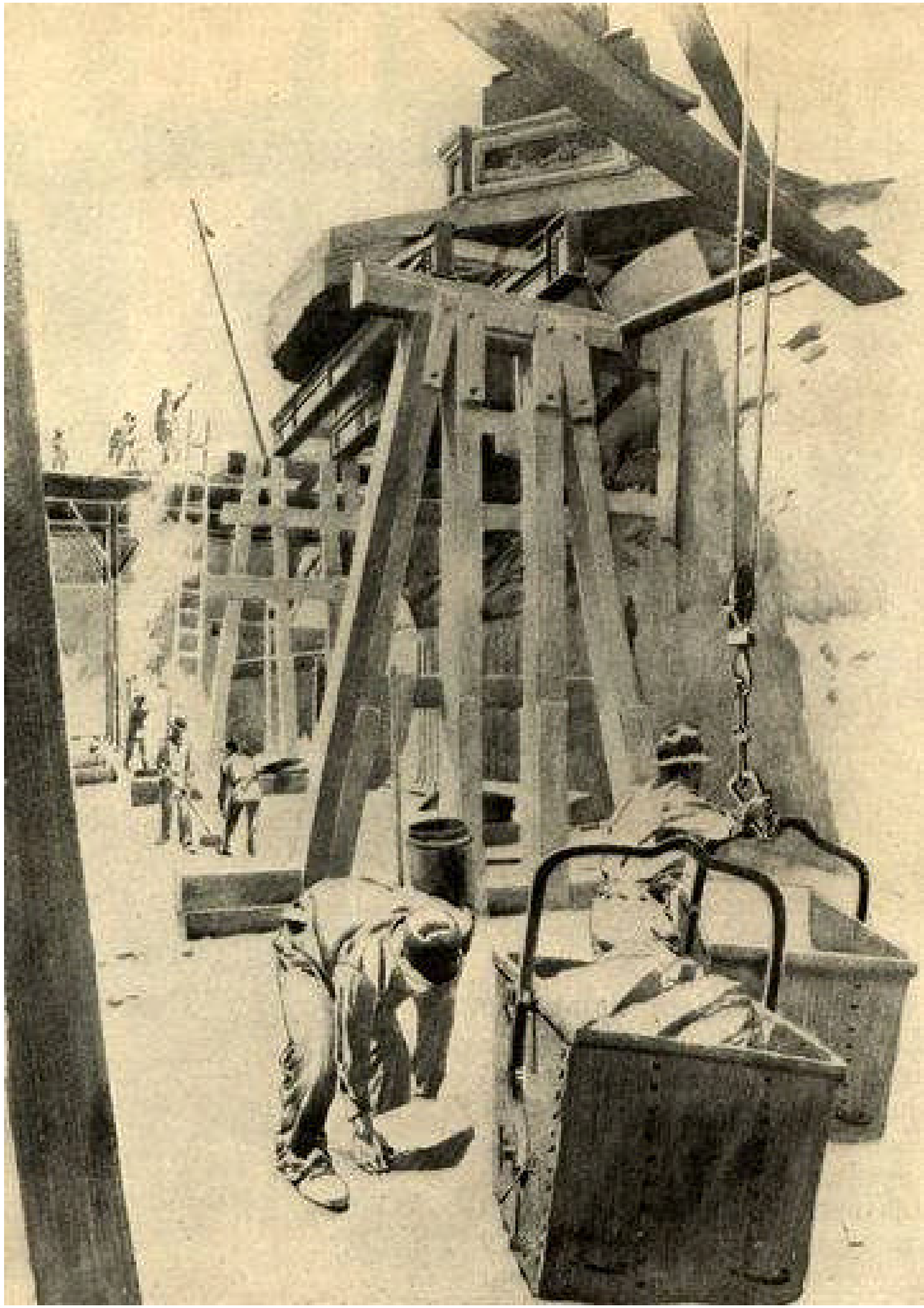
<u>Above</u>: caption: "The circle at Eighth Avenue, Broadway, and Fifty-ninth Street, where the rapid transit tunnel passes close under three lines of electric surface cars and the Columbus Monument, and where the work of excavation is especially difficult."

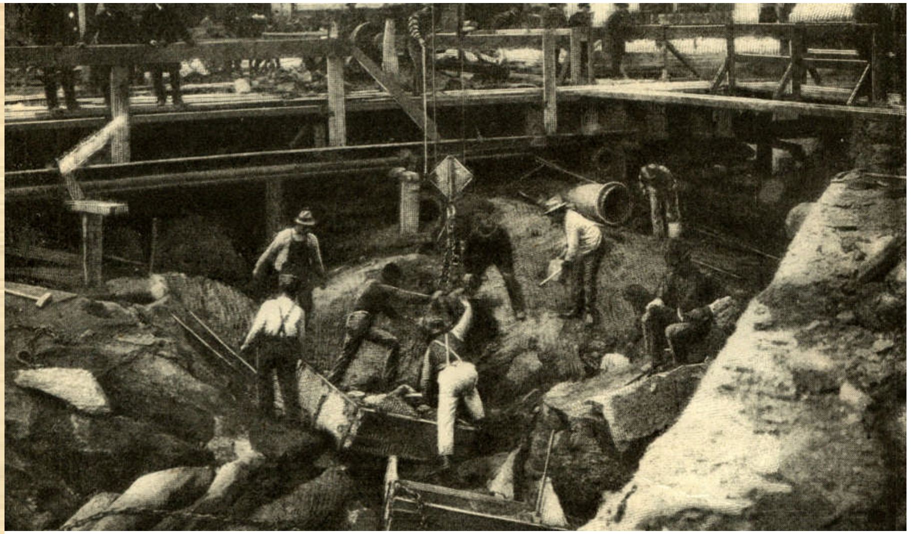
<u>Left</u>: caption: "Preliminary work in the circle at Eighth Avenue and Fifty-ninth Street, where the tracks of the electric surface line on upper Broadway were completed while the construction of the tunnel road was beginning"



"…A trench ten feet deep was dug around the east side of the monument, exposing the upper part of the foundation where it extended over the line of the subway. From this trench a gallery, or slot, six feet high was cut about twenty-five feet horizontally into the face of the foundation masonry, and as it advanced, vertical timber posts were set on its floor and wedged up to support its roof. When the slot extended about thirty feet through the corner of the foundation, two solid steel girders, like beams in a railroad-bridge, were set in it between the rows of posts…"

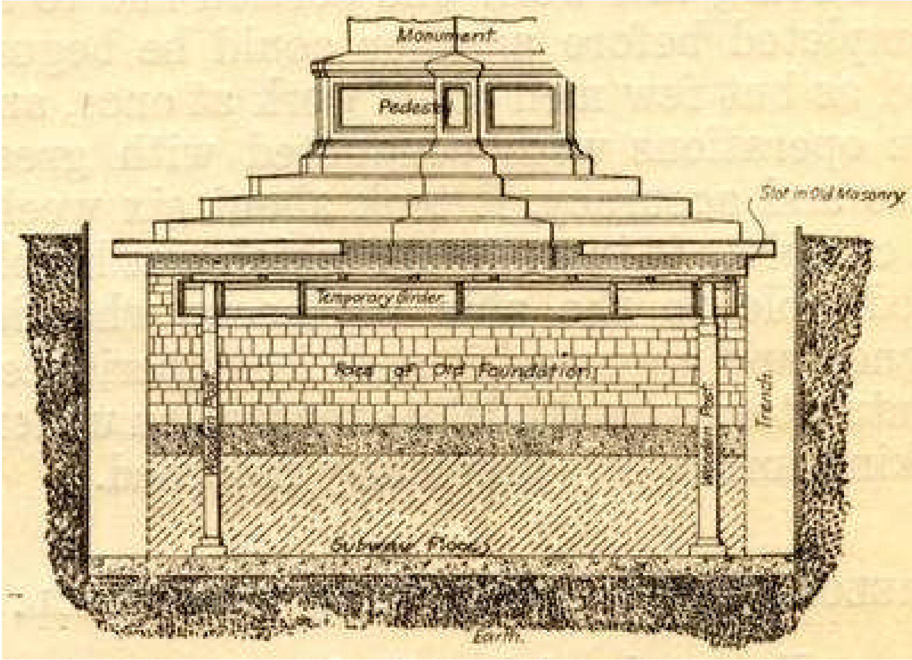
***Century Magazine,* October 1902**





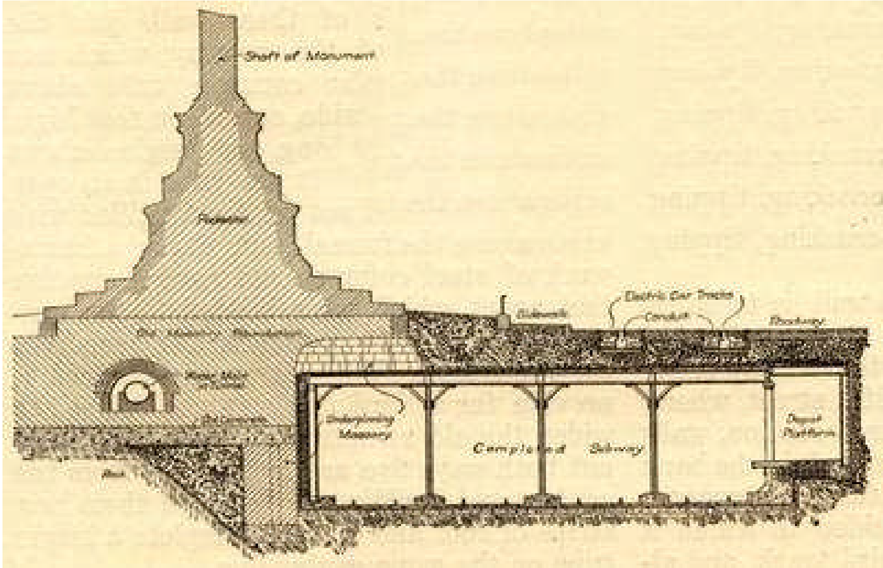
Above: caption: "The great rock excavation in the circle at Eighth avenue and Fifty-ninth Street, where one of the stations of the underground road will be constructed under the surface car tracks"

Left: caption: "The foundations of the monument are supported on temporary steel girders and wooden posts while undermined for subway excavation under the monument and over sloping rock surface. The concrete floor of subway is shown finished and ready to receive the steel columns which will support its roof and the overhanging monument. The steel buckets containing excavated rock are hoisted by steam-derricks and dumped into wagons."



"…A pit was dug close to the foundation at each end of the slot, and the bottom was covered with concrete, which afterward formed part of the subway floor. On this concrete were set braced wooden posts to carry the ends of the girders, which were thus lifted clear of the floor of the slot. Pairs of steel wedges were driven between the tops of the girders and the roof of the slot until they lifted the whole mass of masonry a fraction of an inch and transferred the weight of the overhanging portion to the girders. Then the roof posts were removed, and the outer edge of the foundation and all that portion below the slot were cut away, the excavation completed, and the subway built in it, under the overhanging foundation and around the posts which supported the girders…"

***Century Magazine,* October 1902**



"…Under the edge of the overhanging foundation, outside of the girders, a wall was built on the concrete roof of the subway which is very strong, with steel beams and columns. A course of cut stone was laid in the upper part of the wall, and on it many pairs of steel wedges supported a loose course of cut stone carefully fitted in under the overhanging masonry of the foundation. The wedges were driven up, and developed an enormous pressure, which lifted the monument again, transferred part of its weight to the new wall, and released the girders. They were removed, and the spaces they had occupied were filled in solid with masonry, built and wedged up from the center outward in the same manner as the wall. Liquid cement was forced into the interstices between the wedges, and solidifying as hard as flint, perfected the support of all the overhanging foundation on top of the finished subway. In doing this work one portion had to be completed before another could be begun, and as but few men could work at once, and the operations were conducted with great care and accuracy, it took about six weeks to complete it in a manner which was highly creditable to the able engineers who designed and approved it and the experienced contractors who skillfully executed an undertaking unlike any previously recorded…"

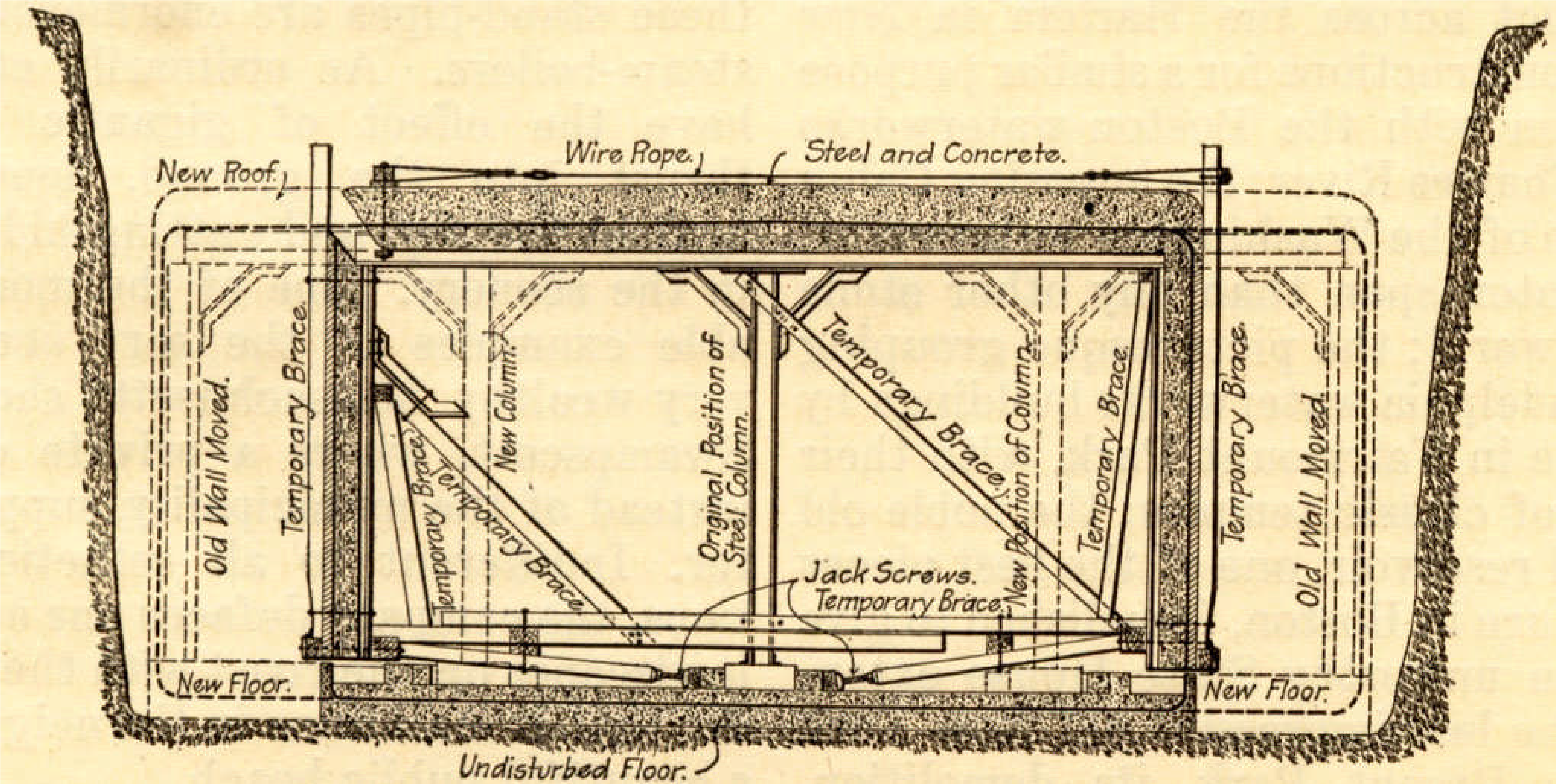
Century Magazine, **October 1902**

To Move a Tunnel

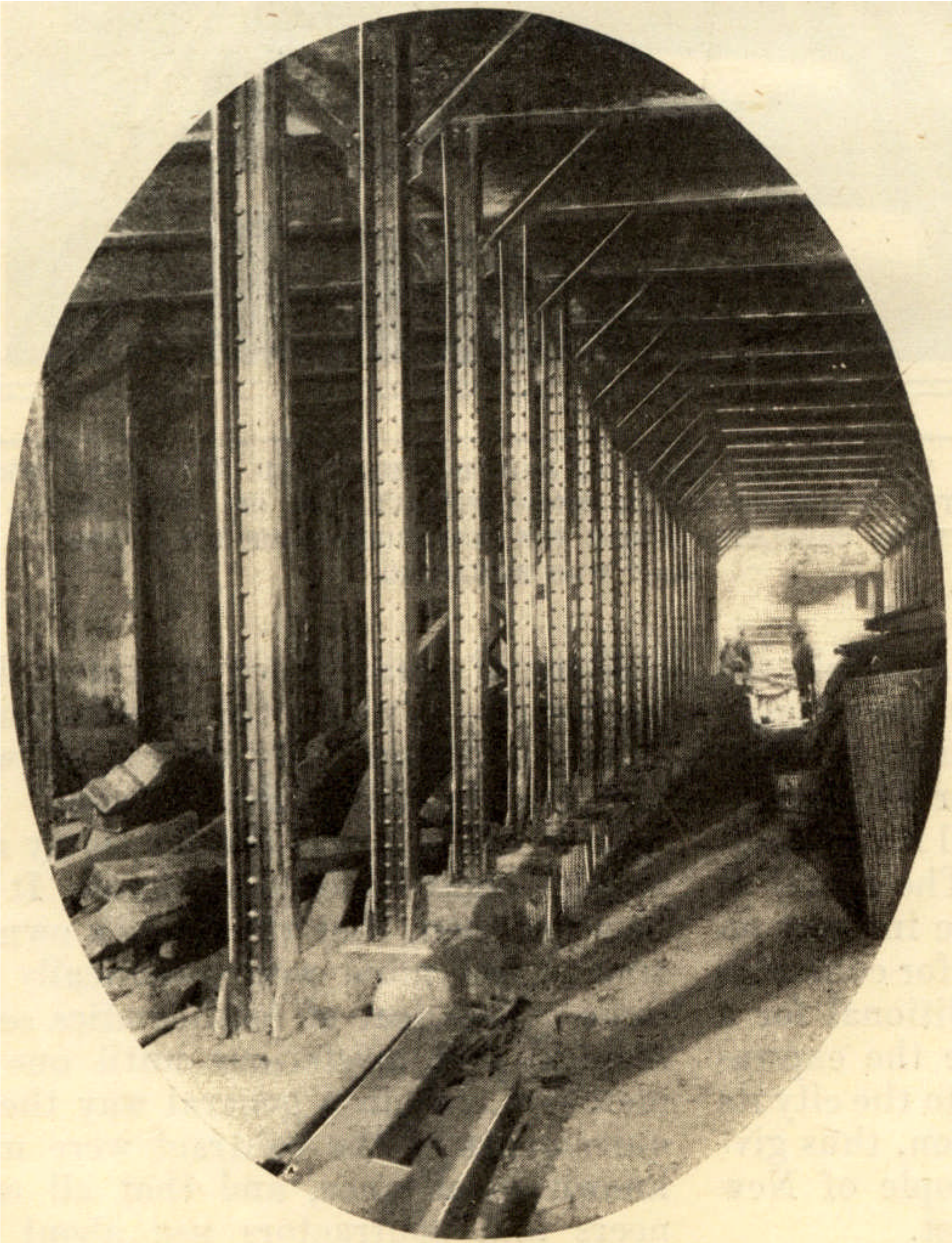
At *134th Street* and *Broadway,* a two-track structure of the steel I-beam type (about 200-feet long) was completed. Approaching it from the south, leading from the *Manhattan Valley Viaduct*, was an open cut with retaining walls 300-feet long and from three to thirteen-feet in height. After all this work was finished (it was the first finished on the route), it was decided to widen the road to three tracks. The retaining walls were moved bodily on slides, by means of jacks, to a line 6.25-feet on each side, widening the roadbed 12.5-feet without a break in either wall. The method of widening the steel I-beam typical Subway portion was equally novel. The west wall was moved bodily by jacks the necessary distance to bring it in line with the new position of the west retaining wall. The remainder of the structure was then moved bodily, also by jacks, 6.25-feet to the east. The new roof of the usual type was then added over 12.5-feet of additional opening.

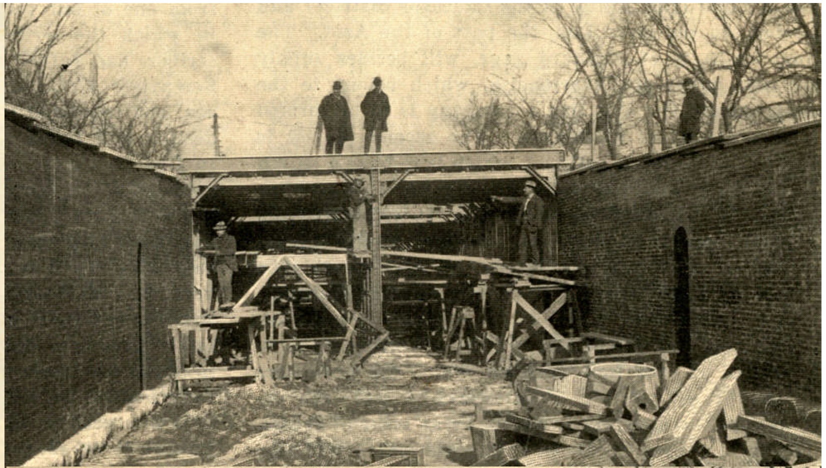
Left: caption: "Moving brick and concrete retaining wall to make room for third track – Broadway and 134th Street"

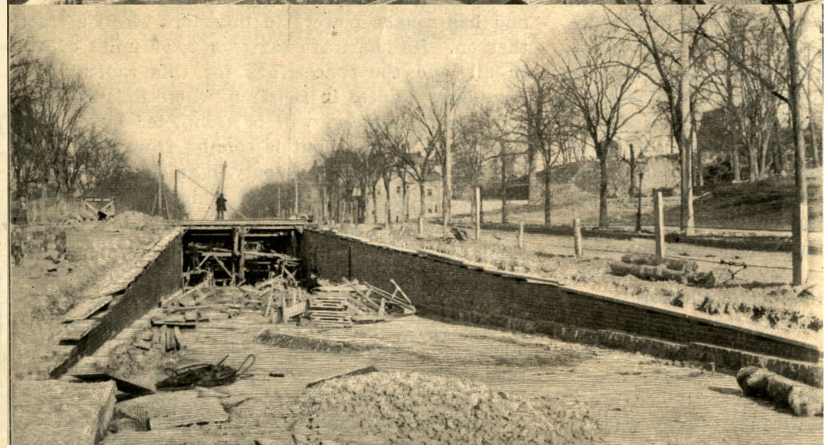
Right: caption: "Moving west-side wall to widen Subway for third track – 135th Street and Broadway"



New Roof.
Wire Rope.
Steel and Concrete.
Old Wall Moved.
Temporary Brace.
Temporary Brace.
Temporary Brace.
New Column.
Original Position of Steel Column.
Temporary Brace.
New Position of Column.
Temporary Brace.
Temporary Brace.
Old Wall Moved.
Jack Screws.
Temporary Brace.
New Floor.
New Floor.
Undisturbed Floor.

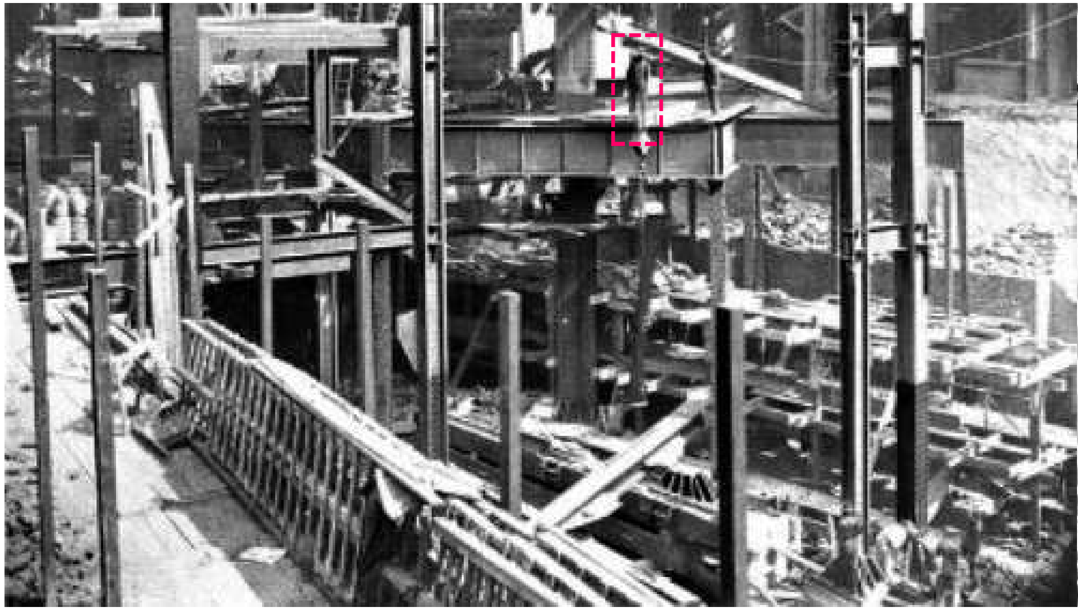
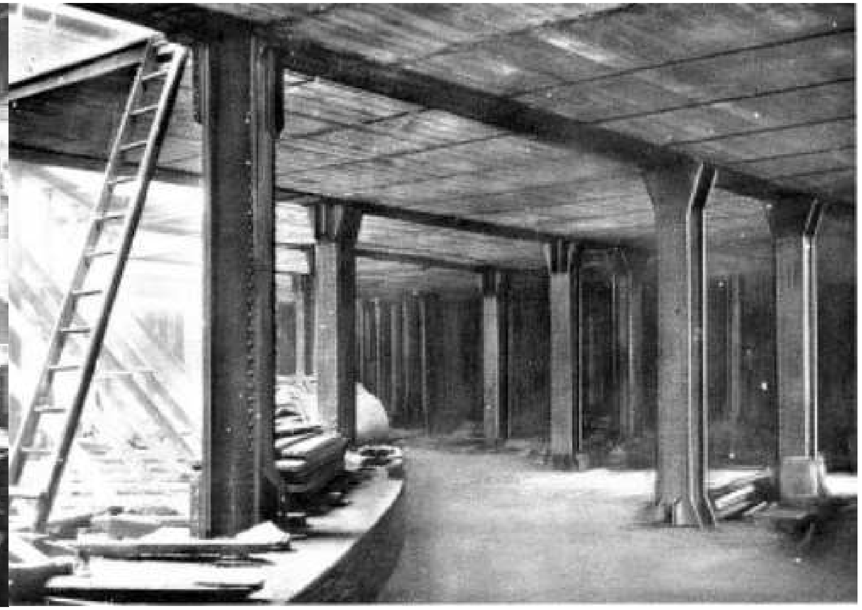






<u>Above Top</u>: caption: "Portal of Subway at 135th Street" (before widening)
<u>Above Bottom</u>: caption: "Approach to Subway, showing portal in distance. Picture taken before three-track widening project"
<u>Left</u>: caption: "The first completed section of the tunnel, at Broadway and 135th Street- this shows the steel framework of the double tunnel, and the concrete roof and side walls" (before widening)"

Over, Under and Above

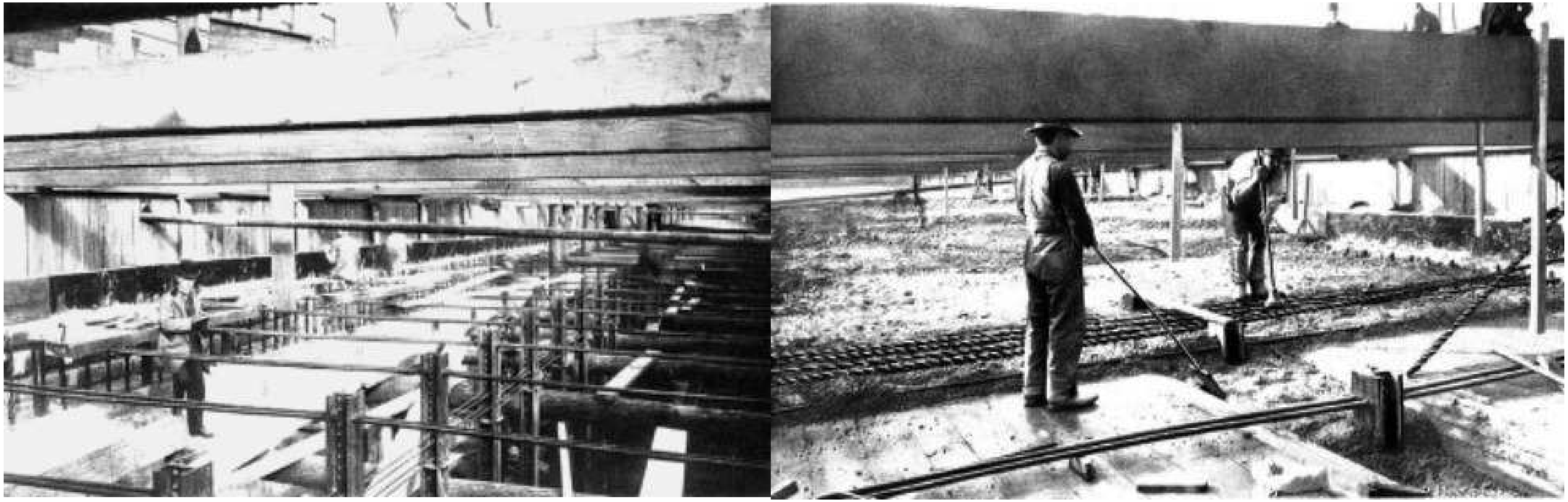



Provision had to be made not only for buildings along the route that towered far above the street but also for some which burrowed far below the Subway itself. An interesting example occurred at *42nd Street* and *Broadway* where the pressroom of the *New York Times* building was below the Subway, the first floor above it and the first basement alongside it. The steel structure of the building and the Subway were independent of one another, the columns of the building passing through the Subway station. At *42nd Street* and *Park Avenue,* the Subway passed directly under the *Hotel Belmont*, which necessitated the use of extra heavy steel girders for the support of the hotel.

<u>Left</u>: caption: "Subway through new 'Times' Building, showing independent construction - the workmen stand on floor girders of Subway"

<u>Right</u>: caption: "Columns of Hotel Belmont, passing through Subway at 42nd Street and Park Avenue"

2) Reinforced Concrete Construction



The reinforced concrete construction substituted 1.25-inch square steel rods, from six to ten-inches apart (depending on the roof load/s), for steel roof beams. Rods 1.13-inches in diameter tied-in the side-walls (passing through angle columns in the walls and the bulb-angle columns in the center). Layers of concrete were laid over the roof rods to a thickness of from eighteen to thirty-inches and carried two inches below the rods thus embedding them. For the sides-walls, similar square rods and concrete were used and angle columns spaced five-feet apart. The concrete of the side-walls was from fifteen to eighteen-inches thick. The rods used were of both square and twisted cross-section.

Above: reinforced concrete construction

3) Concrete Lined Tunnels

"…I have often been asked about the prodigious difficulties in the way of the tunnel. There are really none that cannot be overcome by intelligent and diligent labor. There has been, as long as I can remember, a popular impression that Manhattan Island consists generally of a mixture of granite and quicksand. That belief is not well founded. There certainly is a great deal of rock, especially in the upper portion. It is gneiss, really hard, but quite workable with the aid of pneumatic drills and blasting powder. The only thing resembling quicksand that we have thus far met is a bit of old swamp fifteen feet below the surface of Broadway at One Hundred and Fifteenth Street. There we found a quaking mixture of thin sand and bluish mud, in which a man would be quickly swallowed up. We dug it all out for the space of eighty feet in length and sixty feet in width. The quicksand was only eight feet in depth, and it was at the bottom of the tunnel. The vacant space was filled with gravel, thus making a firm, trustworthy roadbed…"

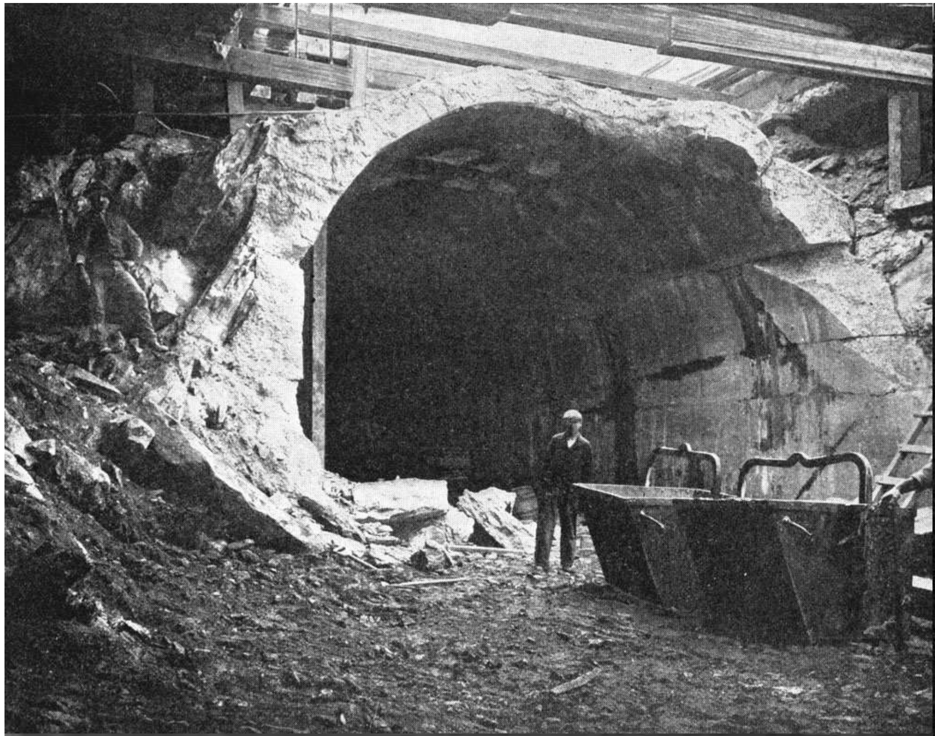
***John B. McDonald,* 1902**

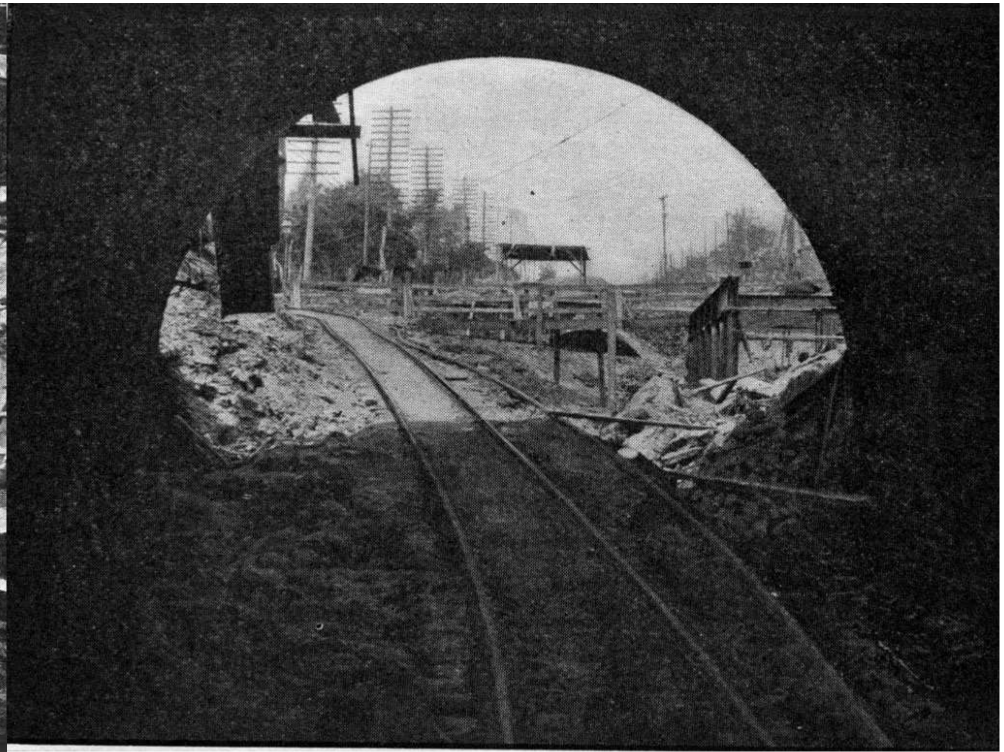
Left: caption: "A pneumatic drill at work - about a million cubic yards of rock will be excavated in building the tunnel. The rock of Manhattan Island is gneiss, pretty hard, but quite workable."

Between *33rd Street* and *42nd Street* (under *Park Avenue*), between *116th Street* and *120th Street* (under *Broadway*), between *157th Street* and *Fort George* (under Broadway and *Eleventh Avenue* - the second longest double-track rock tunnel in the *United States* (the *Hoosac Tunnel* being the only one of greater length, at the time) and between *103rd Street* and Broadway (under *Central Park* to *Lenox Avenue* and *110th Street*), the route was in rock tunnel lined with concrete. From 116th Street to 120th Street, the tunnel was 37.5-feet wide; one of the widest concrete arches in the world. On the section from Broadway and 103rd Street to Lenox Avenue and 110th Street, under Central Park, a two-track subway was driven through micaceous rock by taking out top headings and then two full-width benches. The work was done from two shafts and one portal. All drilling for the headings was done by an eight-hour night shift using percussion drills. The blasting was done early in the morning and the day gang removed the spoil which was hauled to the shafts and/or the portal in cars drawn by mules. A large part of the rock was crushed for concrete aggregate. The concrete floor was the first part of the lining to be put in place. Rails were laid on it for a traveler having molds attached to its sides against which the walls were built. A similar traveler followed with the centering for the arch roof, a length of about fifty-feet being completed in one operation.

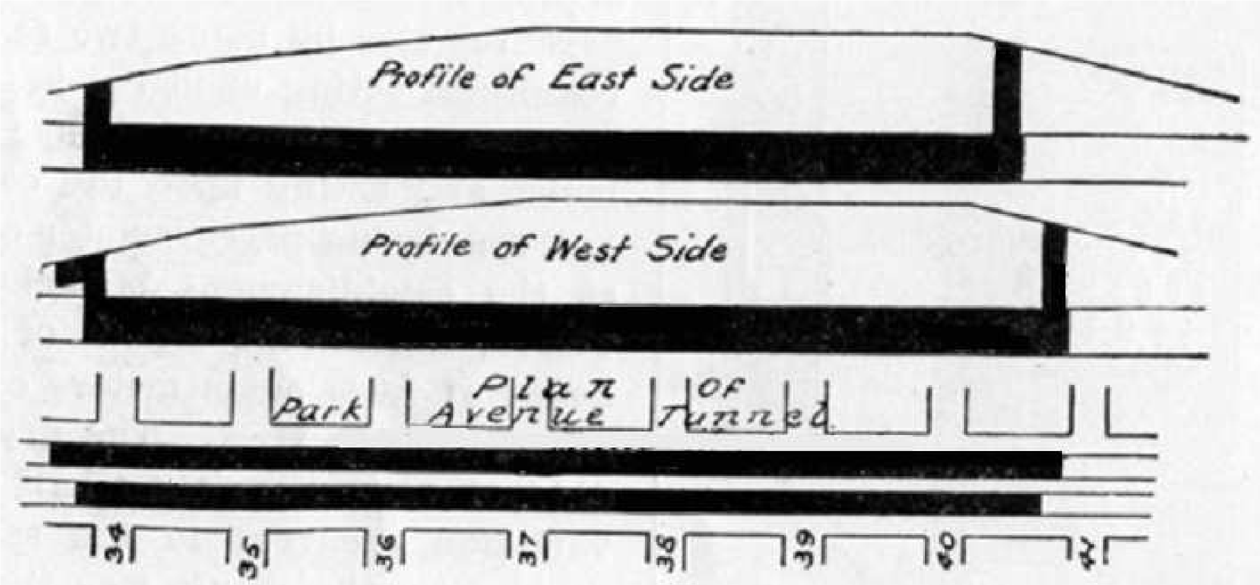
<u>Top Left</u>: caption: "Side drift looking from tunnel toward shaft"
<u>Top Right</u>: caption: "Traveler for erecting forms, Central Park Tunnel – in this tunnel ducts are built in the side-walls"
<u>Left</u>: caption: "Three-track concrete arch – 117th Street and Broadway"

<u>Above</u>: caption: “View of the work on Broadway, looking south from One Hundred and Fifty Seventh Street, toward Trinity Church Cemetery. Both north and south of this point are hills through which a tunnel is being driven, the northern tunnel being nearly two miles long.”





__Top Left__: caption: "Tunnel portal at Broadway and 120th Street"
__Top Right__: caption: "Looking Out from the Subway Tunnel, 157th Street and Broadway"
__Left__: caption: "Concrete-lined Three-Track Arch; 37.5 ft. Span"



On the *Park Avenue* section from *34th Street* to *41st Street,* two separate double-track tunnels were driven below a double-track electric railway tunnel, one on each side. The work was done from four shafts, one at each end of each tunnel. At first, top headings were employed at the north ends of both tunnels and at the south end of the west tunnel; at the south end of the east tunnel a bottom heading was used. Later, a bottom heading was also used at the south end of the west tunnel. The rock was very irregular and of treacherous character and the strata inclined so as to make the danger of slippage ever present. The two headings of the west tunnel met in February 1902 and those of the east tunnel in March 1902, then the widening of the tunnels to their full section was begun. Despite the adoption of every precaution suggested by experience in such work, some disturbance of the surface above the east tunnel resulted and several house fronts were damaged. The portion of the tunnel affected was bulk-headed at each end, packed with rubble and grouted with Portland cement mortar injected under pressure through pipes sunk from the street surface above. When the interior was firm, the tunnel was re-driven, using much the same methods that were employed for tunnels through earth when the arch lining was built before the central core was removed. The work had to be done very slowly to prevent any further settlement of the ground and the completion of the widening of the other parts of the tunnels also proceeded very slowly. After the lining was complete, Portland cement grout was again injected under pressure through holes left in the roof until the fill overhead was absolutely stable.

Left: caption: "Plan and profiles (east & west) of the Park Avenue Tunnel"
Right: caption: "Station excavation and portal of tunnel and 33d Street, 1902"

The Most Arduous Piece of Work

"…The most arduous piece of work on the road is the boring of the Fort Washington tunnel, through the great hill of gneiss extending along Broadway and Eleventh Avenue from One Hundred and Fifty Eighth Street to a point near Fort George. This tunnel will be two miles long. Next to the Hoosac tunnel, it will, I believe, be the longest in the United States. Yet it excites little public attention. It is in the eye of the wayfaring man a mere incident of the whole rapid transit plan…"

John B. McDonald, **1902**

<u>Left</u>: caption: "In the tunnel under Fort George. Miners at work in the heading; muckers wheeling spoil to cars on tracks in finished excavation. Temporary timbering to support dangerous roof until concrete arch can be built."

"…It was in the tunnel just below One Hundred and Sixty-ninth street that another of those accidents occurred which is the price of every great achievement of engineering construction. Here again a slanting stratum became loosened, and slipping down, killed five of the men who were working beneath. I asked one of the workmen from just what part of the heading the rock had fallen. 'That chunk of work,' said he, cheerfully, pointing straight at the roof above us, 'fell out just over where you're standing now.'…"

Century Magazine, **October 1902**

RE: the tunnel between *157th Street* and *Fort George* was built in remarkably short time considering the fact that the work was prosecuted from two portal headings and from two shafts. One shaft was at *168th Street* and the other at *181st Street*, the work proceeding both north and south from each shaft. The method employed for the work was similar to that used under *Central Park*. The shafts at 168th Street and 181st Street were located at those points so that they might be used for the permanent elevator equipment for the stations at these streets. These stations had an arch span of fifty-feet, lined with brick.

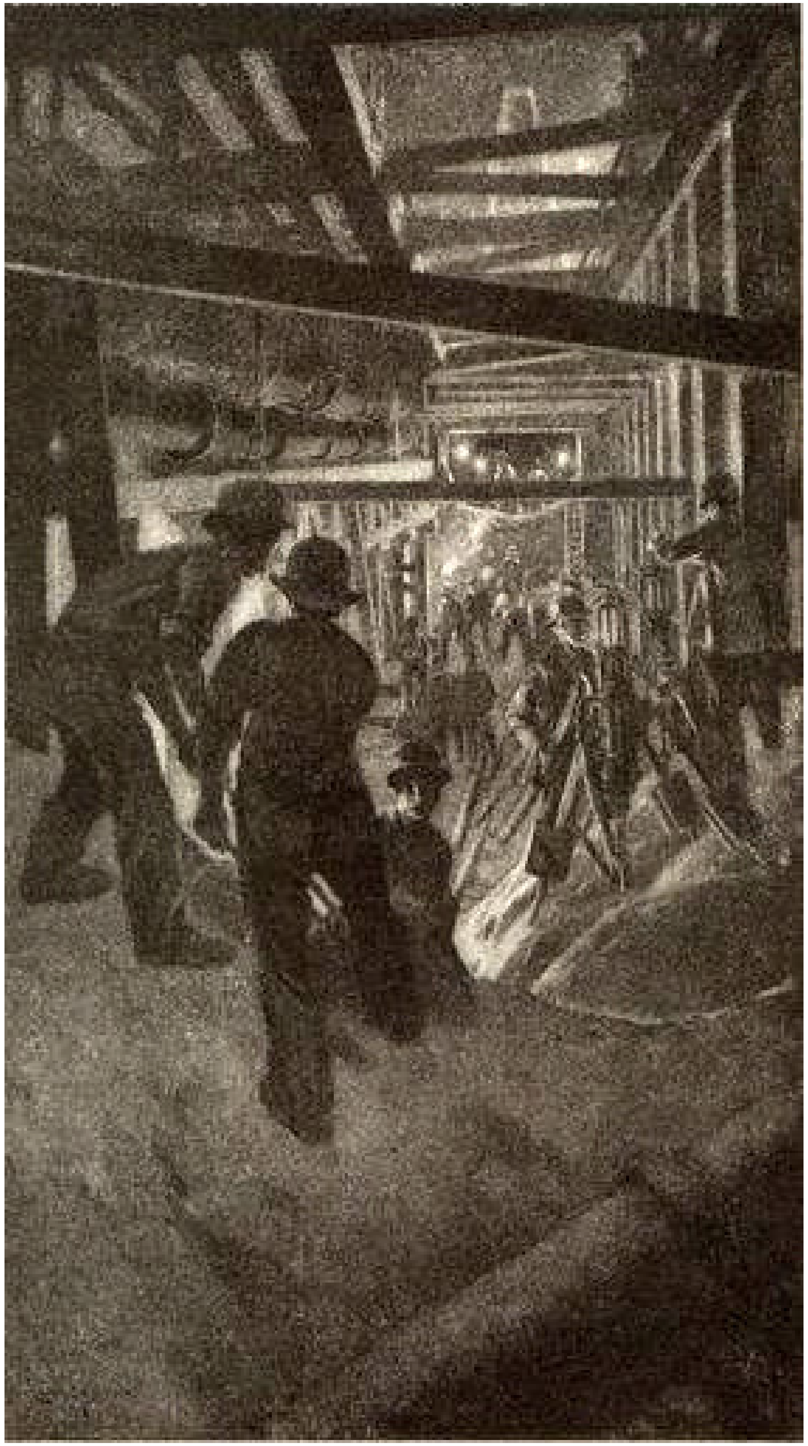
<u>Above</u>: caption: "Construction of Fort George Tunnel"

"…The boring is being done from headings at either end, and in both directions from intermediate shafts at One Hundred and Sixty Ninth and One Hundred and Eighty First Streets. On the shore of the Hudson River, half way between these points, is a large compressor plant, from which compressed air is conveyed in pipes to the drilling machines in the tunnel. Each of the shafts goes down one hundred feet to the floor of the tunnel. When the road is finished, elevators will carry passengers up and down. More men than would make a regiment have been at work here continuously during the last year. The drills never cease. The men work in three shifts of eight hours each. The tunnel will be carried forward in this way until it is finished. Although the popular name for the underground road is the 'Tunnel Route,' this Fort Washington section is about the only one that deserves that title…"

John B. McDonald, **1902**


DOWN TOWN
TRAINS

The Great Trench



"…So small is the amount of quicksand along the route of the great trench, that it does not appear in the calculations. All the excavation is estimated as earth and rock: 927,135 cubic yards of earth, and 921,182 cubic yards of rock, chiefly gneiss. From the Fort Washington tunnel, and from two or three other very short sections of similar boring, there will be drilled and blasted out 368,606 cubic yards of rock. During the past winter thirty five hundred men have been engaged in boring, excavating, and road building. The nature of the operations carried on can be seen by a glance at the occupations of this army - civil engineers, foremen (in drilling and steel construction), engineers, hoisters, pipe fitters, masons, caulkers, bracers, carpenters, blacksmiths, riveters, machinists, steam and air drill runners, and watchmen. As soon as the open season is well settled, this army will be increased to ten thousand men. In many sections besides the big tunnel work will be carried on day and night…"

***John B. McDonald,* 1902**

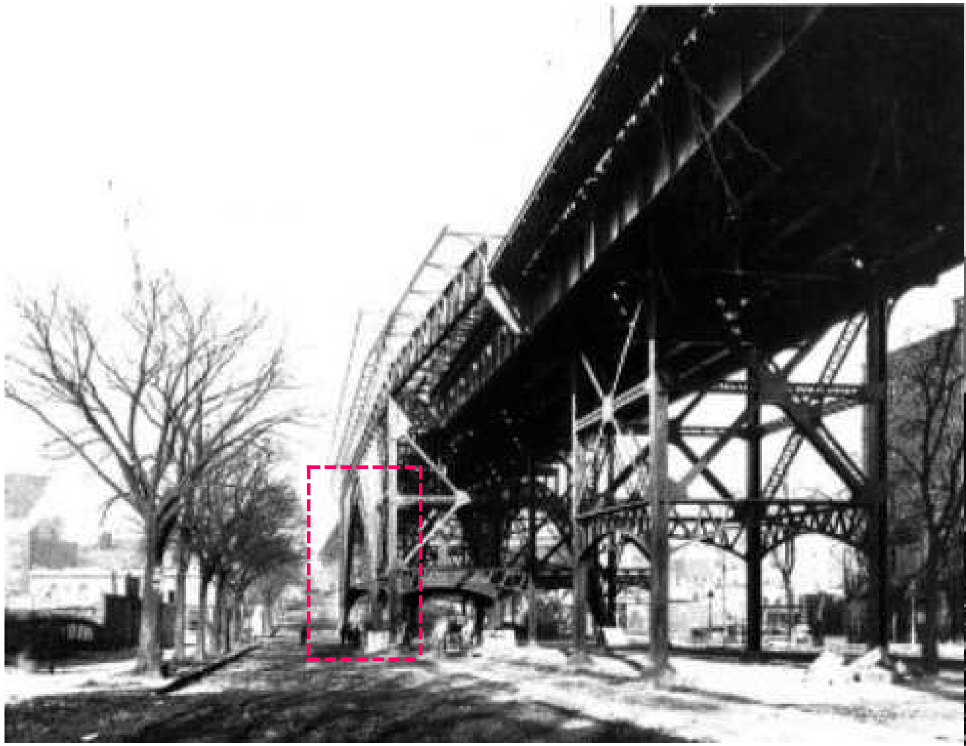
4) Elevated Viaduct Construction

The elevated viaduct construction extended from *125th Street* to *133rd Street* and from *Dyckman Street* to *Bailey Avenue* on the *Western Branch* and from *Brook* and *Westchester Avenue/s* to *Bronx Park* on the *Eastern Branch*, a total distance of about five miles. The three-track viaducts were carried on two column bents (left) where the rail was not more than 29-feet above ground level and on four-column towers (right) for higher structures. In the latter case, the posts of a tower were 29-feet apart transversely and 20 or 25-feet longitudinally, as a general rule, and the towers were from 70 to 90-feet apart on centers. The tops of the towers had X-bracing and the connecting spans had two panels of intermediate vertical sway bracing between the three pairs of longitudinal girders. In the low viaducts, where there were no towers, every fourth panel had zigzag lateral bracing in the two panels between the pairs of longitudinal girders. The outside longitudinal girder on each side of the viaduct had the same depth across the tower as in the connecting span, but the four intermediate lines were not so deep across the towers.


The *Manhattan Valley Viaduct* on the *Fort George* (Western) Branch had a total length of 2,174-feet. Its most important feature was a two-hinged arch (right) of 168.5-foot span which carried platforms shaded by canopies, but no station buildings (the station was on the ground between the surface railway tracks). Access to the platforms was obtained by means of escalators. It had three lattice-girder two-hinge ribs 24.5 feet apart on centers, the centerline of each rib being a parabola. Each half rib supported six spandrel posts carrying the roadway, the posts being seated directly over vertical web members of the rib. The chords of the ribs were six-feet apart and of an H-section, having four 6 x 6-inch angles and six 15-inch flange and web plates for the center rib and lighter sections for the outside ribs. The arch was erected without falsework.

Left: caption: “Erection of Arch, Manhattan Valley Viaduct”

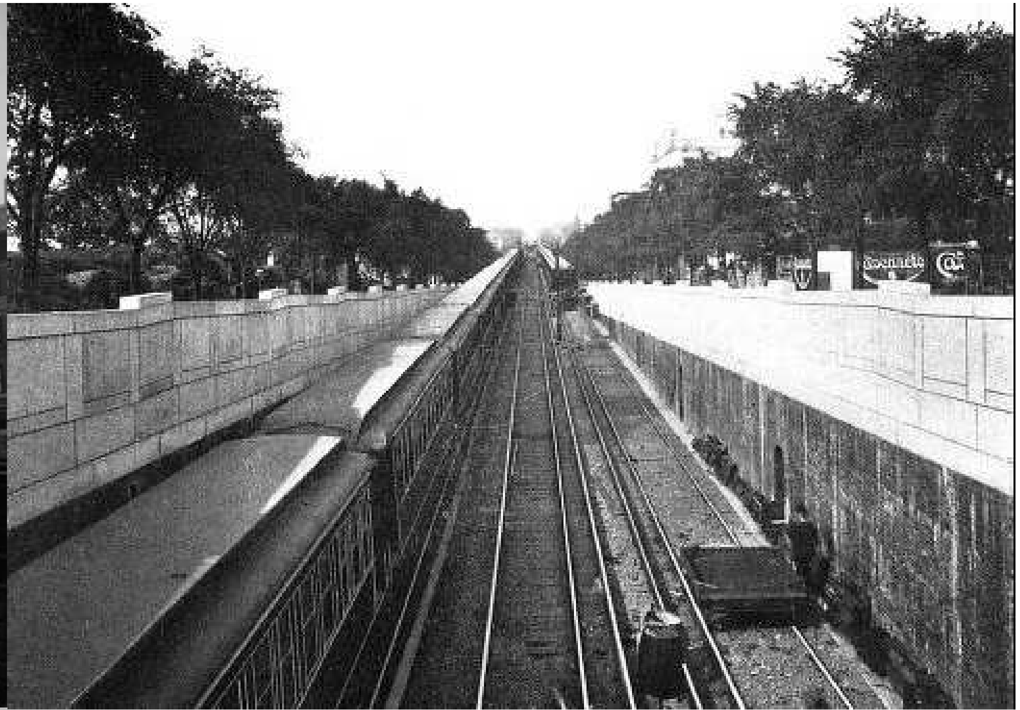
Right: caption: “Steel Arch Span, looking southeast down 125^{th} Street” (present day)



The viaduct spans (left) of either approach to the arch (highlighted) were 46 to 72-feet long. All transverse girders were 31.33-feet long The two outside longitudinal girders of deck spans were 72-inches deep and the other 36-inches. All were 3/8-inch thick. At each end of the viaduct there was a through span with 90-inch (web) longitudinal girders. Each track was proportioned for a dead-load of 330 pounds per lineal foot and a live-load of 25K pounds per axle. The axle spacing was five-feet and the pairs of axles were alternately 27 and/or 9-feet apart. The traction load was taken at 20% of the live-load and a wind pressure of 500 pounds per lineal foot was assumed over the whole structure.

<u>Left</u>: caption: “Manhattan Valley Viaduct, looking North”

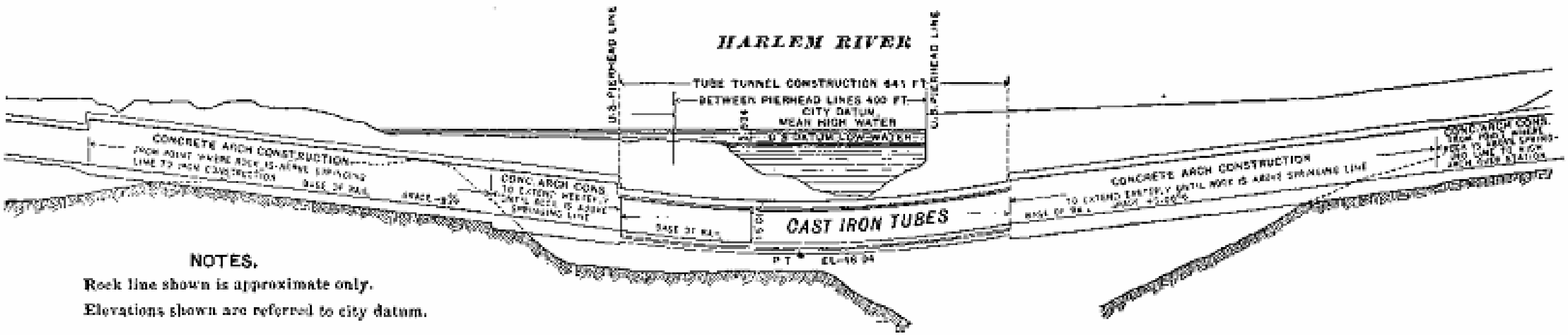
<u>Right</u>: caption: “Platforms and tracks on Manhattan Valley Viaduct” (present day)



Top Left: southern masonry approach (view southwest from *123rd Street*)
Top Right: tunnel approach (123rd Street) from viaduct (beyond)
Left: *Manhattan Valley Viaduct* tunnel approach

<u>Above</u>: ornamental stair entrance to platform
<u>Left</u>: east stair and platform entrance (at *125th Street*)

5) Sub-Aqueous Tunnel/s

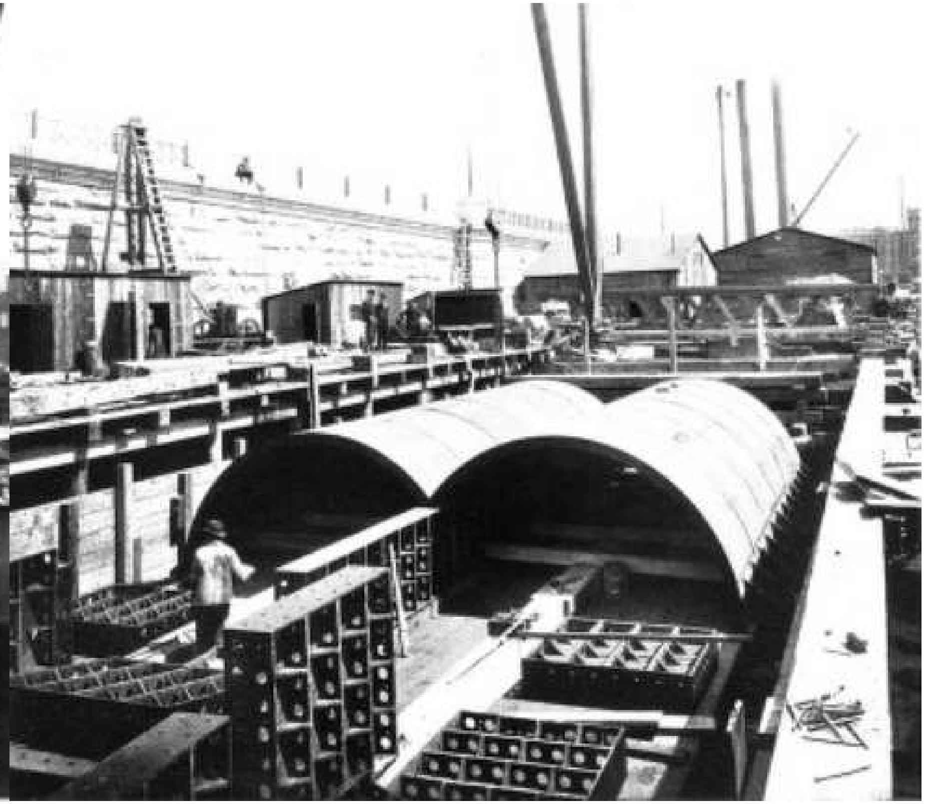


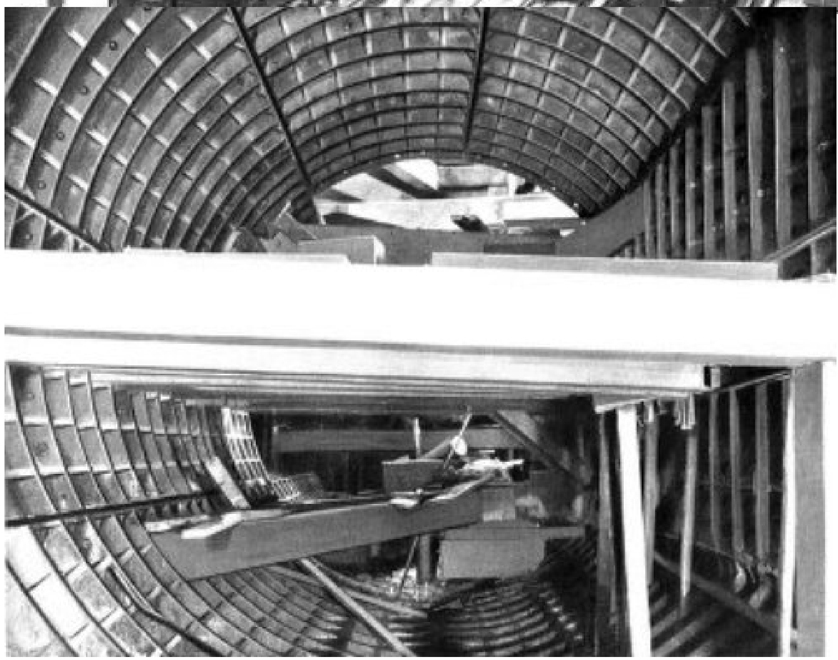
One of the most interesting sections of the IRT route was that which approached and passed under the *Harlem River,* carrying the two tracks of the *Bronx Park* (Eastern) Branch. The *War Department* required a minimum depth of twenty-feet in the river at low tide which fixed the elevation of the roof of the submerged part of the tunnel. This part of the line, 641-feet long, consisted of twin single-track cast-iron cylinders 16-feet in diameter enveloped in a large mass of concrete and lined with same. The approach on either side was a double-track concrete arched structure. The total length of the section was 1,500-feet. The methods of construction employed were novel in sub-aqueous tunneling. The bed of the Harlem River at the point of tunneling consisted of mud, silt and sand, much of which was in a nearly fluid condition allowing it to be removed by means of a water jet. The maximum depth of excavation was about fifty-feet. Instead of employing the usual method of a shield and compressed air at high pressure, a more expeditious method was developed.

<u>Above</u>: caption: "Profile of Harlem River Tunnel and Approaches"

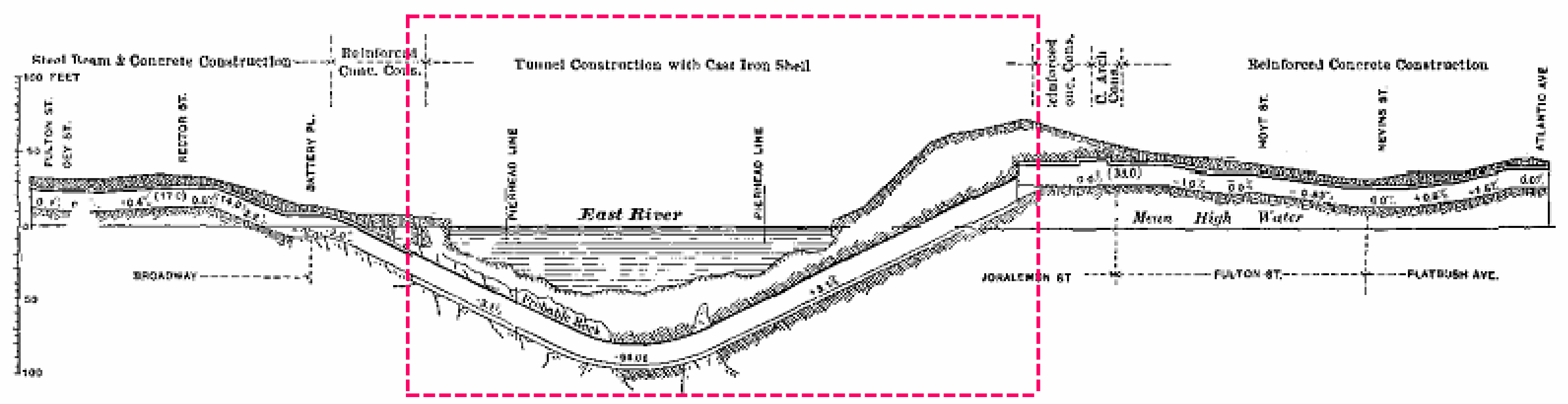
The *Harlem River* crossing was built in two sections. The west section was built first (the *War Department* having forbidden the closing of more than half the river at one time). A trench was dredged over the line of the tunnel about 50-feet wide and 39-feet below low water. This depth was about 10-feet above the sub-grade of the tunnel. Next, three rows of piles were driven on each side of the trench from the west bank to the middle of the river and on them working platforms built, forming two wharves 38-feet apart in the clear. Piles were then driven over the area to be covered by the subway, 6.33-feet apart laterally and 8-feet longitudinally. They were cut off about 11-feet above the center line of each tube and capped with timbers twelve-inches square. A thoroughly-trussed framework was then floated over the piles and sunk on them. The trusses were spaced so as to come between each transverse row of piles and were connected by eight longitudinal sticks or stringers, two at the top and two at the bottom on each side. The four at each side were just far enough apart to allow a special tongue and grooved twelve-inch sheet piling to be driven between them. This sheathing was driven to a depth of ten to fifteen-feet below the bottom of the finished tunnel. A well-caulked roof of three courses of twelve-inch timbers separated by two-inch plank was then floated over the piles and sunk. It had three timber shafts 7 x 17-feet in plan and when it was in place and covered with earth it formed the top of a caisson with the sheet piling on the sides and ends, the latter being driven after the roof was in place. The excavation below this caisson was made under air pressure, part of the material being blown out by water jets and the remainder removed through the airlocks in the shafts. When the excavation was complete, the piles were temporarily braced and the concrete and cast-iron lining put in place, the piles being cut off as the concrete bed was laid up to them.

The second or eastern section of this crossing was carried on by a modification of the western plan. Instead of using a temporary timber roof on the side walls, the permanent iron and concrete upper half of the tunnels was employed as a roof for the caisson. The trench was dredged nearly to sub-grade and its sides provided with wharves as before, running out to the completed half of the work. The permanent foundation piles were then driven and a timber frame sunk over them to serve as a guide for the twelve-inch sheet piling around the site. Steel pilot piles with water jets were driven in advance of the wood-sheet piles and if they struck any boulders, the latter were drilled and blasted. The steel piles were withdrawn by a six-part tackle and hoisting engine and then the wooden piles driven in their place. When the piling was finished, a pontoon 35-feet wide, 106-feet long and twelve-feet deep was built between the wharves. Upon a separate platform, the upper half of the cast-iron shells were assembled, their ends closed by steel-plate diaphragms and the whole covered with concrete. The pontoon was then submerged several feet, parted at its center and each half drawn out endwise from beneath the floating top of the tunnel. The latter was then loaded and carefully sunk into place, the connection with the shore section being made by a diver who entered the roof through a special opening. When it was finally in place, men entered through the shore section and cut away the wood bottom, thus completing the caisson so that work could proceed below it as before. Three of these caissons were required to complete the east-end of the crossing. The construction of the approaches to the tunnel was carried out between heavy sheet piling. The excavation was over forty-feet deep in places and very wet and the success of the work was largely due to the care taken in driving the twelve-inch sheet piling.

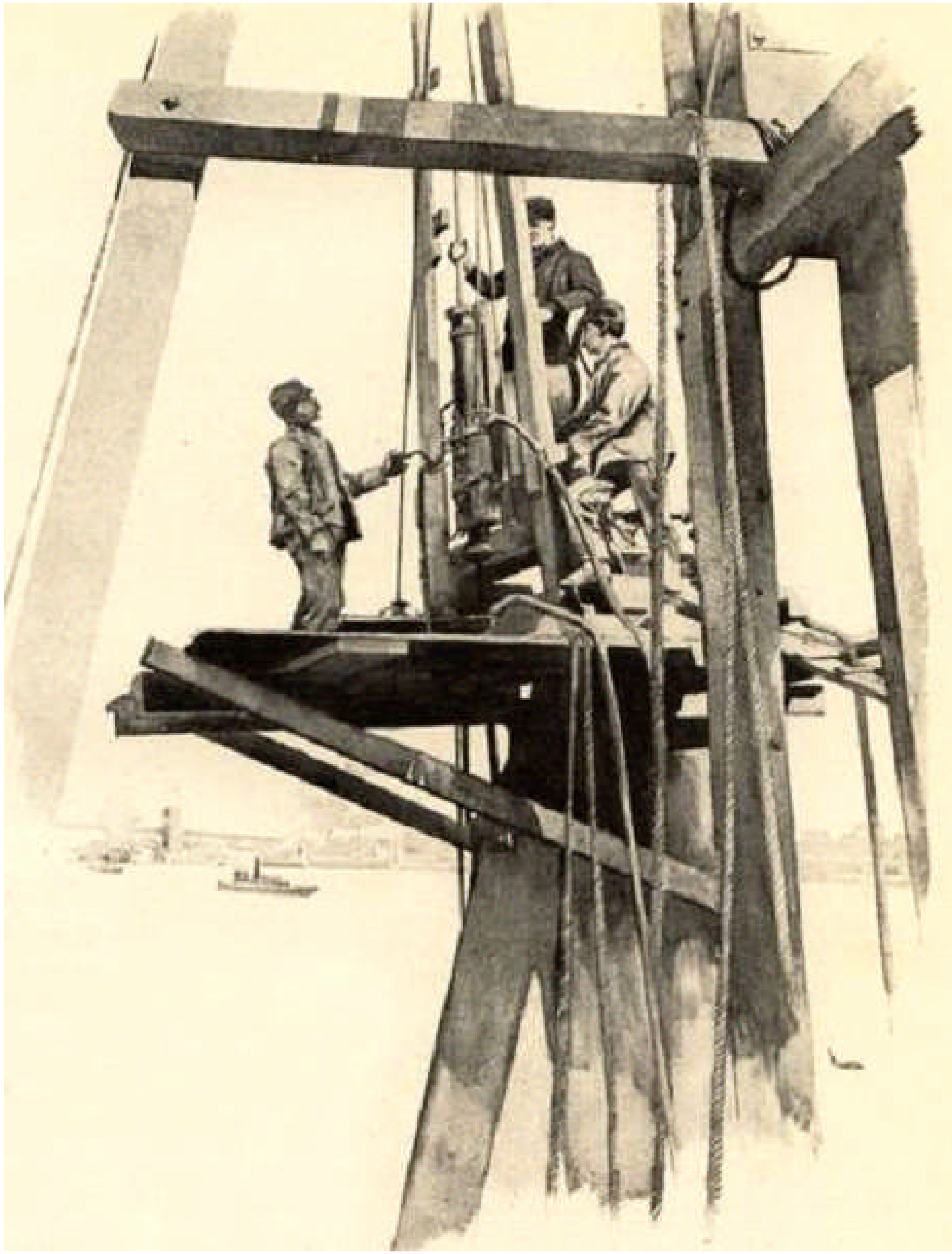




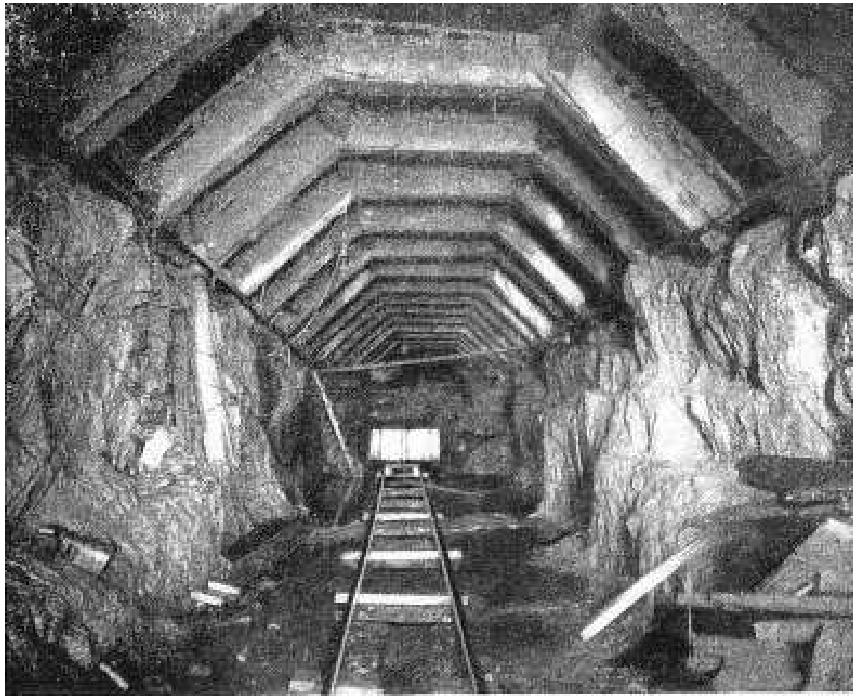
<u>Top Left:</u> caption: “Showing concrete over iron work – Harlem River Tunnel”
<u>Top Right</u>: caption: “Assembling iron work on pontoon – Harlem River Tunnel”
<u>Left</u>: caption: “Section of Harlem River Tunnel during construction”

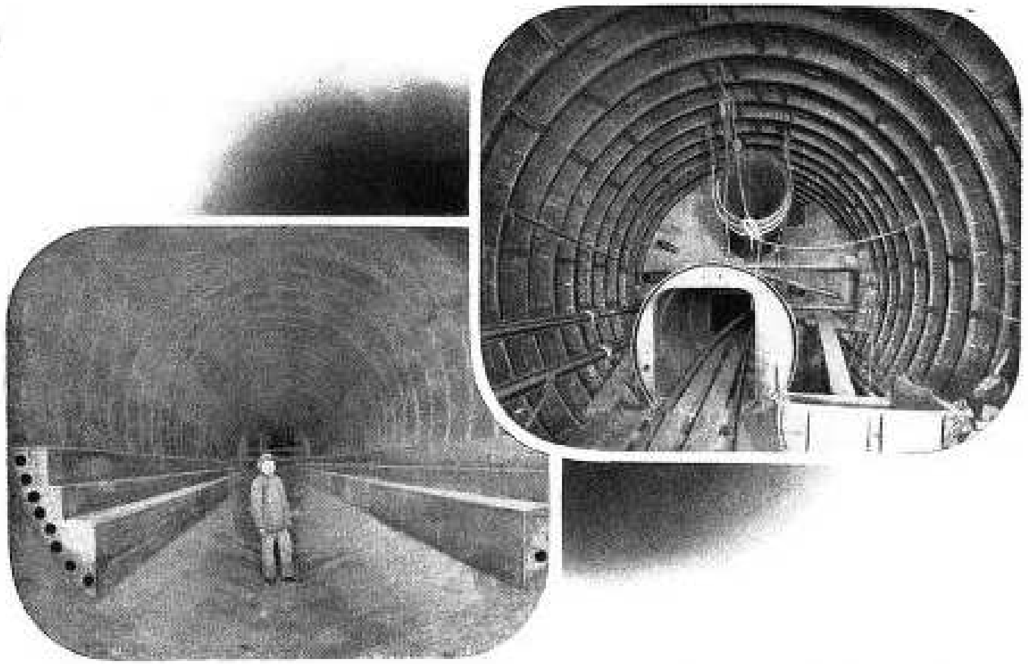


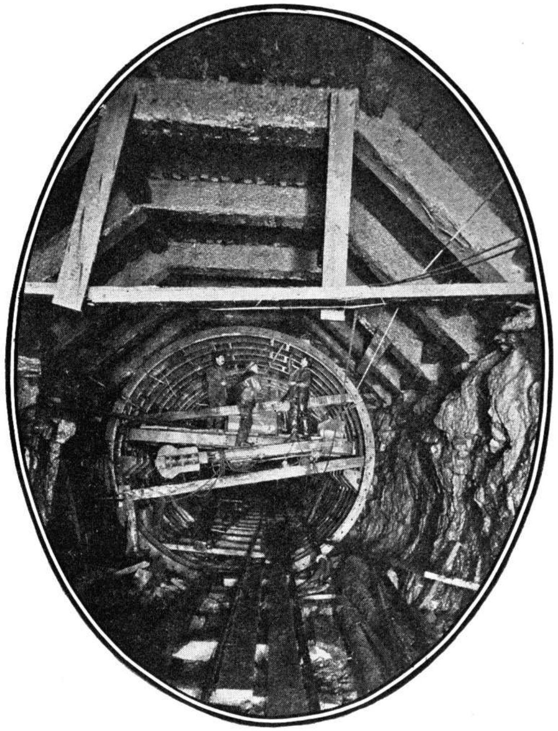
The types of construction on the *Brooklyn Extension* (above) included typical flat-roof steel I-beam and/or reinforced concrete. Two single track cast-iron lined sub-aqueous tubular tunnels extended from *Battery Place*, under the *East River*, then under *Joralemon Street* to the *Brooklyn Terminus* at *Atlantic* and *Flatbush Avenue/s*. The two twin tubes under the river, including their approaches, were each 6,544-feet in length. The tunnel (highlighted) consisted of two cast-iron tubes 15.5-feet inside diameter, the lining being constructed of cast-iron plates, circular in shape, bolted together and reinforced by grouting outside of the plates and "beton" filling on the inside to the depth of the flanges. The tubes were constructed under air pressure through solid rock from the *Manhattan* side to the middle of the East River by the ordinary rock tunnel drift method and on the *Brooklyn* side through sand and silt by the use of hydraulic shields. Four shields were installed, weighing 51-tons each. They were driven by hydraulic pressure of about 2K-tons. The two shields drifting to the center of the river from *Garden Place* were in water-bearing sand and were operated under air pressure. The river tubes were on a 3.1% grade and in the center of the river reached the deepest point, about 94-feet below mean high-water level.



<u>Left</u>: caption: “Exploring the bottom of the East River with soundings for the Brooklyn tunnel. The working platform built on a cluster of piles in deep, swift water was many times swept away. A large steel pipe was sunk by a powerful water jet through mud and clay to rock, and the diamond drill was lowered inside it, and the hole extended many feet into the rock, bringing up solid cylindrical cores.”





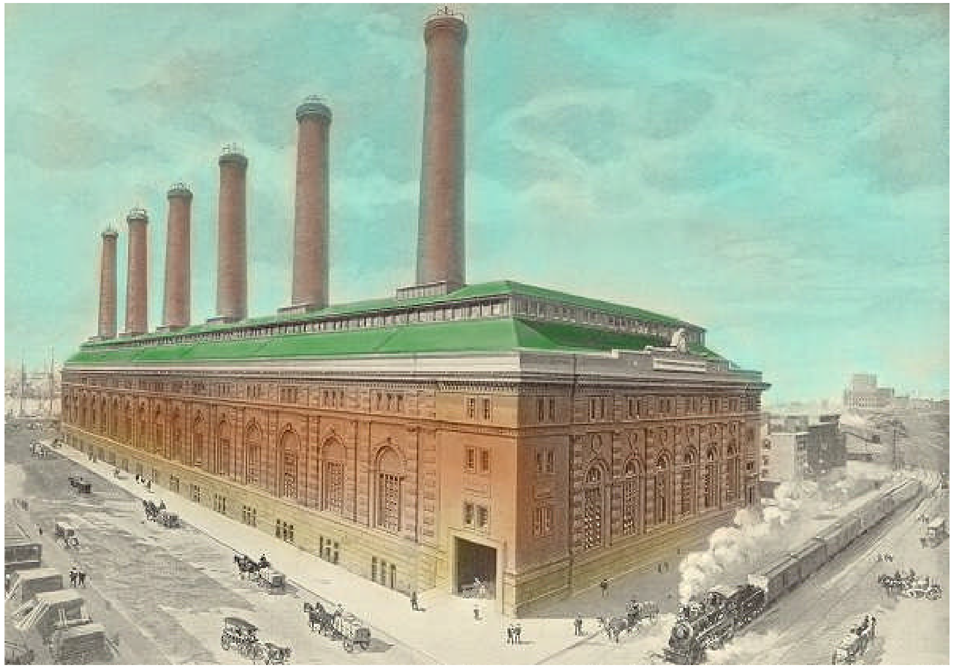
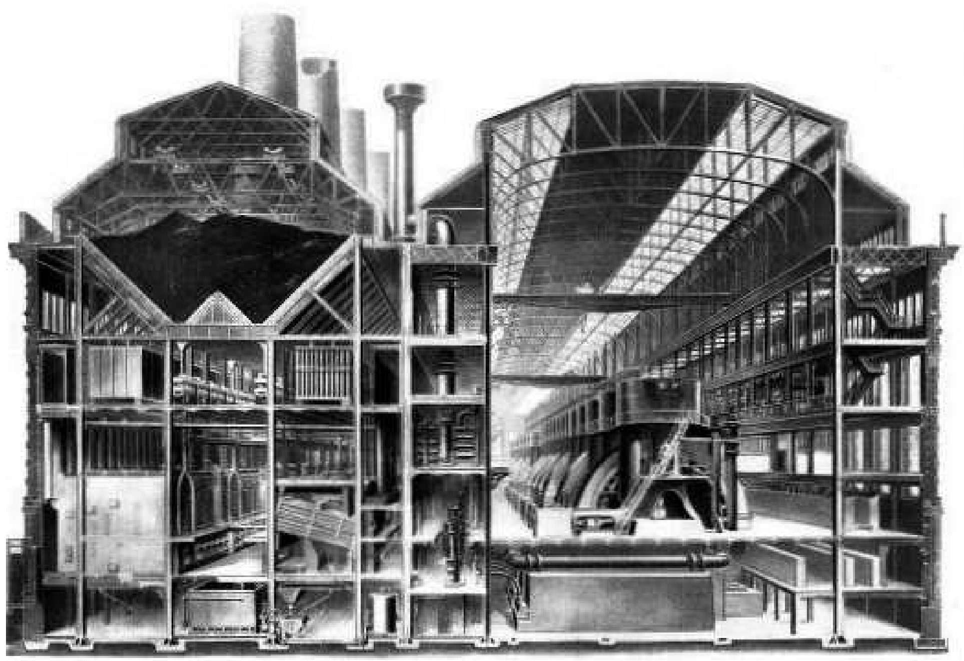


Top Left & Right: caption: “East River Tunnel during construction”
Left: caption: “Rock Work, Entrance to East River Tunnel at the Battery, 1904”

Part 4

Plant & Equipment

The Power House

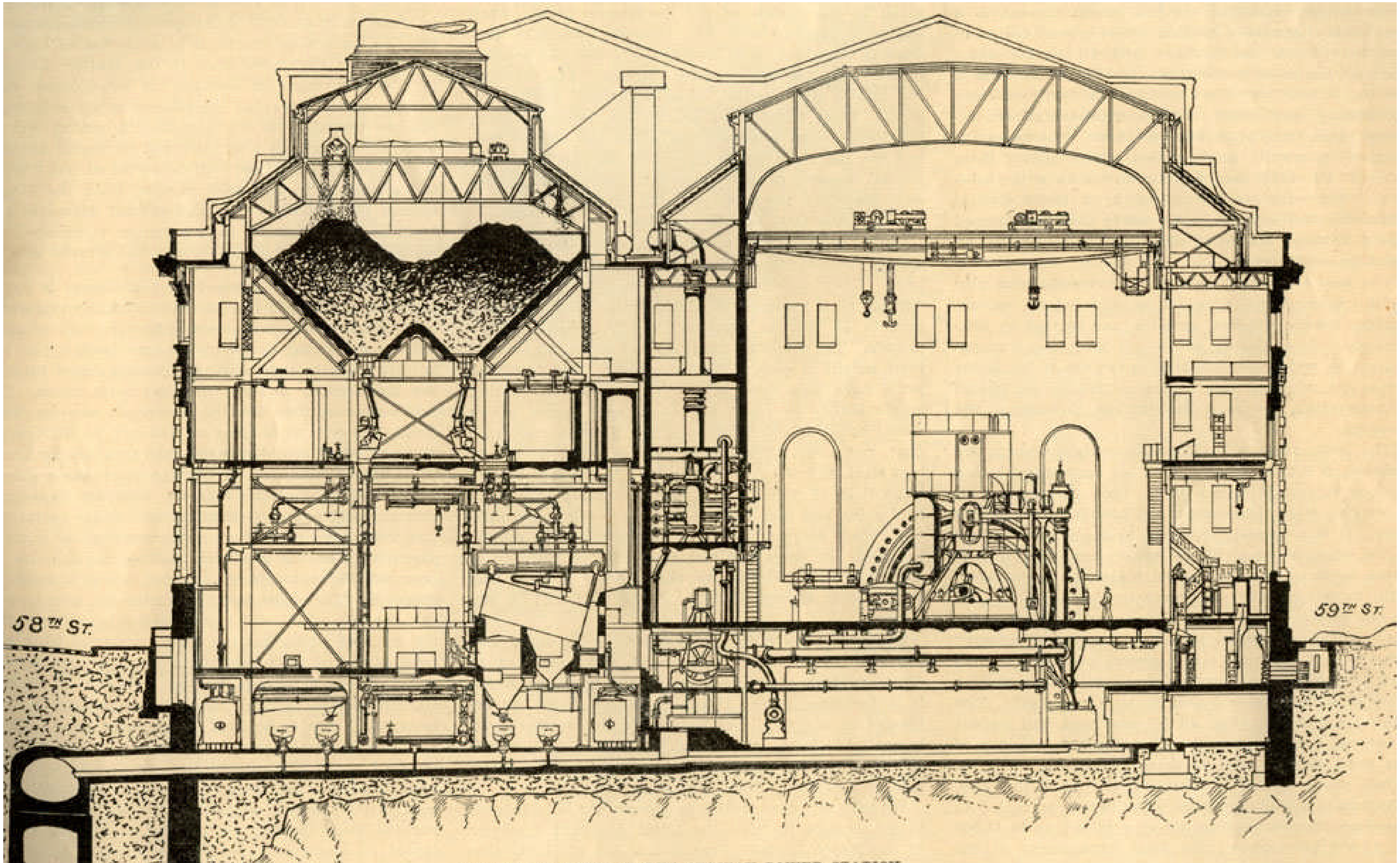



"…the great power station, which has been built at Fifty-ninth Street and the North River, the spot being chosen for its central location with regard to the distribution of the current, and because of the facilities afforded for water transportation, and transportation by rail on the New York Central Railroad tracks, which run past the power house. The building occupies an entire block, and measures 200 feet in width by 694 feet in length. It is divided longitudinally by a central wall into two portions. The northern half, 117 feet in width, is known as the operating room, while the southerly half, 83 feet in width, is the boiler house…the operating room or engine house is built with galleries extending the whole length on each side, those on the northerly side containing the electrical apparatus, those on the southerly side being occupied chiefly by the steam-pipe equipment…"

Scientific American, **October 29th 1904**

Left: exterior view of Power House

Right: cross-section of Power House (in perspective)



SECTIONAL VIEW OF THE SUBWAY POWER STATION.

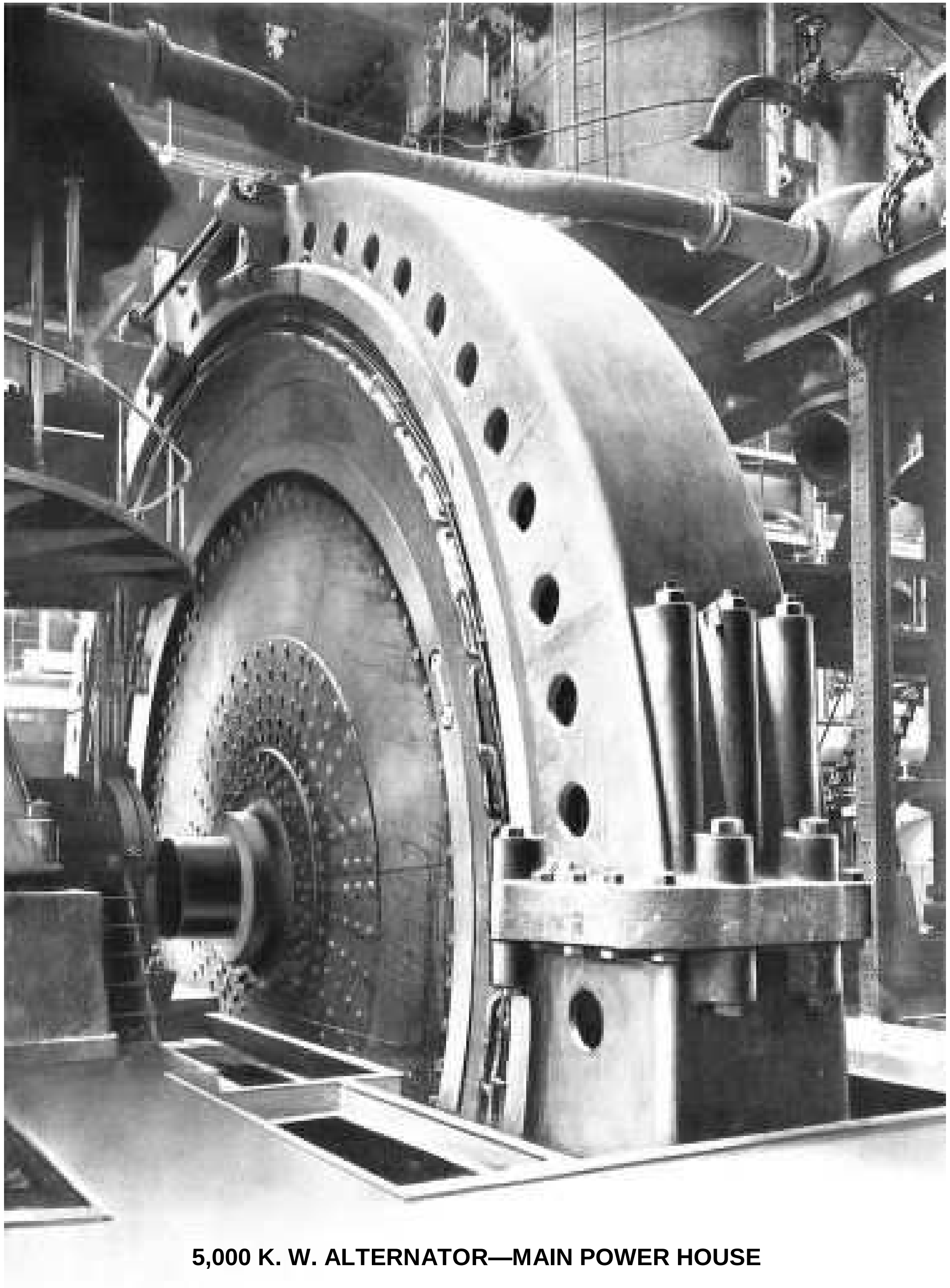
Width, 200 feet; length, 694 feet.

"…The boiler room will ultimately contain seventy-two Babcock & Wilcox boilers, with an aggregate heating surface of 432,576 square feet. They will operate at a working steam pressure of 225 pounds to the square inch…The engine equipment when all is completed will consist of eleven 7,500-horse-power Allis-Chalmers engines of the same general type as those installed in the 76th Street power station of the elevated road of this city…As these are capable of working at overload up to 11,000 or 12,000 horse-power, the total horse-power of the plant for traction purposes alone will aggregate say 121,000 horse-power. To this must be added four steam turbines used for electric lighting and two exciter engines, which would bring up the total horsepower for this station to a maximum capacity, when pushed to the utmost, of 132,000…"

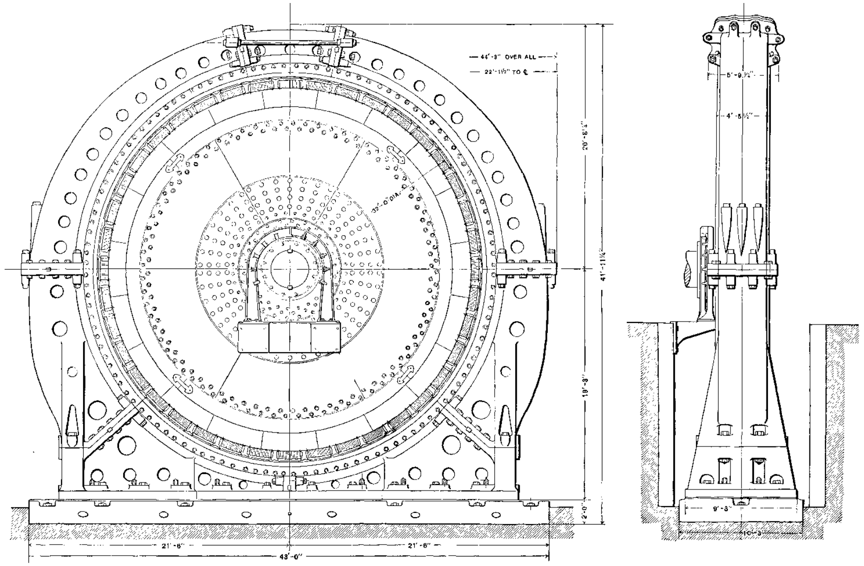
Scientific American, **October 29th 1904**

"…The 5,000-kilowatt alternators, like the engines, closely resemble those of the Manhattan Railway Company. They deliver 25-cycle alternating three-phase current at a pressure of 11,000 volts. The revolving part is 32 feet in diameter, and it weighs 332,000 pounds. The machines stand 42 feet in height, and the total weight of each is 889,000 pounds. The revolving parts have been constructed with a view to securing ample ability to resist the centrifugal forces which would be set up should the engines, through some accident, run away. The hub of the revolving field is of cast steel, and the rim is connected to the hub by two huge disks of rolled steel. The alternators have forty field poles, and they operate at 75 revolutions per minute. Field magnets form the periphery of the revolving field, the poles and rim of which are built up of steel plates, dovetailed to the driving spider. The armature is carried outside of the field and is stationary…"

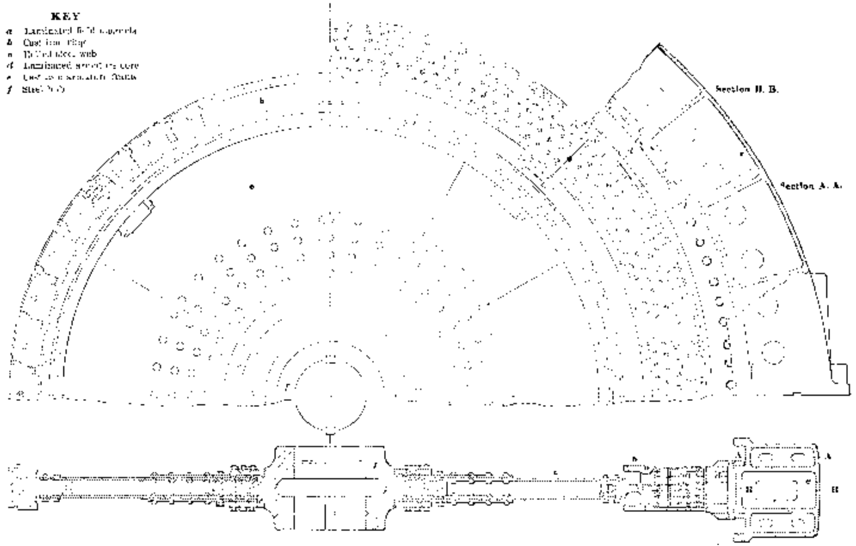
***Scientific American,* October 29th 1904**



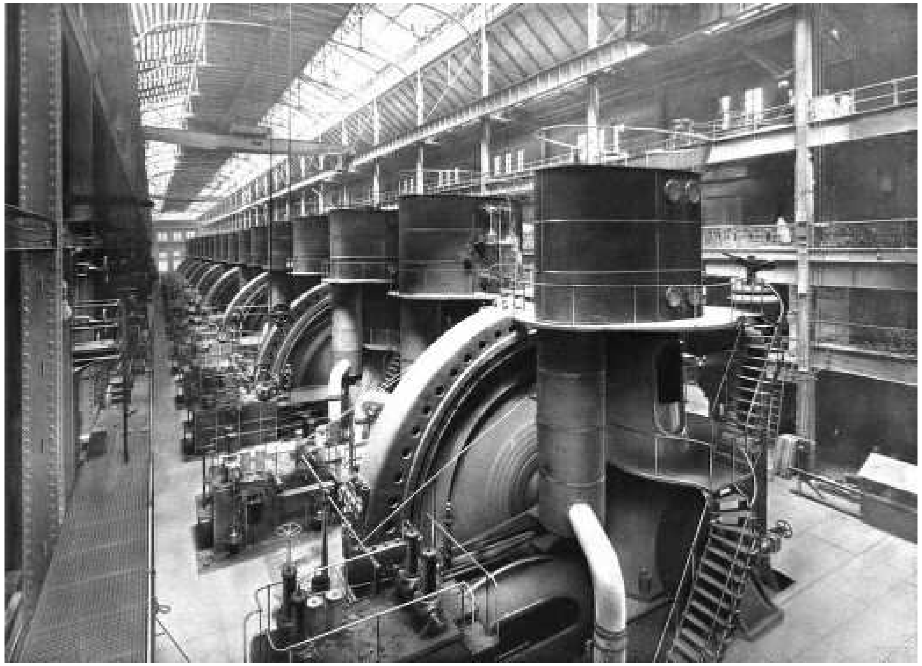
5,000 K. W. ALTERNATOR—MAIN POWER HOUSE



SIDE AND END ELEVATIONS OF ALTERNATOR



SIDE ELEVATION AND CROSS SECTION OF ALTERNATOR WITH PART CUT AWAY TO SHOW CONSTRUCTION

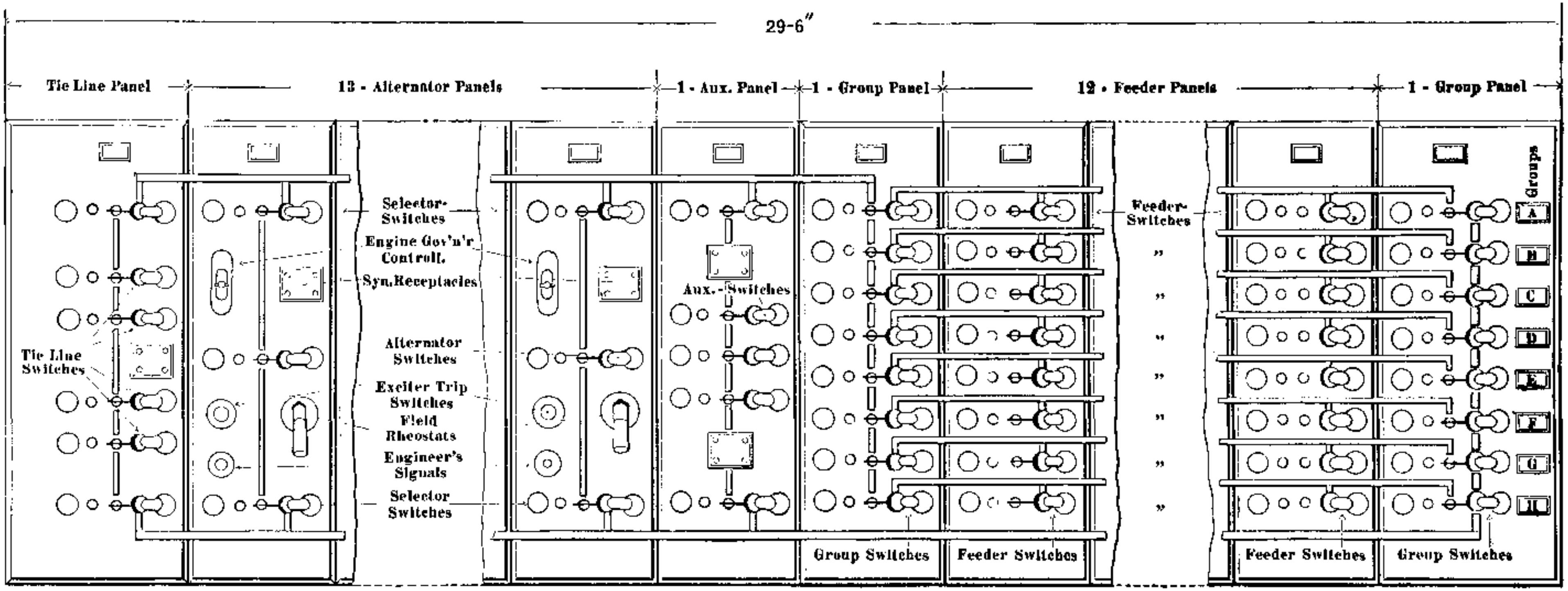


The 5K-KW generating unit/s were chosen because it was practically as large a unit of the direct-connected type as could be constructed by the engine builders unless more than two bearings were used - an alternative deemed inadvisable by the engineers of the IRTC. The adoption of a smaller unit would have been less economical of floor space and would have tended to produce extreme complications in so large an installation and, in view of the rapid changes in load which urban railway service of this character experienced in the morning and again in the late afternoon, was considered extremely difficult to operate. The experience of the *Manhattan Railway* plant demonstrated that the alternators had to be put in service at intervals of twenty minutes to meet the load upon the power station while it was rising to the maximum attained during rush hour/s. After careful consideration of the possible use of steam turbines as prime-movers to drive the alternators, the IRTC's engineers decided in favor of reciprocating engines. This decision was made in 1901, at a time when the steam turbine was making significant progress in its development. However, those responsible for the decision held their opinion that it was a wise choice.

Above: caption: "Operating Room of the Power House"

"…The turbo-generators for electric lighting consist of four Westinghouse-Parsons multiple-expansion, parallel-flow turbines, each consisting of two turbines arranged in tandem-compound. The alternators will run at a speed of 1,200 revolutions per minute, and produce current at a pressure of 11,000 volts. Each unit will have a normal output of 1,700 horse-power, and it is guaranteed to operate under 450 degrees of superheat. The guarantee under a full load of 1,250 kilowatts is 13.8 pounds per electrical horse-power hour, which, it will be seen, is considerably lower than the guarantee for the reciprocating engines. There are also two exciter engines of the compound type, direct-connected to 250 kilowatt generators…"

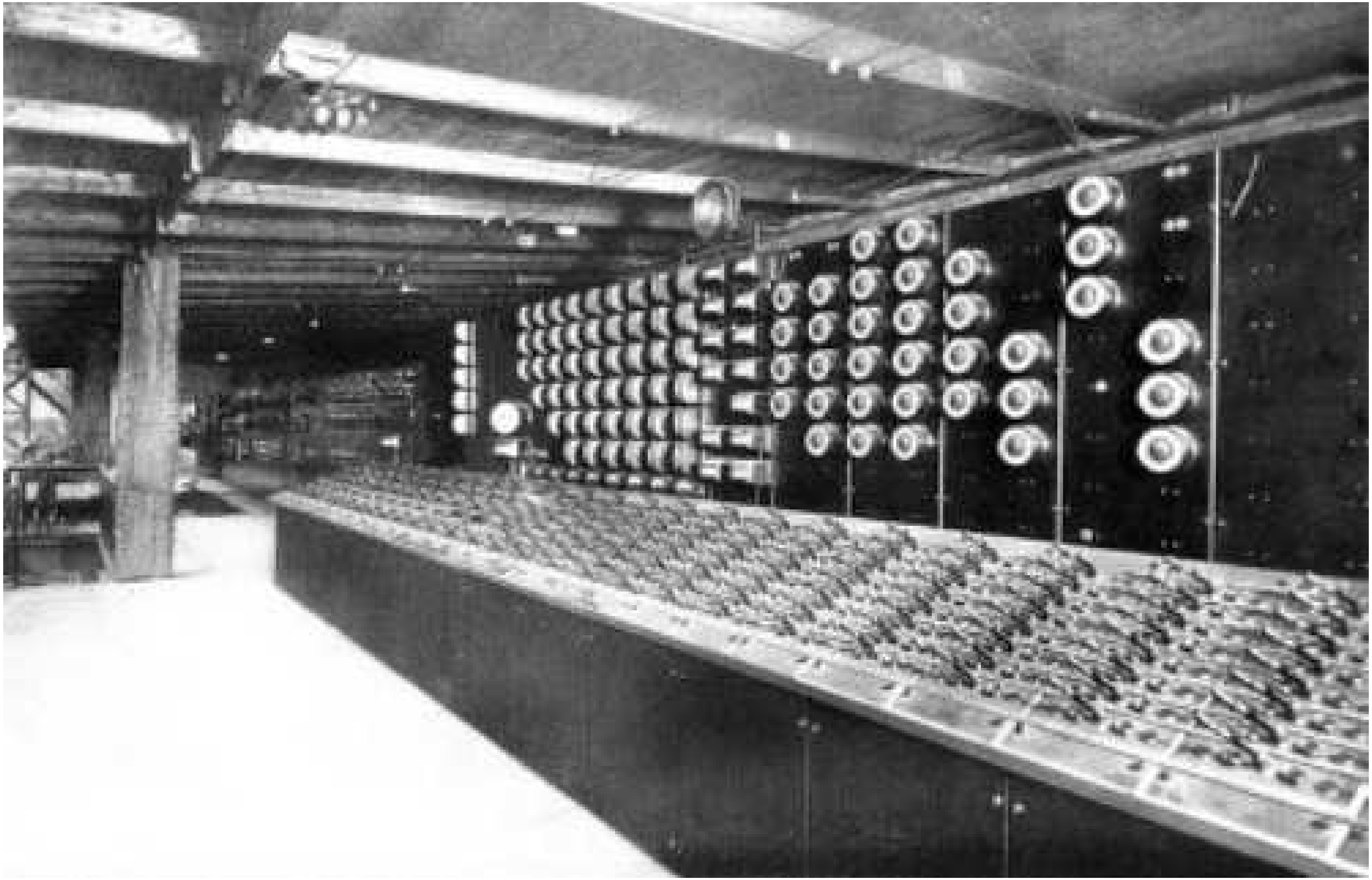
***Scientific American*, October 29th 1904**



"Current is delivered at 11,000 volts to eight substations, where it is transformed and converted to direct current at a potential of 625 volts, at which it is delivered to the third or contact rails…the third rail is protected by a lateral and overhead shield, which should prove fully effective in safeguarding the workmen or passengers from injury."

***Scientific American*, October 29th 1904**

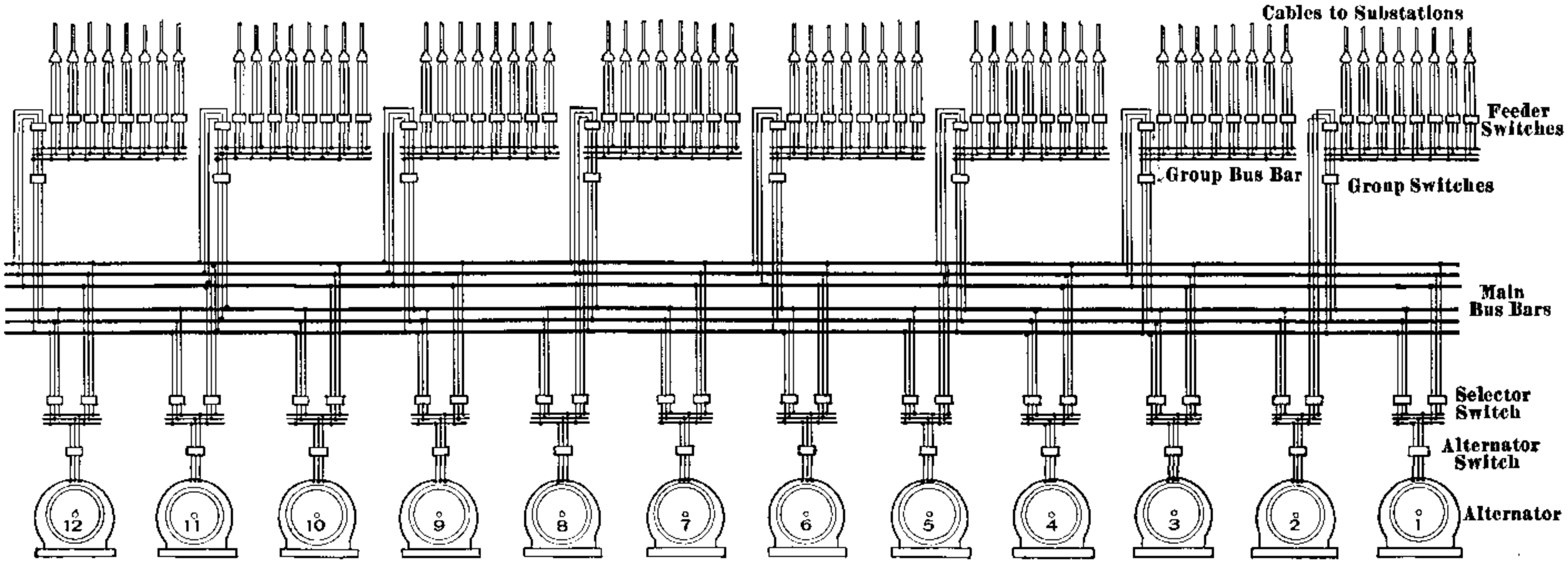
<u>Above</u>: caption: "Main controlling board in power station"



<u>Above</u>: caption: "Control and Instrument Board – Main Power Station"

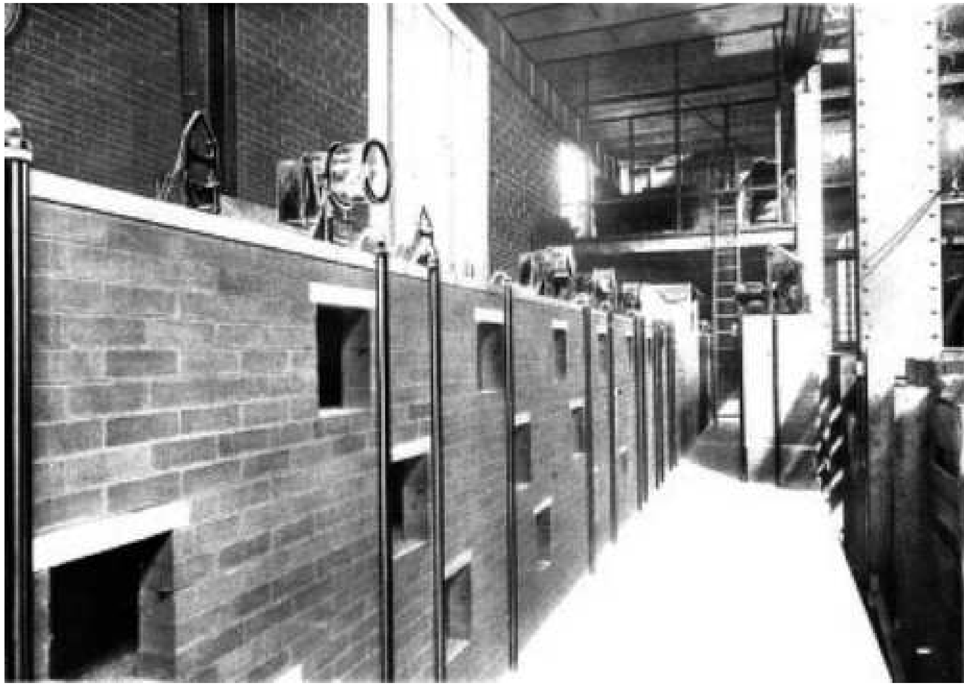
Power Distribution

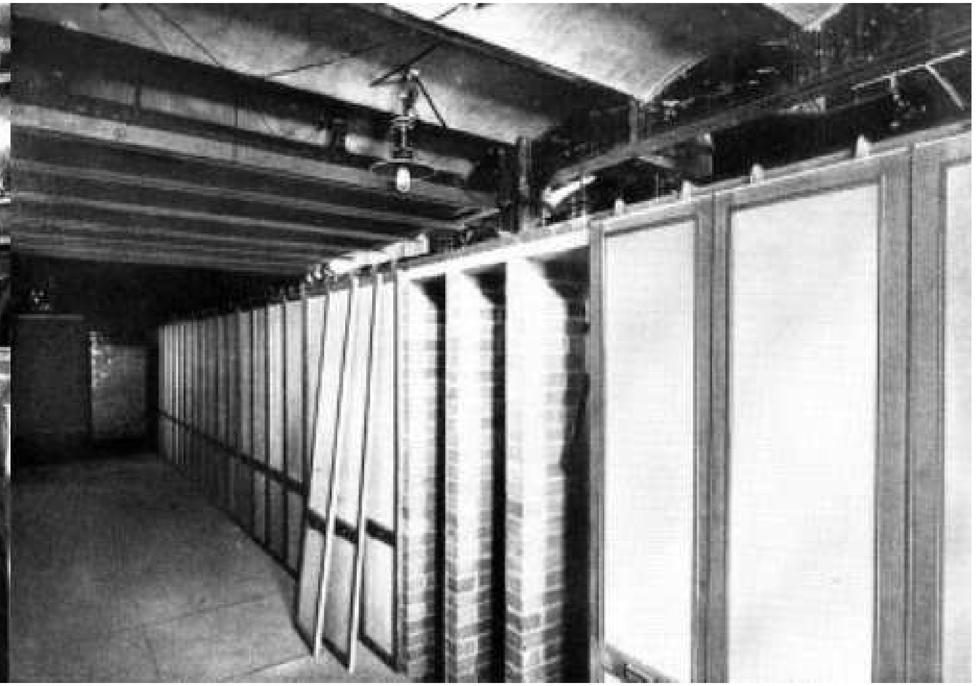
The system of electrical supply chosen for the IRT Subway comprised alternating current (AC) generation and distribution and direct current (DC) operation of car motors. In 1900, when the engineering plans were being developed, the single-phase alternating current railway motor was in an embryonic state of development. The comparatively limited headroom available in the Subway prohibited the use of an overhead system of conductors (pantograph) and this limitation, in conjunction with the obvious desirability of providing a system permitting interchangeable operation with the lines of the *Manhattan Railway* system excluded tri-phase traction systems and led directly to the adoption of the third-rail direct current system. It was impracticable to predict with certainty the ultimate traffic conditions to be met thus, the generator plant was designed to meet all probable traffic demands expected to arise within a year or two of the beginning of operation of the system. Each express train comprised five motor cars and three trail cars and each local train comprised three motor cars and two trail cars. The weight of each motor car, with maximum live-load, was 88K pounds and the weight of each trailer car was 66K pounds. The plans adopted provided electric equipment capable of operating express trains at an average speed of twenty-five miles per hour, while the control system and motor units were so chosen that higher speeds up to a limit of about thirty miles per hour could be attained by increasing the number of motor cars. Experience in operation demonstrated that such higher speeds could be safely obtained. The speed of local trains between *City Hall* and *96th Street* averaged about fifteen miles per hour while north of *96th Street*, on both the *Western* and *Eastern Branches*, their speed averaged about eighteen miles per hour (owing to the greater average distance between local stations).



As the result of careful consideration of various plans, the IRTC's engineers recommended that all the power required for the operation of the system be generated in a single Power House in the form of three-phase alternating current at 11K Volts. This current was to be generated at a frequency of twenty-five cycles per second delivered through three-conductor cables to transformers and converters in sub-stations suitably located with reference to the track system. At the sub-station/s, the current was to be transformed and converted to direct current for delivery to the third-rail conductor at a potential of 625 volts.

__Above__: caption: "General Diagram of 11,000 Volt Circuits in Main Power Station"



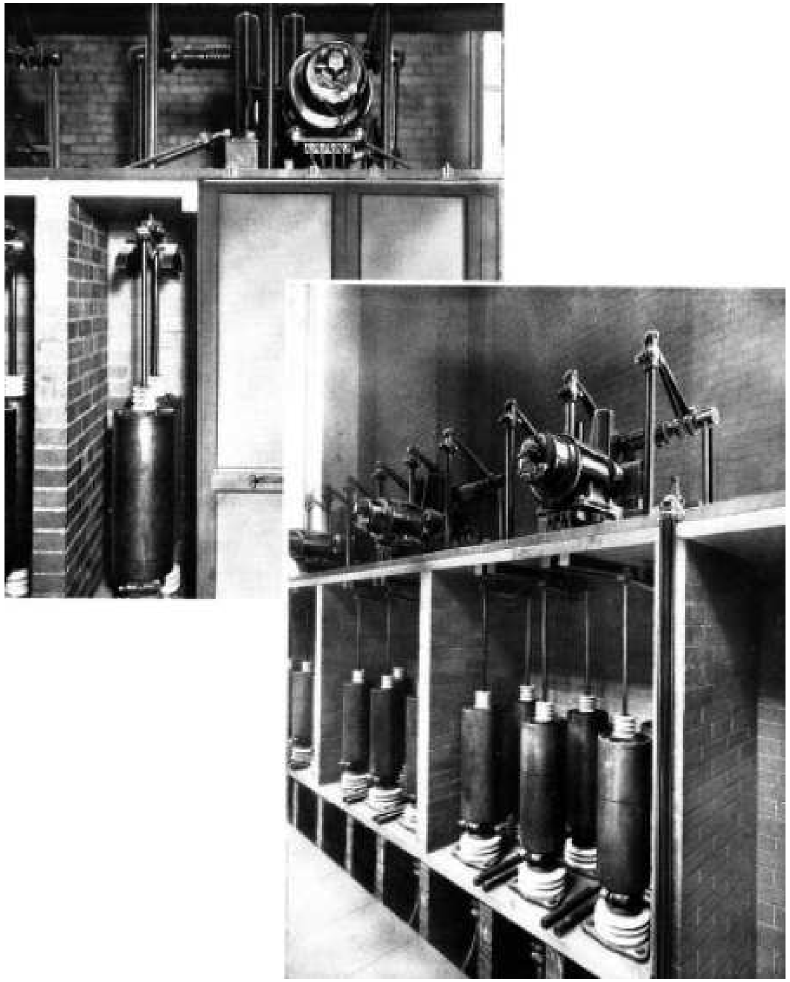


Calculations based upon contemplated schedules required for traction purposes and for heating and lighting cars determined a maximum delivery of about 45K-KW at the third rail. Allowing for losses in the distributing cables, transformers and converters, this implied a total generating capacity of approximately 50K-KW and having in view the possibility of future extensions of the system, it was decided to design and construct the Power House building for the ultimate reception of eleven 5K-KW units for traction current in addition to the lighting sets. Each 5K-KW unit was capable of delivering during rush hour/s an output of 7,500-KW or approximately 10K electrical horse power and, setting aside one unit as a reserve, the contemplated ultimate maximum output of the power plant was, therefore, 75K-KW or approximately 100K electrical horse power.

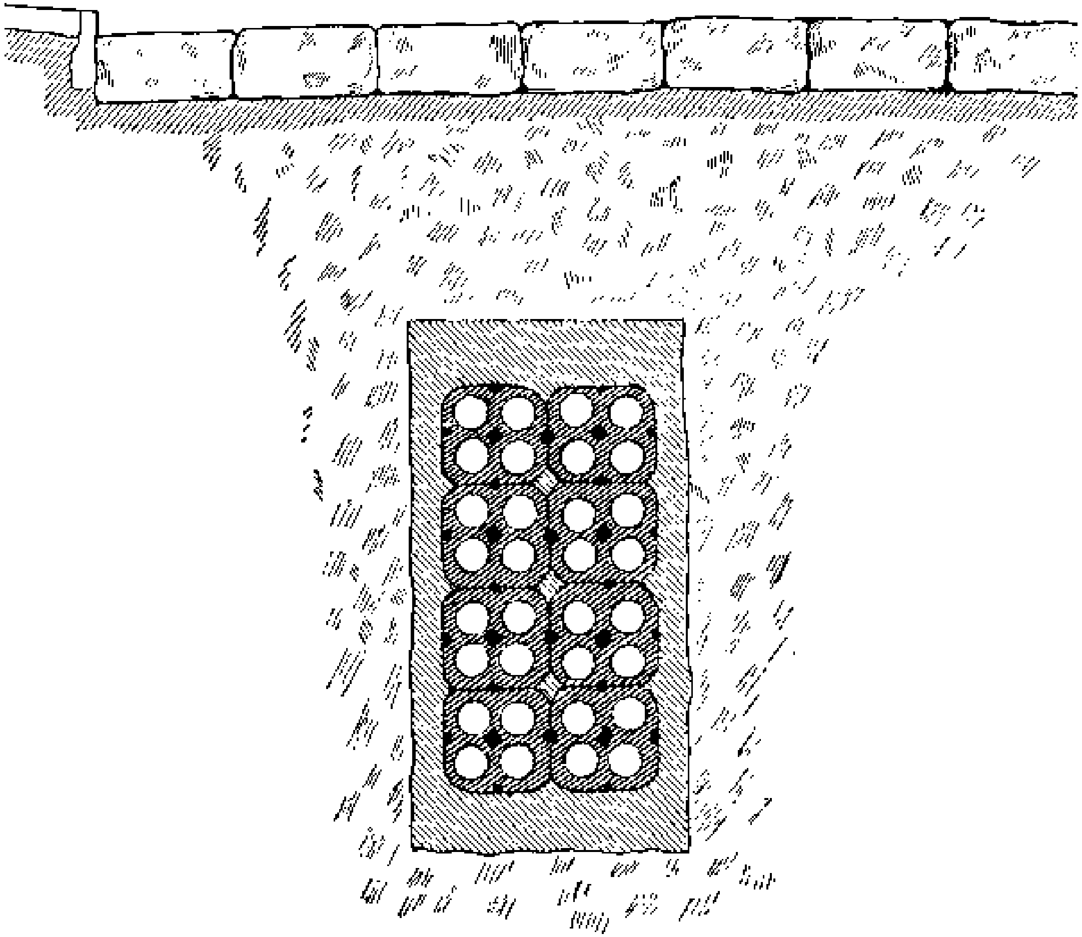
Left: caption: "Part of Bus Bar Compartments – Main Power Station"

Right: caption: "Rear View of Bus Bar Compartments – Main Power Station"

Provision was made for an ultimate total of twelve sub-stations, to each of which as many as eight feeders could be installed (eight sub-stations were required initially) and to some of these not more than three feeders were necessary. The aggregate number of feeders installed for the initial operation of the subway system was thirty-four. Each feeder circuit was provided with a type H-oil switch arranged to be open and closed at will by the operator and also to open automatically in case of abnormal flow of current through the feeder. The feeders were arranged in groups, each group being supplied from a set of auxiliary bus bars, which in turn received its supply from one or the other of the two sets of main bus bars. Means for selection being provided (as in the case of the alternator circuits) by a pair of selector switches, in this case designated as group switches. All switches could be opened or closed at will by the operator standing at the control board. The alternator switches were provided also with automatic overload and reversed current relays and the feeder switches were provided with automatic overload relays. These overload relays had a time attachment which could be set to open the switch at the expiration of a predetermined time ranging from 0.3 of a second to five seconds.

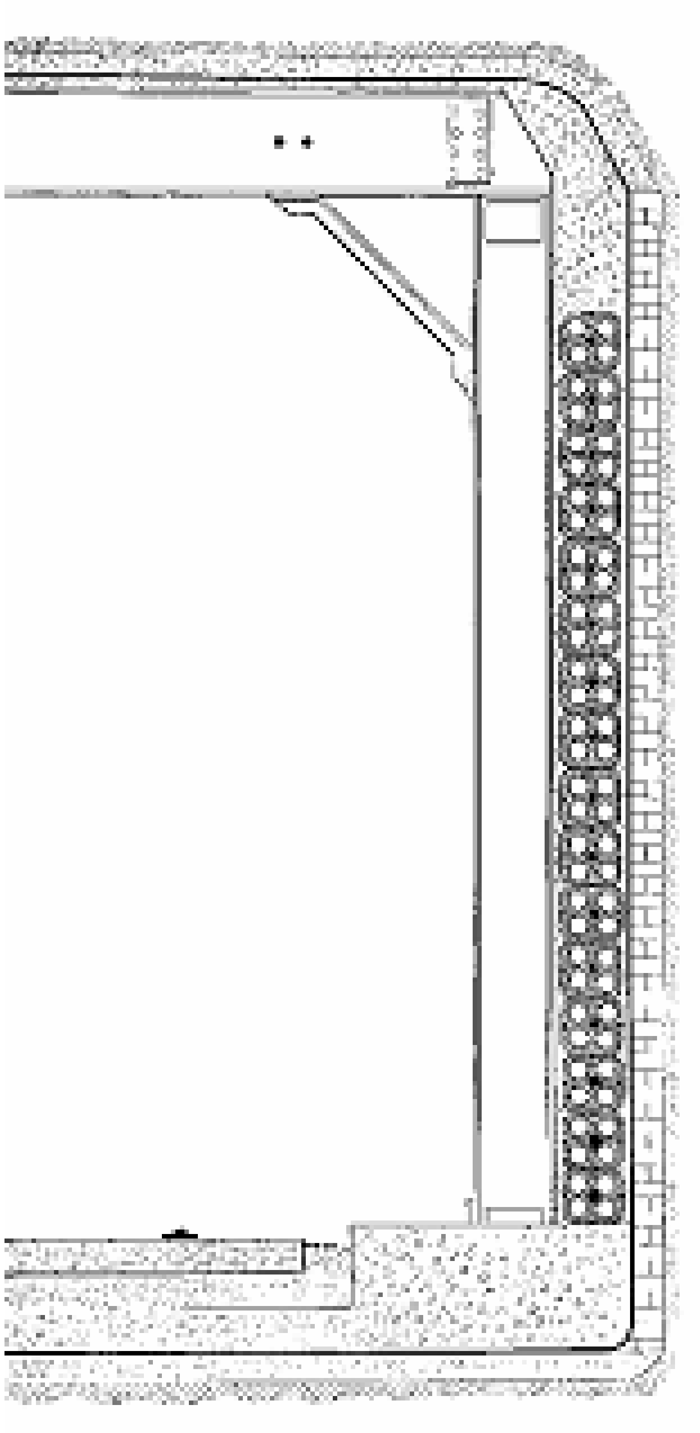


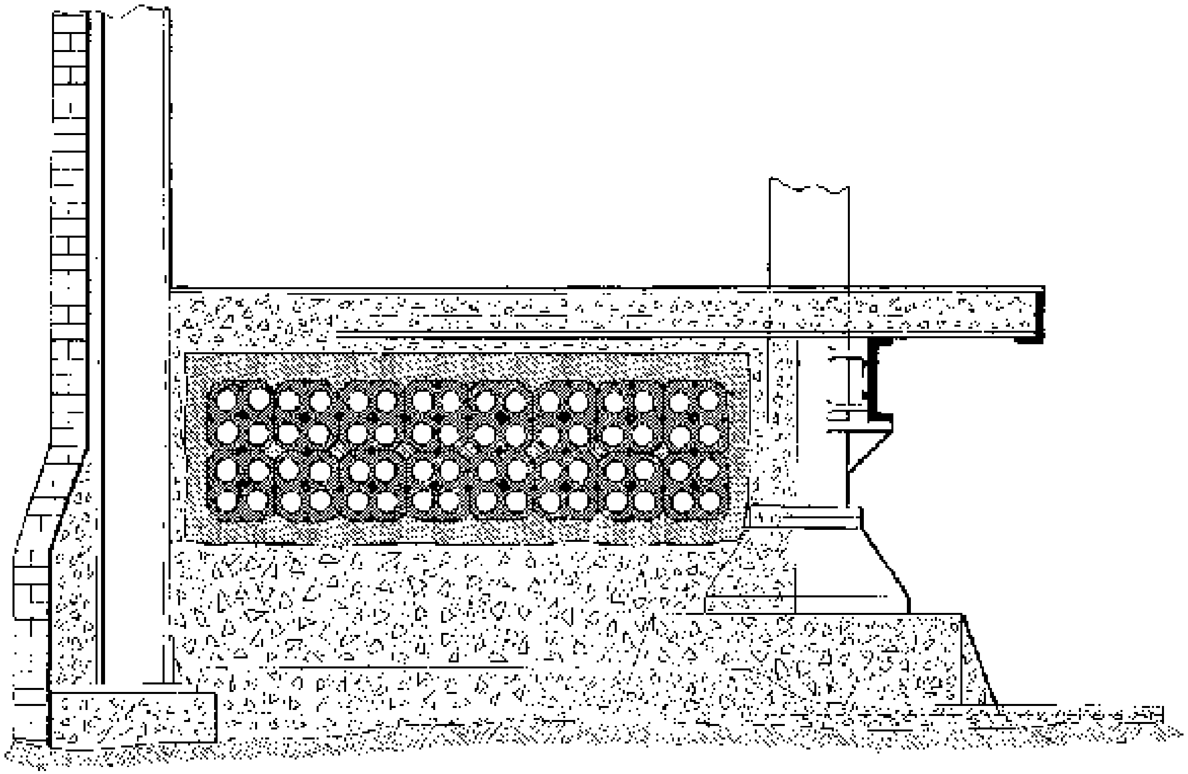
Left: caption: "Oil-Switches – Main Power Station"



From the power house to the Subway at *58th Street* and *Broadway,* two lines of conduit, each comprising thirty-two ducts, were constructed. These conduits were located on opposite sides of the street. The arrangement of ducts is shown in the section above.

<u>Above</u>: caption: "Duct line across 58th Street – 32 Ducts"





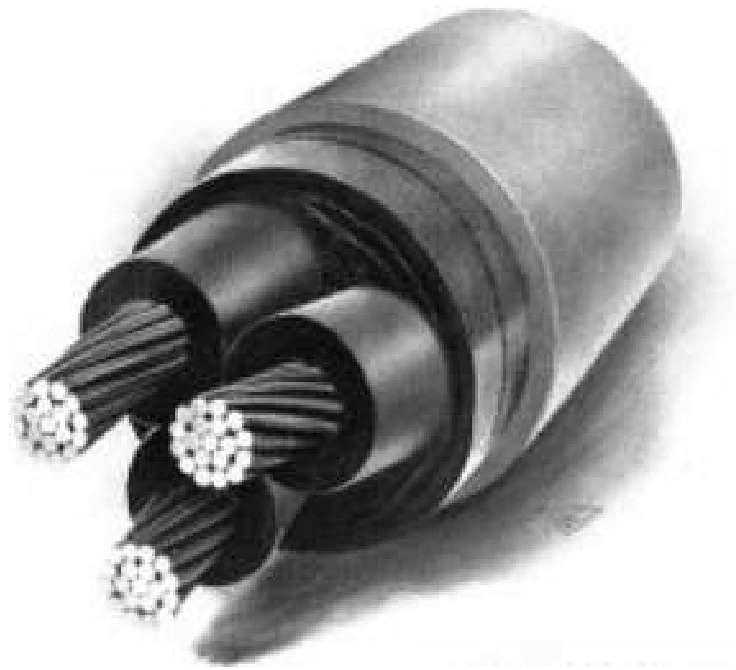
From *City Hall* to *96th Street* (except through the *Park Avenue Tunnel*) sixty-four ducts were provided on each side of the Subway. North of 96th Street, sixty-four ducts were provided for the west-side lines and an equal number for the east-side lines. Between passenger stations these ducts helped to form the side walls (left) of the Subway and were arranged thirty-two ducts high and two ducts wide. Beneath the platform of passenger stations (above), the arrangement was varied because of local obstructions such as pipes, sewers, etc.

Above: caption: "Ducts Under Passenger Station Platform – 64 Ducts"

Left: caption: "Inside Wall of Tunnel Showing 64 Ducts"

The necessity of passing the cables from the 32 x 2 arrangement of ducts (along the side of the tunnel) to 8 x 8 and/or 16 x 4 arrangements of ducts (beneath the passenger platforms) involved serious difficulties in the proper support and protection of cables in manholes at the ends of the station platforms. In order to minimize the risk of interruption of service due to possible damage to a considerable number of cables in one of these manholes (resulting from short circuit in a single cable), all cables except at the joints were covered with two layers of asbestos aggregating a full 0.25-inch in thickness. This asbestos was specially prepared and was applied by wrapping the cable with two strips each three-inches in width (the outer strip covering the line of junction between adjacent spirals of the inner strip). The whole, when in place, was impregnated with a solution of silicate of soda. The joints themselves were covered with two layers of asbestos held in place by steel tape applied spirally. To distribute the strains upon the cables in manholes, radical supports of various curvatures made of malleable cast-iron were used. In order to further diminish the risk of interruption of service due to power supply failure, each sub-station south of *96th Street* received its alternating current from the Power House through cables carried on opposite sides of the Subway. To protect the lead sheaths of the cables against damage by electrolysis, rubber insulating pieces 0.17 of an inch in thickness were placed between the sheaths and the iron bracket supports in the manholes.

Left: caption: “Manholes in Side Wall of Subway”

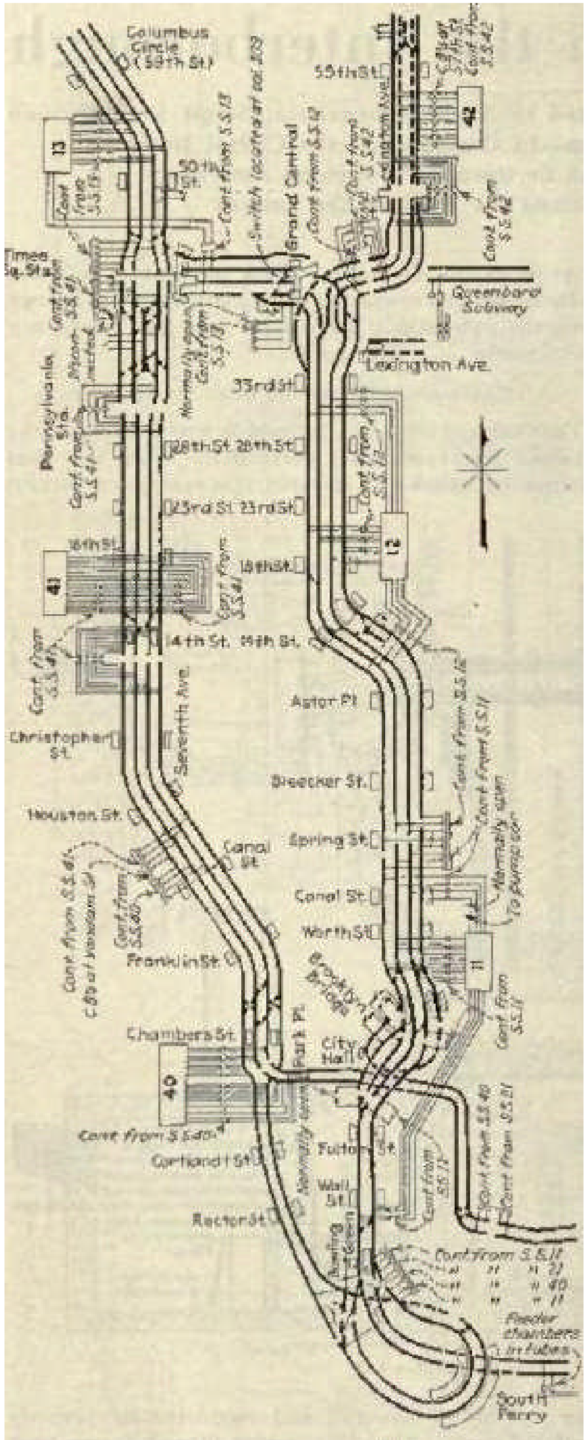


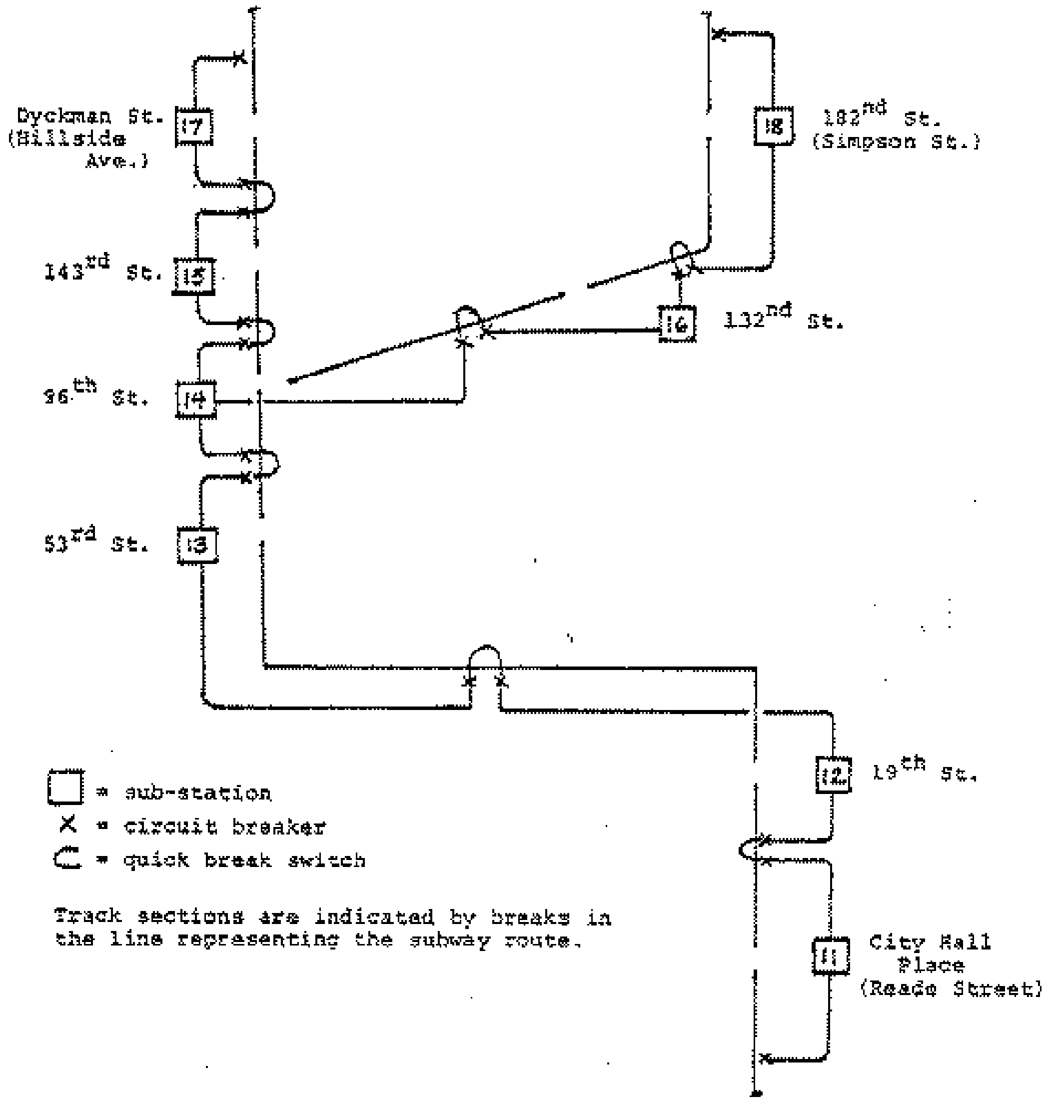
The cables used for conveying energy from the Power House to the several sub-stations aggregated approximately 150 miles in length. The cable used for this purpose comprised three stranded copper conductors each of which contained nineteen wires. The diameter of the stranded conductor thus formed was 0.40 of an inch. Paper insulation was employed and the triple cable was enclosed in a lead sheath 0.14 of an inch thick. Each conductor was separated from its neighbors and from the lead sheath by insulation of treated paper 0.44 of an inch in thickness. The outside diameter of the cables was 2.63-inches and the weight 8.5 pounds per lineal foot. In the factory, the cable was cut into lengths corresponding to the distance between manholes and each length subjected to severe tests including application to the insulation of an alternating current potential of 30K Volts for a period of thirty minutes. These cables were installed under the supervision of the IRTC's engineers and, after joining, each complete cable from Power House to sub-station was tested by applying an alternating potential of 30K Volts for thirty minutes between each conductor and its neighbors and between each conductor and the lead sheath.

Above: caption: "Three-Conductor Cable No. 000 for 11,000 Volt Distribution"

“…Power is furnished to the contact rails from substations located approximately two miles apart. The contact rails within the section supplied by power from a substation is in full control of the operator of that particular substation, and he is under the direction of a system operator located in the main power station. This arrangement has been made possible by the control system in use by which each track section receives power through separate feeders and circuit breakers, and it permits the localizing of any trouble to the track section on which the trouble occurs. The contact rails are further sectionalized for reasons of operating facility during times of emergency, particularly at places where crossovers are located and where it may be necessary to turn or divert trains from one track to another around sections where trouble exists. This is accomplished by creating a gap in the contact rail, around which gap cables are inserted for continuity of power, the cables being in series with a circuit breaker. In the design of this system, one of the fundamentals observed was the elimination wherever possible of any material of an inflammable or combustible character that would tend to create smoke or fumes. Where this was not possible extraordinary preventive measures were followed for the protection of materials of a combustible or inflammable character…”

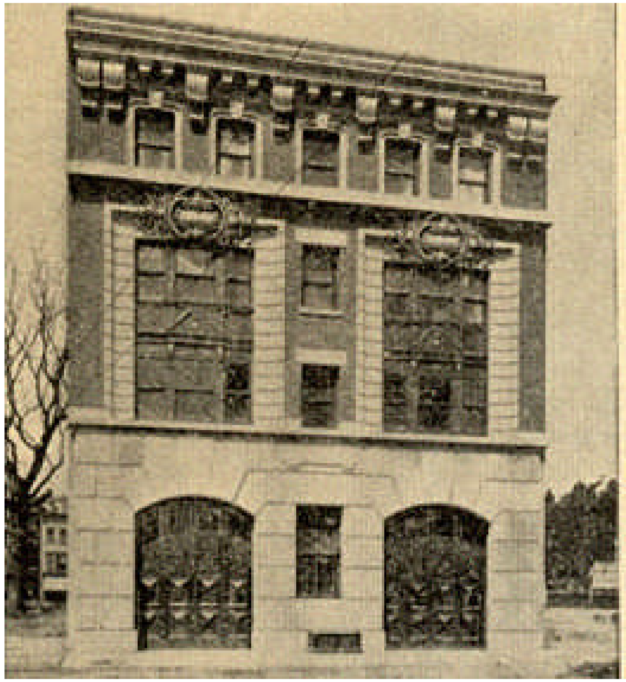
Electric Railway Journal, **January 23rd 1926**

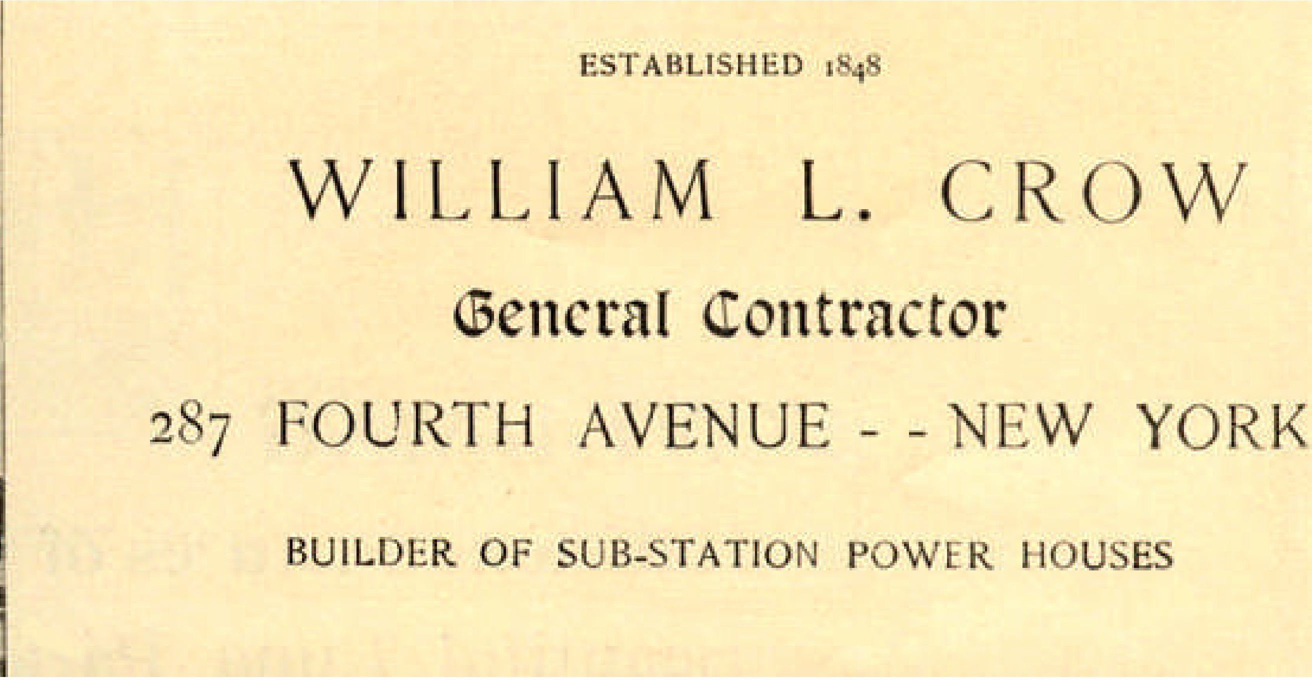




Above: caption: "Sub-Station Schematic Diagram

Left: caption: "Portion of Positive D.C. Feeder Layout Showing Location of Substations, etc."





ESTABLISHED 1848

WILLIAM L. CROW

General Contractor

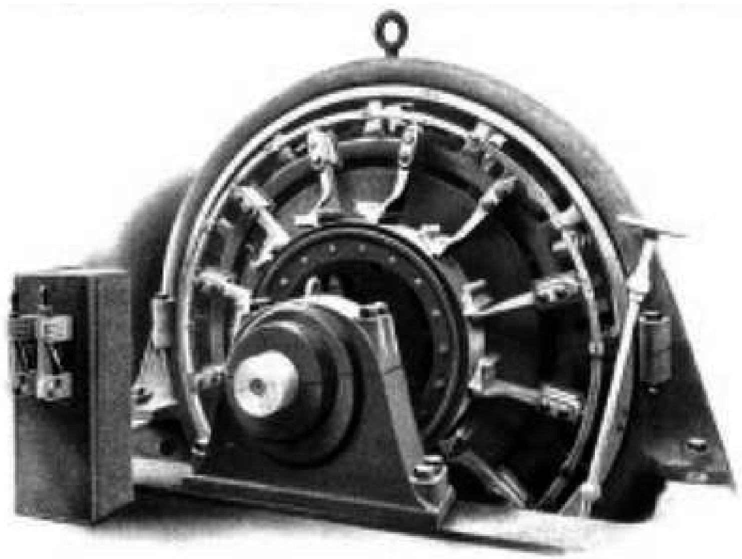
287 FOURTH AVENUE - - NEW YORK

BUILDER OF SUB-STATION POWER HOUSES

The tri-phase alternating current generated at the Power House was conveyed through the high potential cable system to eight sub-stations containing the necessary transforming and converting machinery. These sub-stations were located as follows:

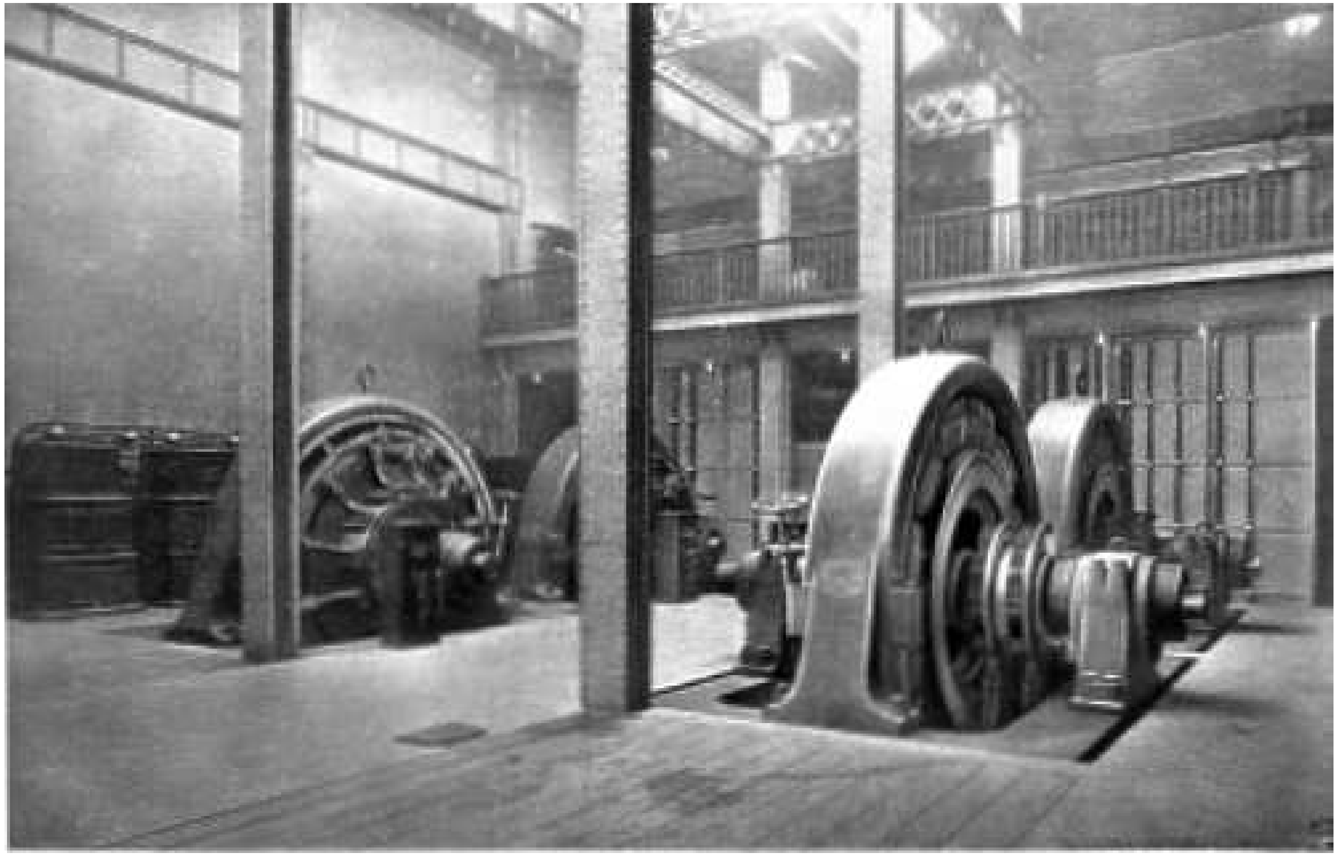
- **Sub-station No. 11—29-33 City Hall Place;**
- **Sub-station No. 12—108-110 East 19th Street;**
- **Sub-station No. 13—225-227 West 53d Street;**
- **Sub-station No. 14—264-266 West 96th Street;**
- **Sub-station No. 15—606-608 West 143d Street;**
- **Sub-station No. 16—73-77 West 132d Street;**
- **Sub-station No. 17—Hillside Avenue, 301 feet West of Eleventh Avenue;**
- **Sub-station No. 18—South side of Fox Street (Simpson Street), 60-feet north of Westchester Avenue**

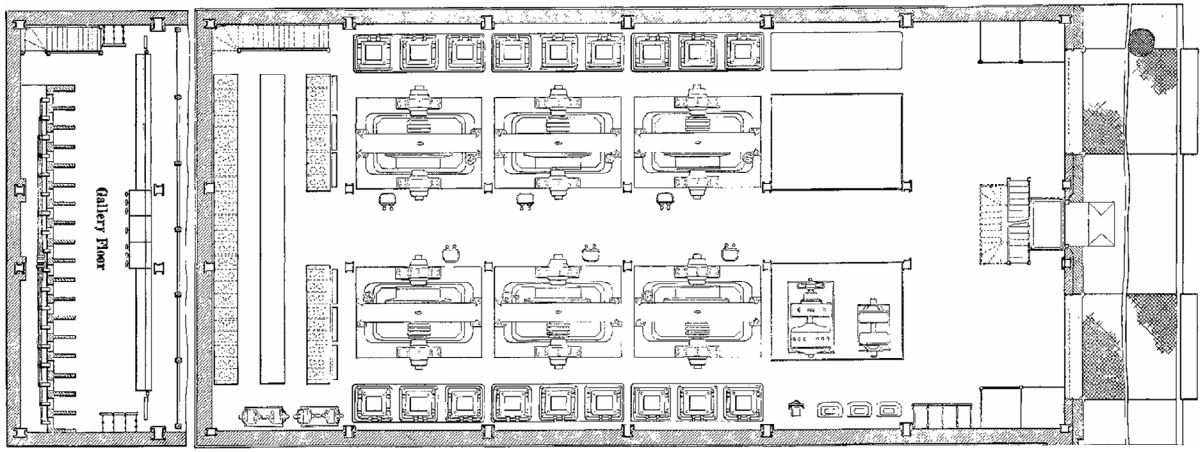
<u>Above & Left</u>: Sub-Station No.18



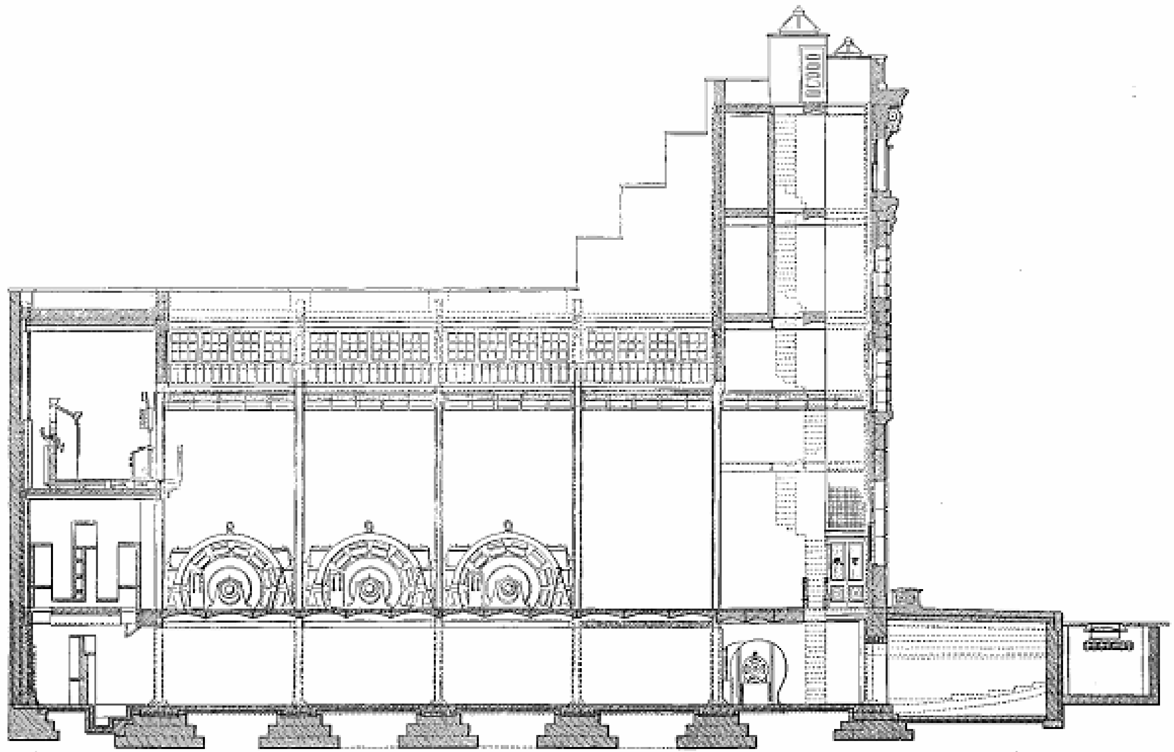
The converter unit selected to receive the alternating current and deliver direct current to the track, etc. had an output of 1,500-KW with ability to carry 50% overload for three hours. The average area of a city lot was 25 by 100-feet and a sub-station site comprising two adjacent lots of this approximate size permitted the installation of a maximum of eight 1,500-KW converters with necessary transformers, switchboard and other auxiliary apparatus. In designing the sub-stations, a type of building with a central air-well was selected. The typical organization of apparatus provided for two lines of converters; the three transformers which supplied each converter were located between it and the adjacent side wall. The switchboard was located at the rear of the station. The central shaft afforded excellent light and ventilation for the operating room. The steel work of the sub-stations was designed with a view to the addition of two storage battery floors, should it have been decided at some future time that the addition of such an auxiliary was advisable.

Above: caption: "1,500 KW Rotary Converter"

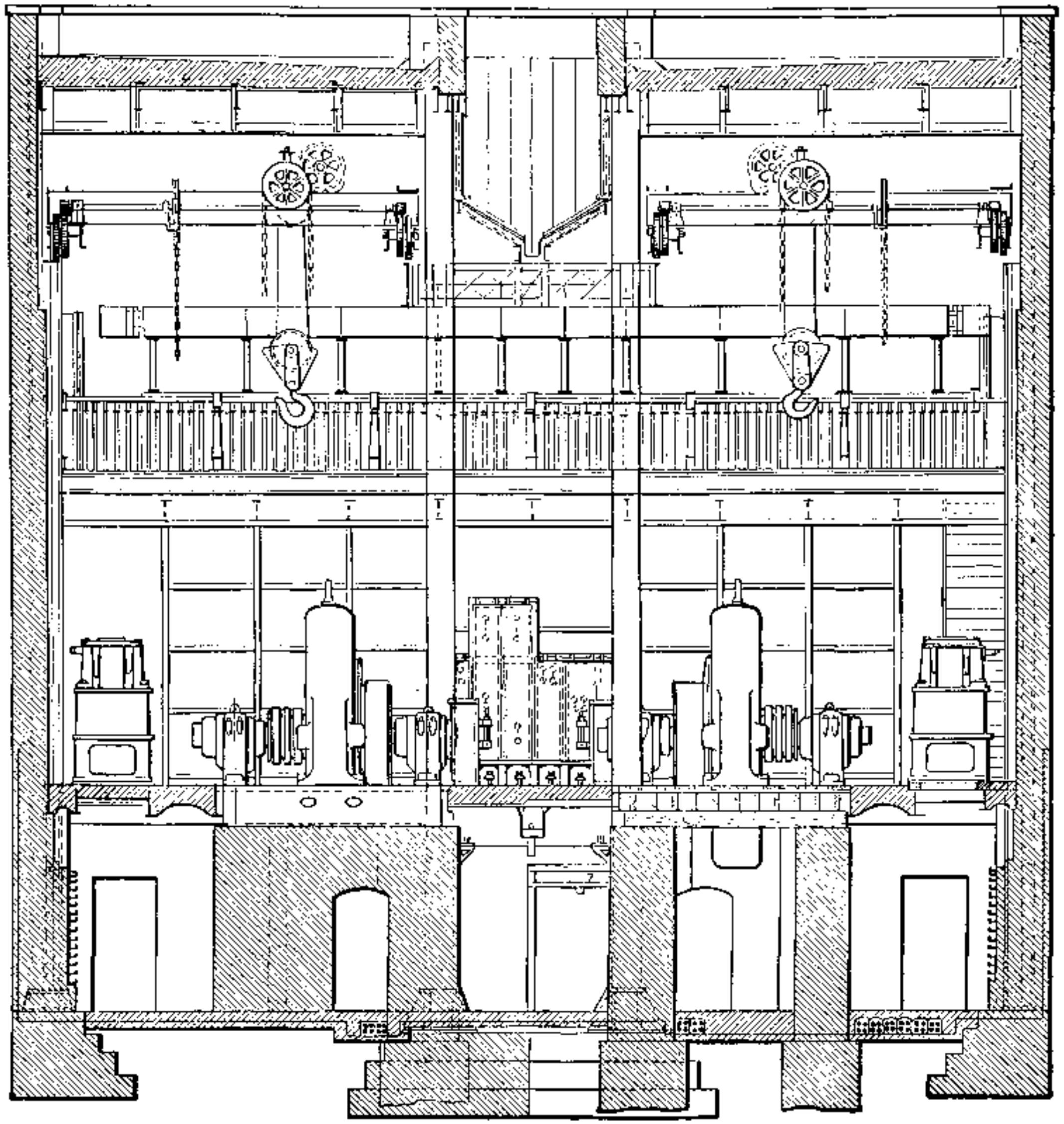




CONVERTER FLOOR PLAN SUB-STATION NO. 14



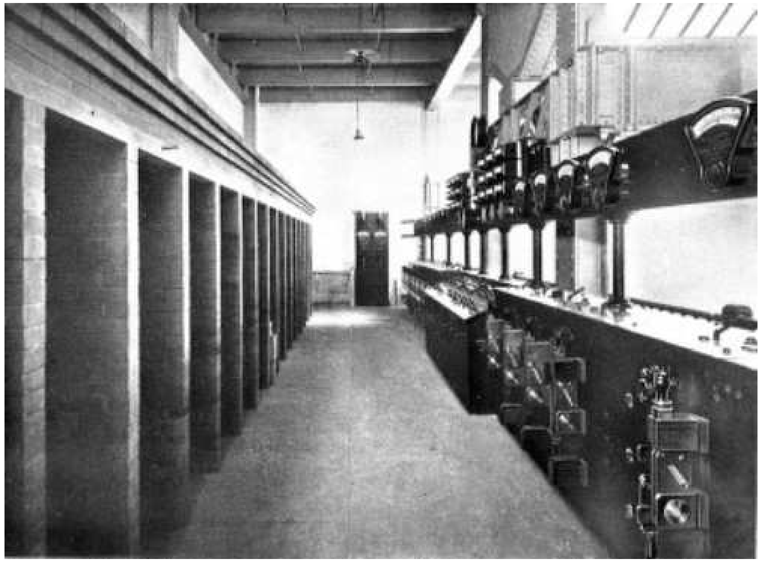
LONGITUDINAL SECTION SUB-STATION NO. 14



CROSS SECTION SUB-STATION NO. 14

The equipment of the sub-stations required sites approximately 50 by 100-feet in dimension/s. Sub-station Nos. 14, 15, 17 and 18 were practically all this size. Sub-station Nos. 11 and 16 were 100-feet in length, but the lots acquired were approximately 60-feet wide. Sub-station No. 12, on account of limited ground space, was 48-feet wide and 92-feet long. In each of the sub-stations foundations were provided for eight converters. Sub-station No. 13 contained a foundation for the potential installation of up to ten converters.

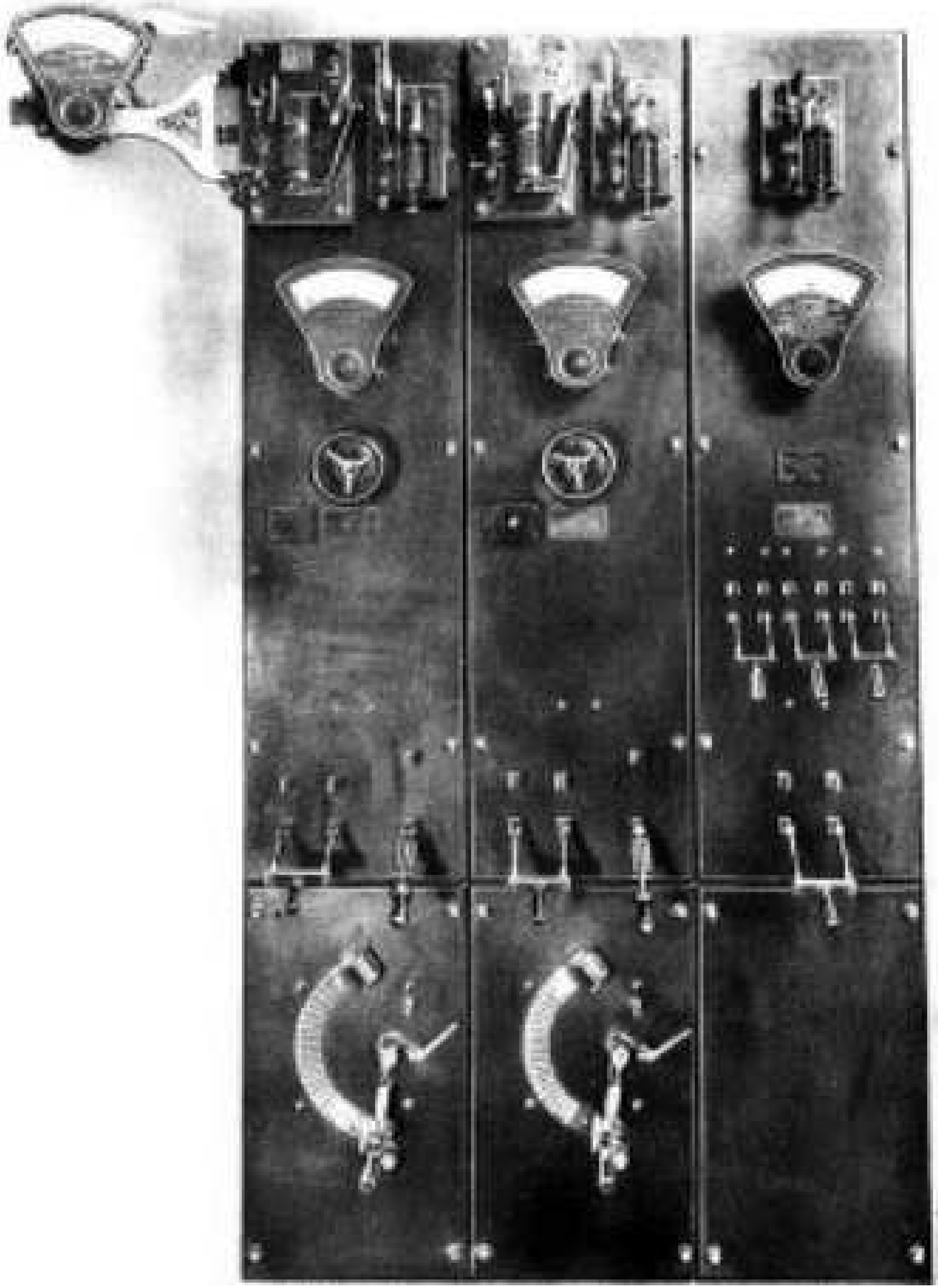
Left: caption: “Exterior of Sub-Station No. 11”

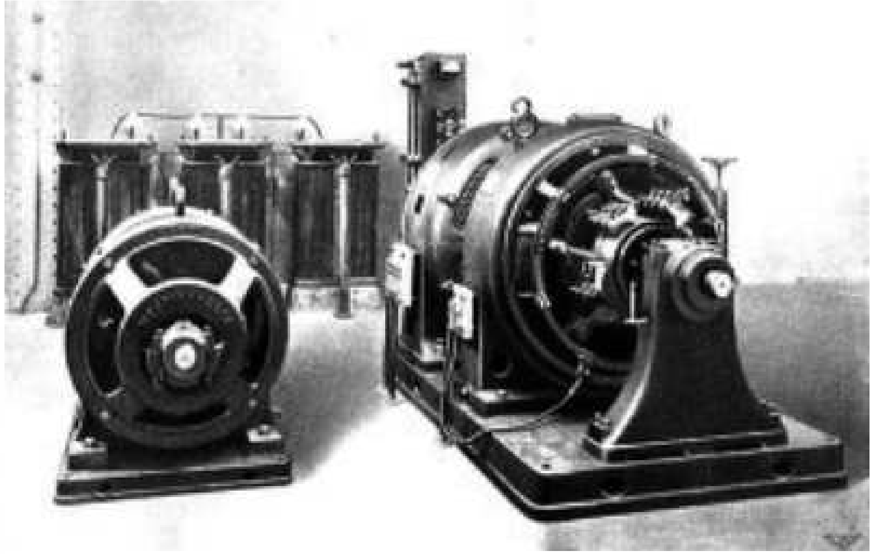


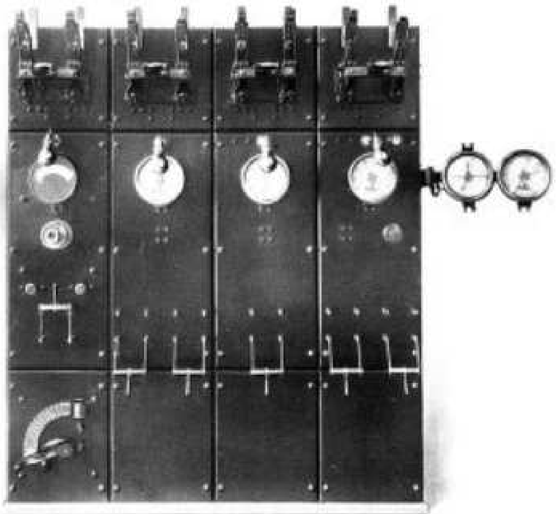
The function of the electrical apparatus in sub-stations was the conversion of the high potential alternating current energy delivered from the Power House through the tri-phase cables into direct current adapted to operate the motors with which the rolling stock was equipped. This apparatus comprised transformers, converters and minor auxiliaries. The transformers, which were arranged in groups of three, received the tri-phase alternating current at a potential approximating 10,500 Volts and delivered equivalent energy (less the loss of about 2% in the transformation) to the converters at a potential of about 390 Volts. The converters receiving this energy from their respective groups of transformers in turn delivered it (less a loss approximating 4% at full load) in the form of direct current at a potential of 625 Volts to the bus bars of the direct current switchboards from which it was conveyed by insulated cables to the contact rails.

Left: caption: "Operating Gallery in Sub-Station"

Right: caption: "Two Groups of Transformers"



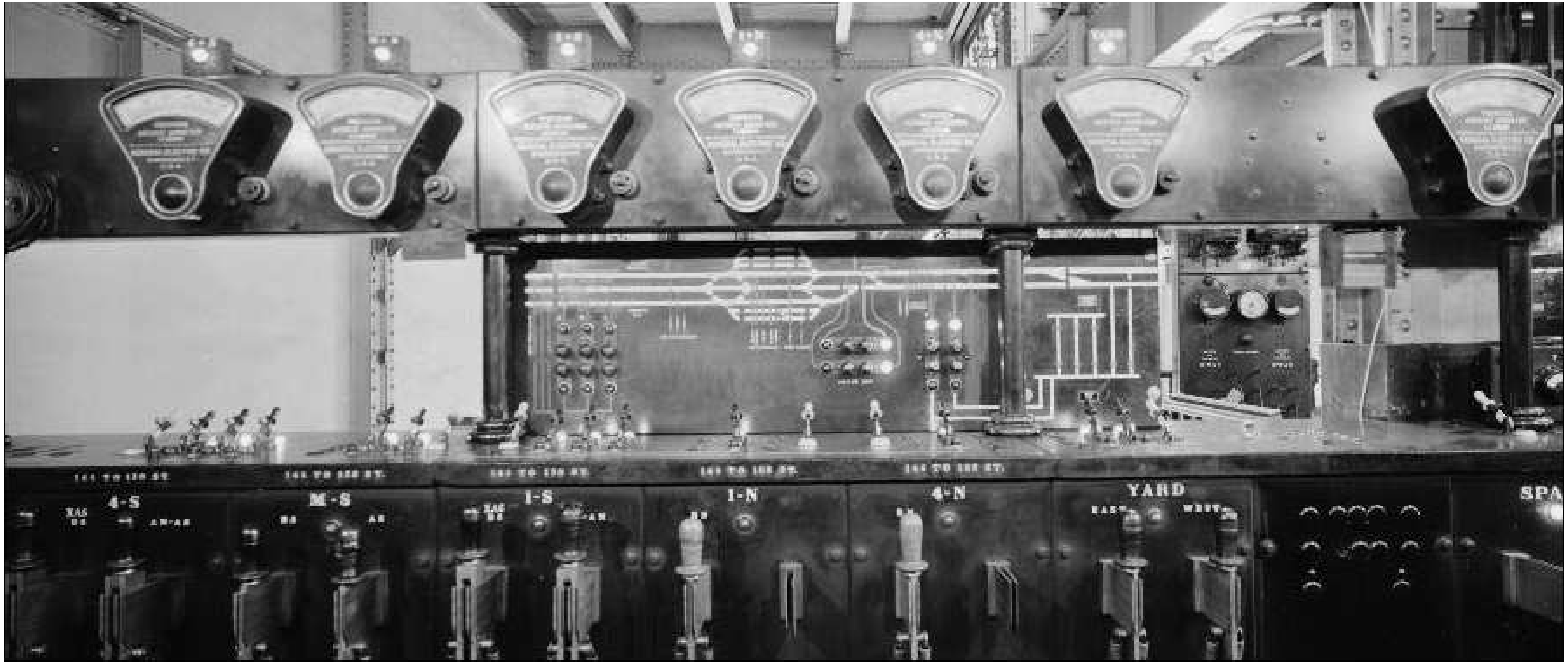




<u>Above Top</u>: caption: "Motor generators and Battery Board for Control Circuits – Sub-Station

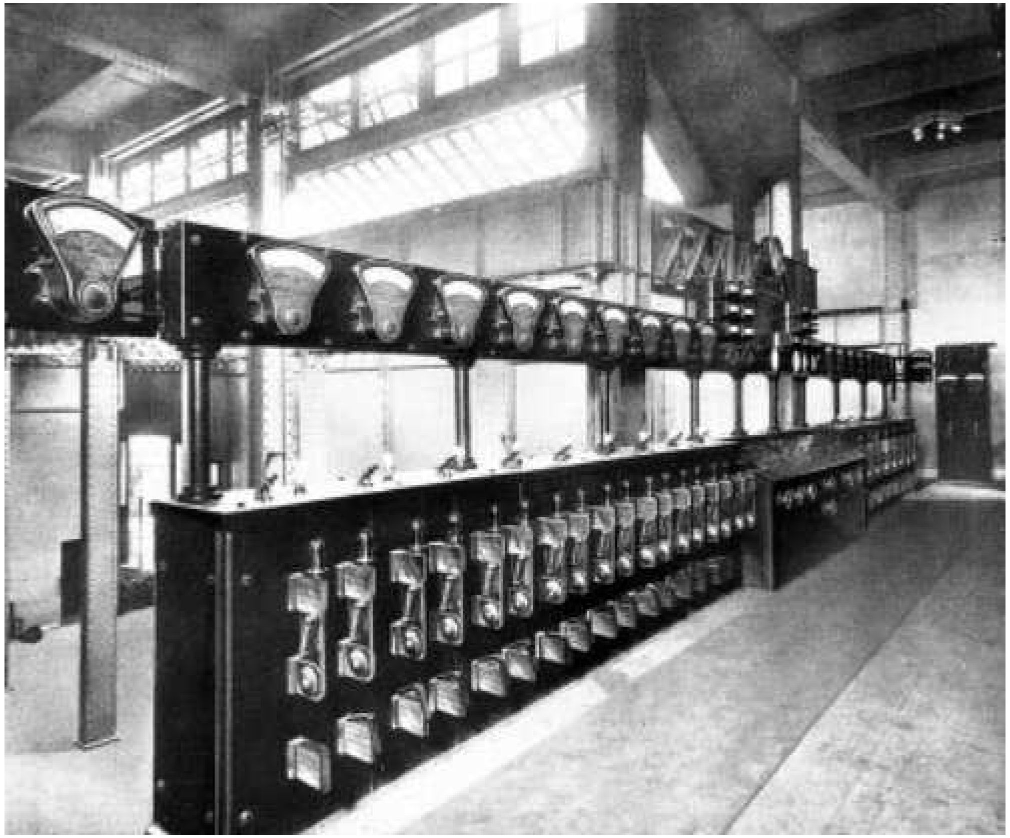
<u>Above Bottom</u>: caption: "Switchboard for Alternating Current Block Signal Circuits – in Sub-Station

<u>Left</u>: caption: "Motor Generators and Battery Board for Control Circuits – Sub-Station"

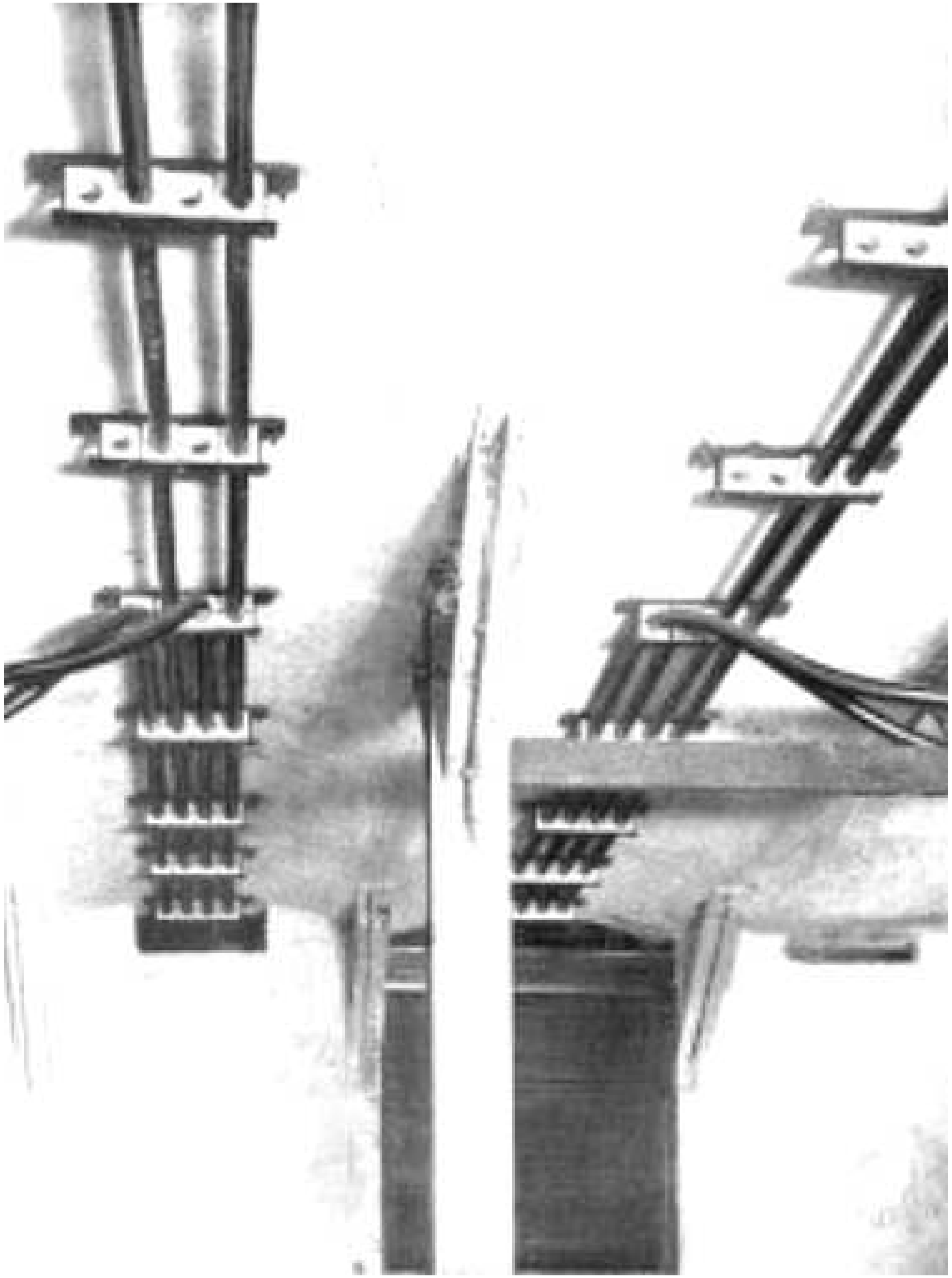


In the sub-stations, as in the Power House, the high potential alternating current circuits were opened and closed by oil switches which were electrically operated by motors, these in turn were controlled by 110 Volt direct current circuits. Diagramatic bench boards were used (as at the Power House), but in the sub-stations they were relatively small and free from complication. The instrument board was supported by iron columns and carried at a sufficient height above the bench board to enable the operator, while facing the bench board and the instruments, to look out over the floor of the sub-station without turning his head. The switches of the direct current circuits were hand-operated and were located upon boards at the right and left of the control board.

Above: caption: “Sub-Station No.15, Gallery Equipment”

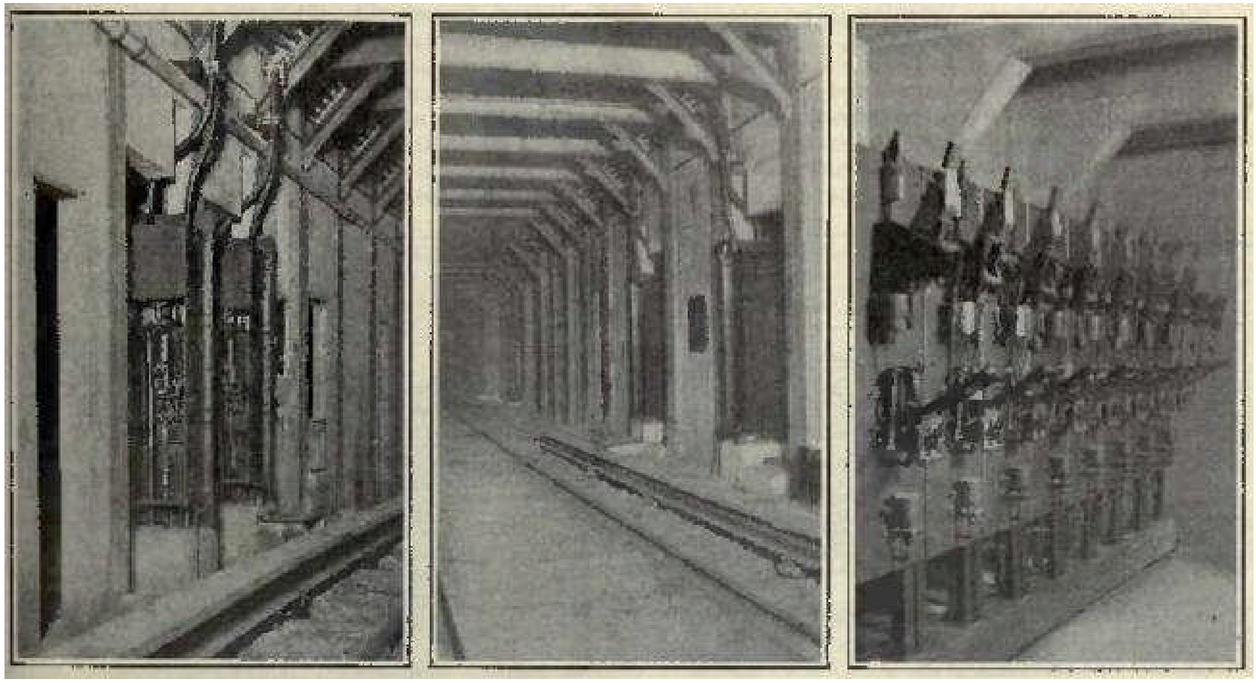


The three conductor cables which conveyed tri-phase currents from the Power House were carried through tile ducts from the manholes (located in the street directly in front of each sub-station) to the back of the station where the end of the cable was connected directly beneath its oil switch. The three conductors, now well separated, extended vertically to the fixed terminals of the switch. In each sub-station only one set of high-potential alternating current bus bars was installed and between each incoming cable and these bus bars was connected an oil switch. In like manner, between each converter unit and the bus bars an oil switch was connected into the high potential circuit. The bus bars were so arranged that they could be divided into any number of sections not exceeding the number of converter units by means of movable links which, in their normal condition, constituted a part of the bus bars. Each of the oil switches between incoming circuits and bus bars was arranged for automatic operation and was equipped with a reversed current relay, which, in the case of a short-circuit in its alternating current feeder cable, opened the switch thus disconnecting the cable from the sub-station without interfering with the operation of the other cables or the converting machinery.



The organization of electrical conductors provided to convey direct current from the sub-stations to the moving trains can be described best by beginning with the contact or "third rail." South of *96th Street,* the average distance between sub-stations was about 12K-feet and north of 96th Street the average distance was about 15K-feet. Each track was provided with a contact rail. There were four tracks and consequently four contact rails from *City Hall* to 96th Street, three from 96th Street to *145th Street* on the west-side, two from 145th Street to *Dyckman Street* and three from Dyckman Street to the northern terminal of the Western (*Fort George*) Branch. From 96th Street, the Eastern (*Bronx Park*) Branch had two tracks and two contact rails to *Mott Avenue* and from that point to the terminal at *182nd Street*, three tracks and three contact rails.

Left: caption: "Direct Current feeders from Manhole to Contact Rail"



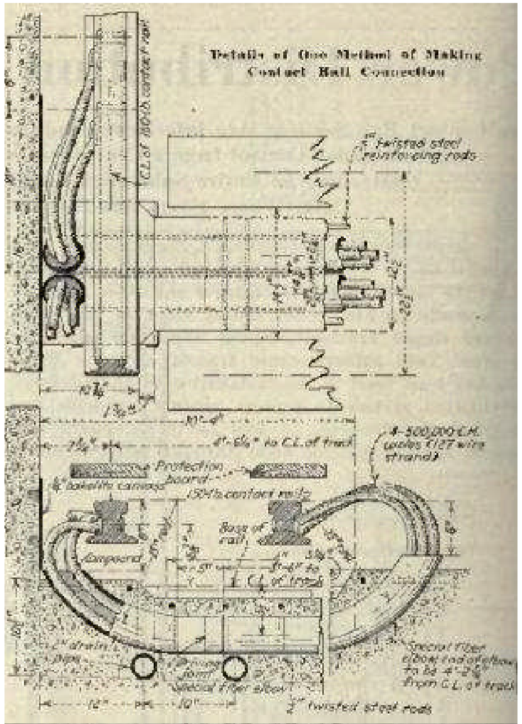
"…Primarily the safety features of the system depend upon the sectionalizing of the third rail, the sections being electrically connected by electro-pneumatic circuit breakers, which are under remote control from a centralized control station. In consequence, the circuit breaker controlling a section, besides automatically opening in case of a super-current flow, will open if an emergency alarm is sent from one of the alarm boxes mounted on the subway wall in that section…"

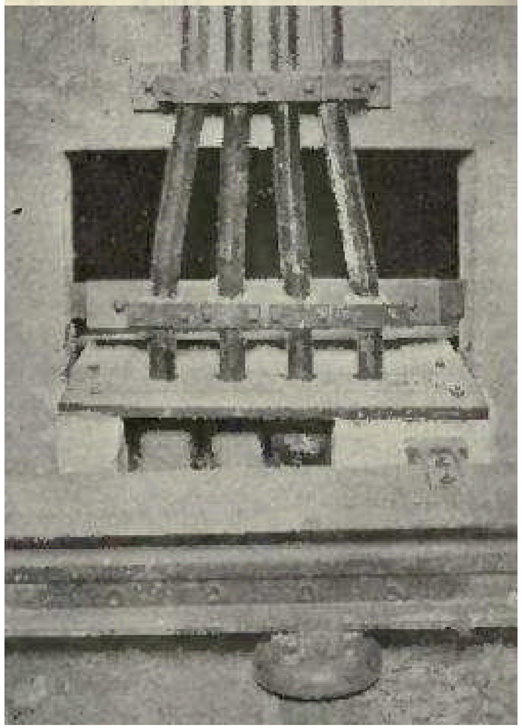
Electric Railway Journal, **January 23rd 1926**

Above: caption: "Left: Circuit Breakers in Boxes on Columns, with Boxes Open at 156th Street and Alexander Avenue. Center: Circuit Breakers in Boxes on Columns with Boxes Closed at 129th Street and Lexington Avenue. Right: Front View of Group of Circuit Breakers in Chamber at 79th Street and Lexington Avenue."

"…The cables which furnish power from the substations to the contact rails are of the concentric type that is to say, there is an inner core that is positive, then a layer of insulation, then a layer of wires forming the negative conductor, then more insulation, and then an outer covering of lead. The purpose of this type of cable construction is to localize any trouble caused by short circuits. At its outer end this cable terminates at a manhole in the side wall of the tunnel where the positive and negative portions of the cable are separated, the negative lead being connected to a bus and the positive lead carried to a circuit breaker. The circuit breaker is of 3,000-amp. capacity and is equipped with an electro-pneumatic valve for the closing operation and a trip coil for the tripping operation. The circuit breaker is mounted on an extra heavy panel. In some cases, these circuit breakers are housed in fireproof boxes and mounted on the columns, but wherever possible, a separate concrete and steel chamber is constructed as part of the subway structure. The negative bus is mounted in a separate chamber immediately adjacent to the circuit breakers. The negative cables are then run from this negative bus to the track rails in fiber conduit, with a sufficient thickness of concrete around the conduit to prevent water from entering it and to protect it from damage that might be caused by its coming in contact with any heavy object, as well as to afford protection against fire…"

Electric Railway Journal, **January 23rd 1926**



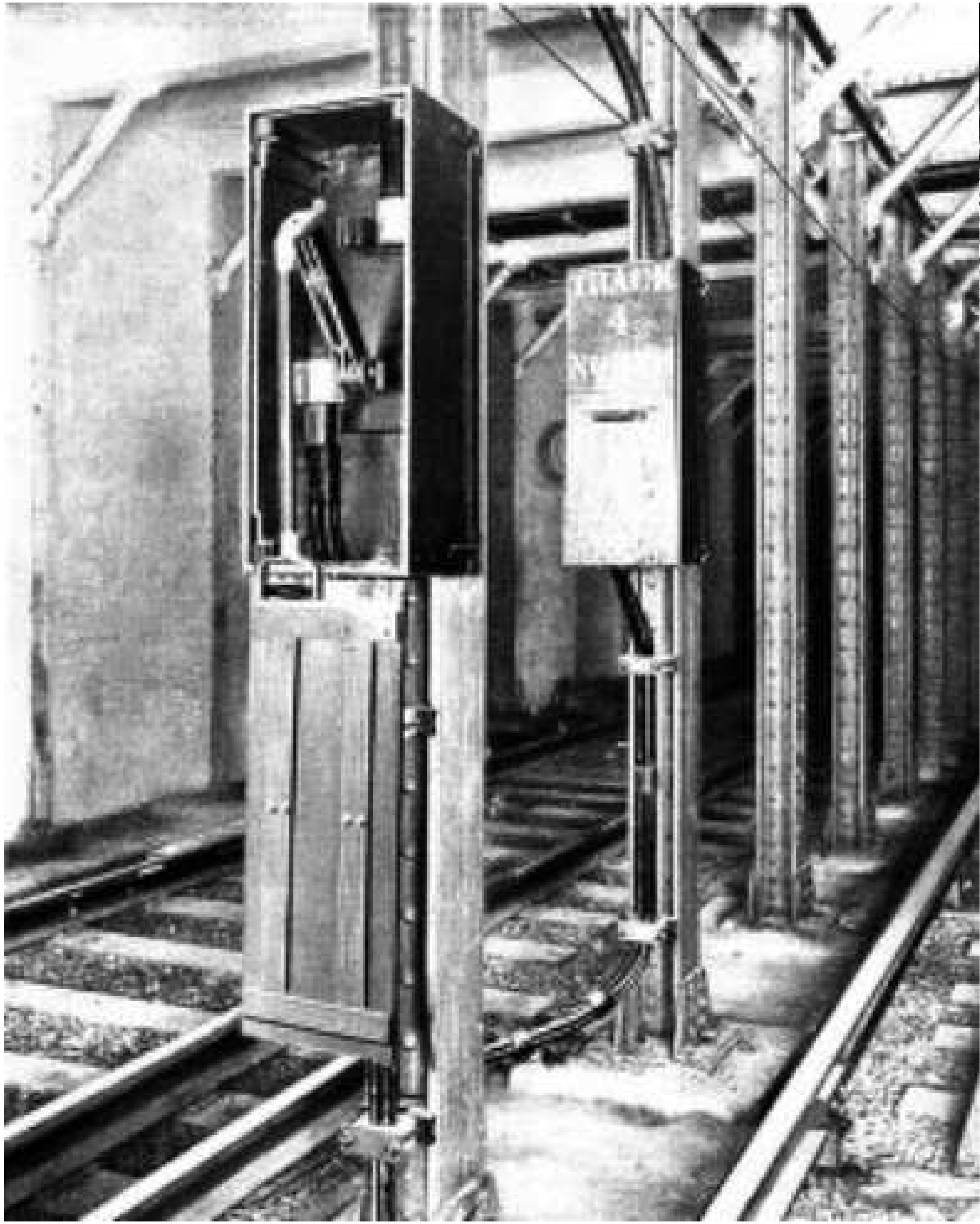


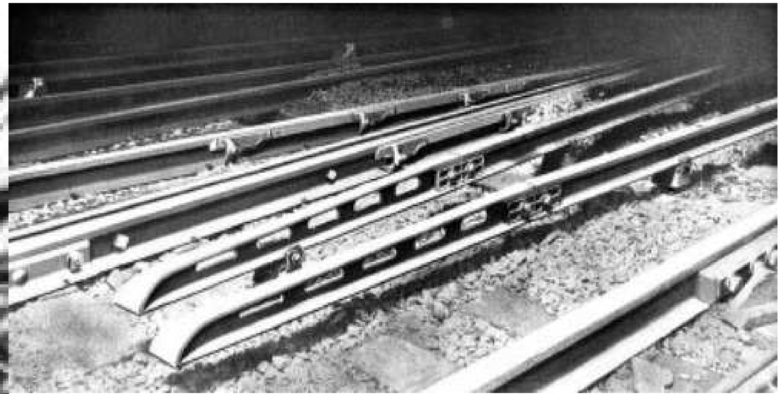
"…The positive connection from the circuit breaker to the contact rail is made by means of 2,000,000-circ. mil cable, insulated by an extra heavy thickness of Kerite insulation, and where it is necessary to install this cable on the steel beams it is further insulated by porcelain insulators. This 2,000,000-circ.mil cable is terminated in a specially devised pothead, constructed of concrete where it is changed to four smaller cables more easily to permit of its being bonded into the contact rails to its full capacity. This change in the size of cables is made by a mechanical connector that permits of ready disconnection whenever necessary. At all locations where it is possible the positive cables are run underneath the track bed…except that as a further insurance against the collection of moisture in the conduits under the track the conduit is filled solidly with a cable compound…"

Electric Railway Journal, **January 23rd 1926**

<u>Top</u>: caption: "Detail of One Method of Making Contact Rail Connection"

<u>Bottom</u>: caption: "Cable Connections at 82nd Street Lower Level, Lexington Avenue Line"



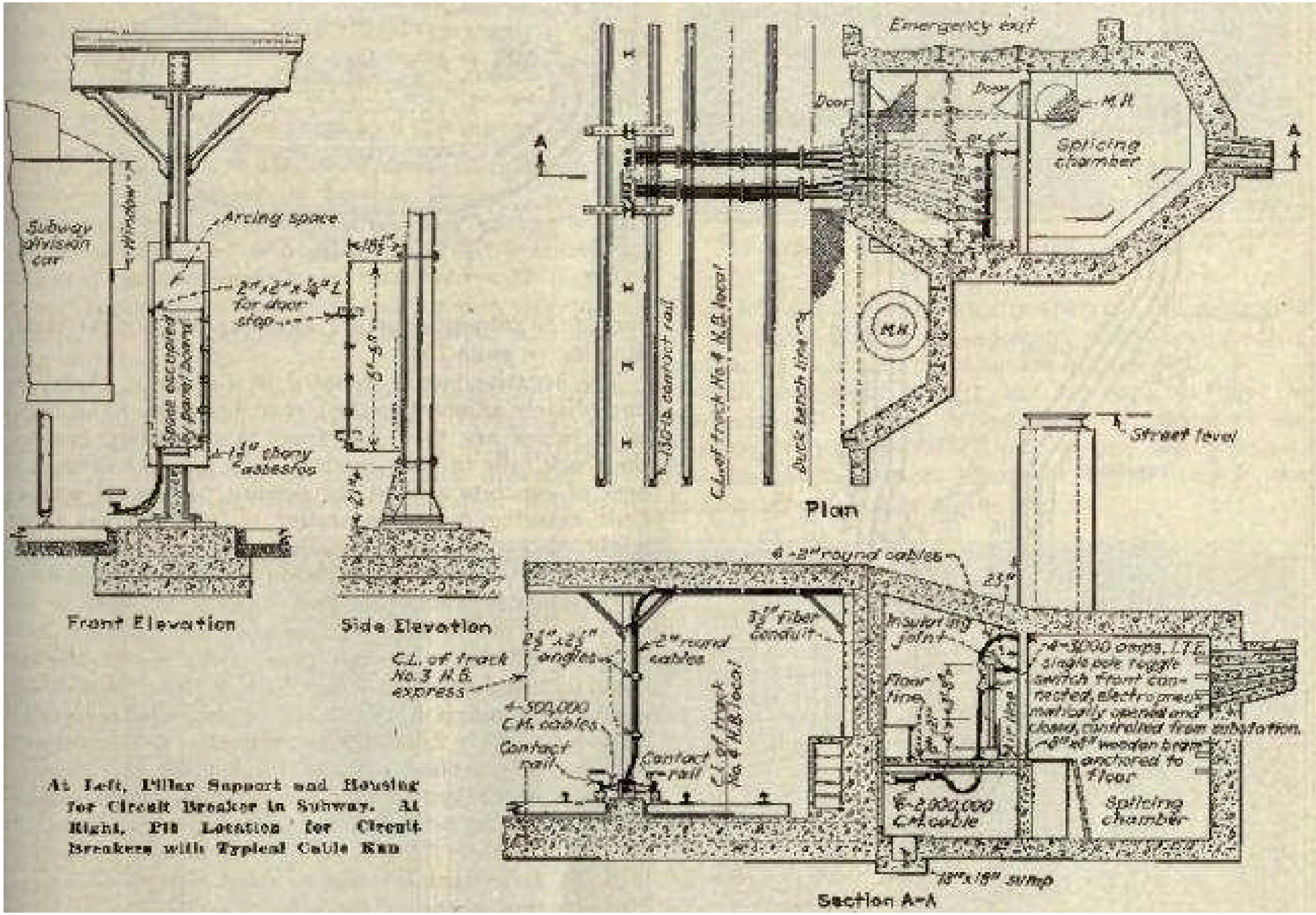


"…The contact rail in the tunnels is protected from the adjacent structures, and particularly from the steel columns, by means of a specially prepared board carried over the top of the rail and supported by properly insulated posts.."

***Electric Railway Journal,* January 23rd 1926**

<u>Above</u>: caption: "Contact rails, showing end inclines"

<u>Left</u>: caption: "Switch connecting feeder to contact rail"

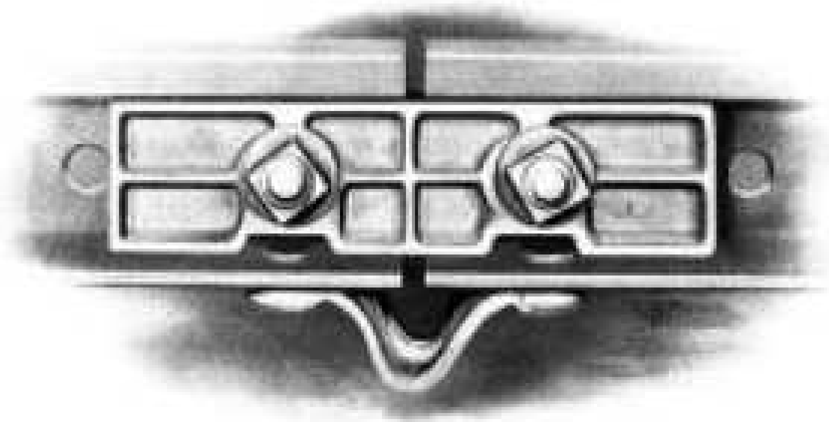
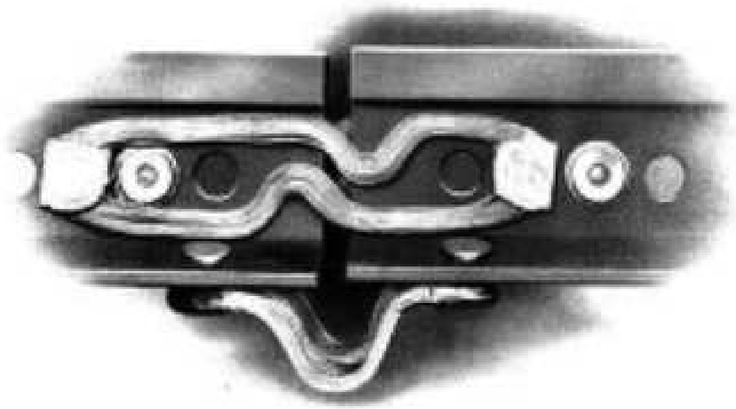


At Left, Pillar Support and Housing for Circuit Breaker in Subway. At Right, Pit Location for Circuit Breakers with Typical Cable Run

<u>Above</u>: caption: "At Left, Pillar Support and Housing; for Circuit Breaker In Subway. At Right, Pit Location for Circuit Breakers with Typical Cable Run."

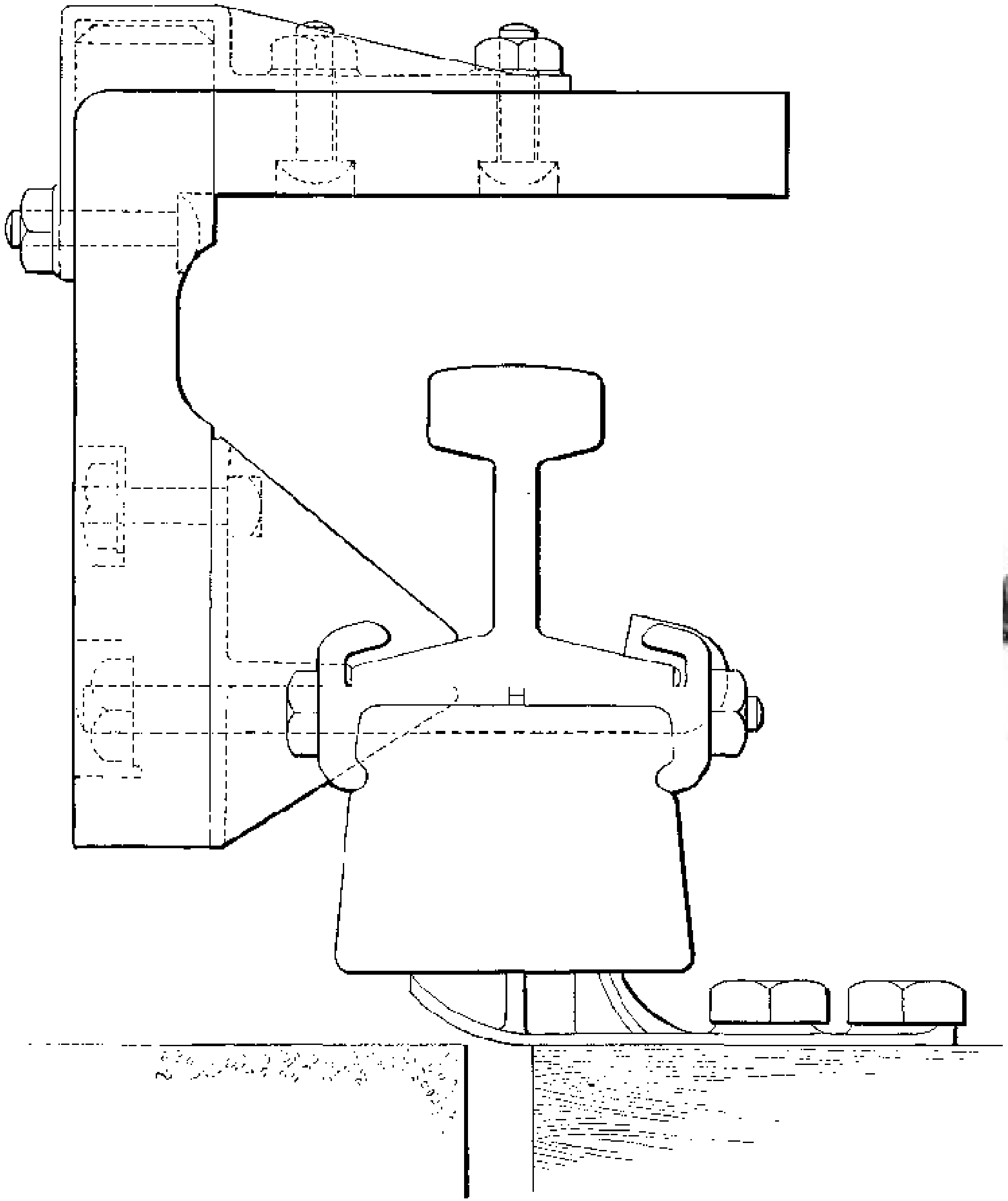
"…The contact-rail sections fed from each substation are terminated at points midway between adjacent substations by gaps in the contact rail, around which are cables connected to a group of circuit breakers in sufficient number to provide separate and distinct circuit breakers for each track and for each substation. That is to say, at the dividing point between substations each substation has its own set of circuit breakers. These circuit breakers are all bus-connected so that the load in all rails will be equalized. Therefore, each contact rail section generally consists of a section of tunnel in sole control of a substation operator and furnished with power from this substation, with each track and section independently operated and controlled by dovetailing into the adjacent substation feeding section…"

***Electric Railway Journal,* January 23rd 1926**

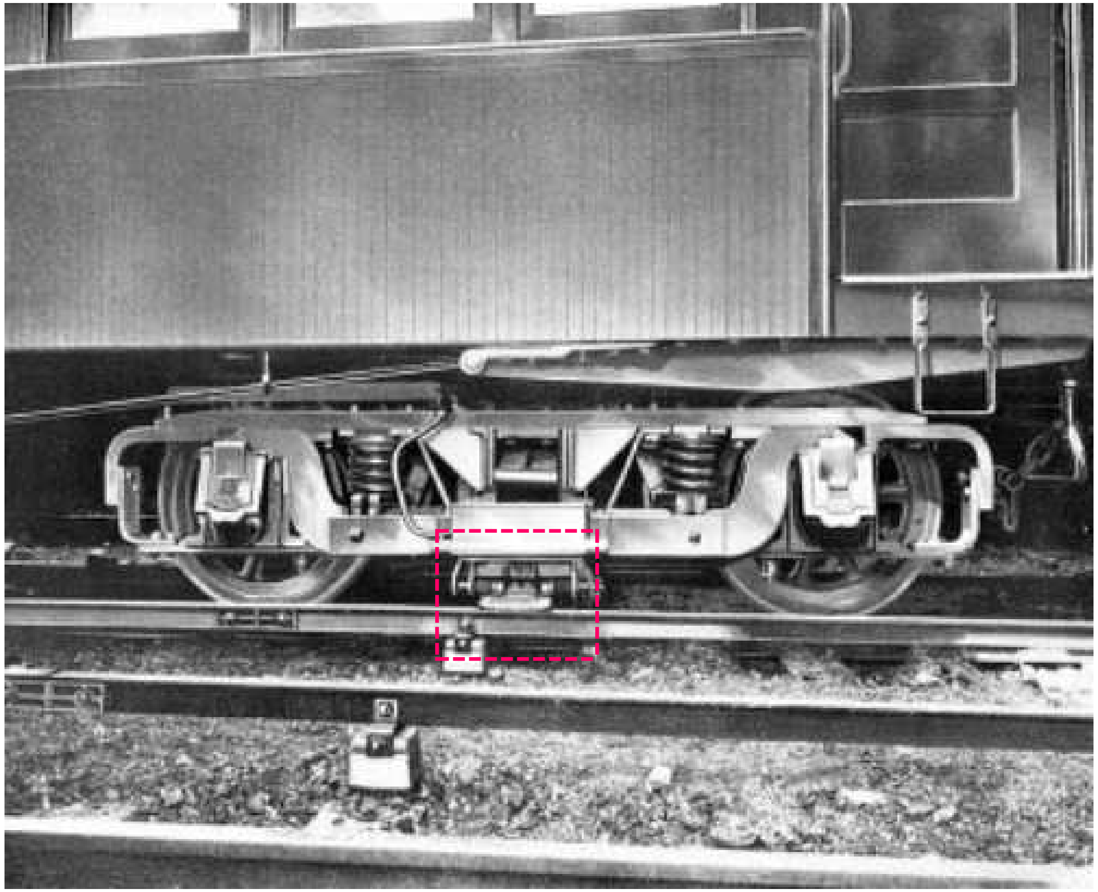
 

Each contact rail was insulated from all contact rails belonging to adjacent tracks. This was done in case of derailment or other accident requiring interruption of service on a given track to allow trains to be operated on the other tracks having their separate and independent channels of electrical supply. The contact rail itself was of special soft steel, to secure high conductivity. The section chosen weighed 75 pounds per yard. The length used, in general, was 60-feet long but in some cases 40-foot lengths were substituted. Each length of rail was anchored at mid-point and a small clearance was allowed between ends of adjacent rails for expansion and/or contraction, which was minimal in the Subway due to the relatively small change of temperature. The contact rail was carried upon block insulators supported upon malleable iron castings. Castings of the same material were used to secure the contact rail in position upon the insulators. A guard in the form of a plank 8.5-inches wide and 1.5-inches thick, which was supported in a horizontal position directly above the rail, was carried by the contact rail to which it was secured by supports. The track rails were 33-feet long of standard ASCE section weighing one-hundred pounds per yard. One rail in each track was used for signal purposes and the other was utilized as a part of the negative return of the power system. The return rails were cross-sectioned at frequent intervals for the purpose of equalizing currents which traversed them.

Left: caption: "Contact rail joint with fish plate"
Right: caption: "Contact rail bands"



<u>Above</u>: caption: “Contact Rail Insulator”
<u>Left</u>: caption: “Assembly of contact rail and protection”



The type of guard adopted by the IRT Subway was used successfully by the *Wilkes Barre & Hazleton Railway* for nearly two years prior to its use on the IRT. Its adoption necessitated the use of a collecting shoe differing significantly from that used on the *Manhattan Railway Division* and the elevated railways employing the third rail system in *Chicago, Boston, Brooklyn* and elsewhere. The shoe was held in contact with the third rail by gravity reinforced by pressure from two spiral springs. The support for the shoe included provision for vertical adjustment to compensate for wear of car wheels, etc.

<u>Above</u>: caption: "Contact Shoe and Fuse"

Signal System

"…A block signal system, which includes the latest refinements in the way of automatic stops at the signals, absolutely preventing a train running into a block when the signals are against it, has been installed, and it is likely that the enviable record of the elevated roads in respect or the small number of accidents, will be surpassed on the Subway system…"

***Scientific American*, October 29th 1904**

Early in the development of the plans for the IRT Subway system it was foreseen that the efficiency of operation of a railroad with heavy traffic would depend largely upon the completeness of the block signaling and interlocking systems adopted for spacing and directing trains. On account of the importance of this consideration, not only for safety of passengers but also for conducting operations under exacting schedules, it was decided to install the most complete and effective signaling system possible. The problem involved the prime consideration of:

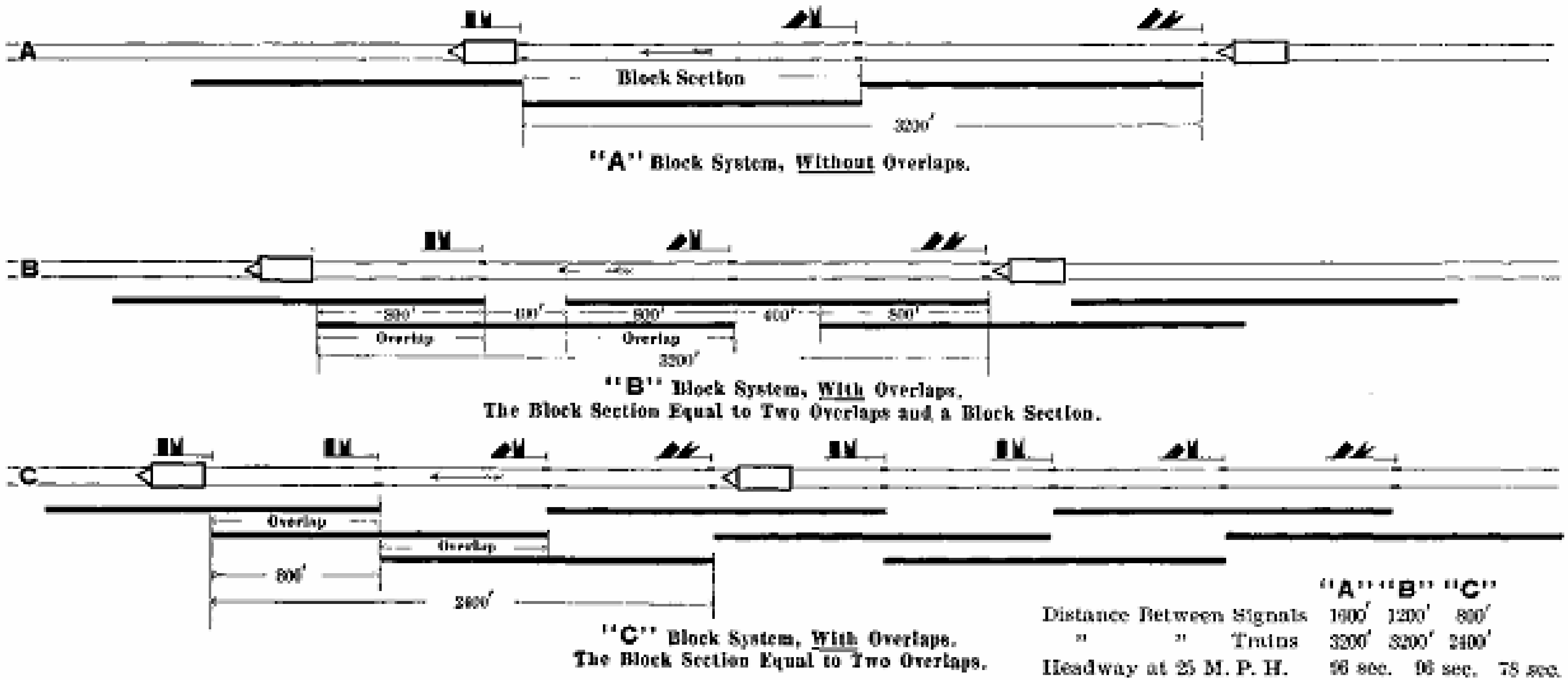
- **Safety**
- **Reliability**
- **Capacity**
- **Operation (under restricted yard and track conditions)**

In order to achieve these goals, it was decided to install a complete automatic block signal system for the high-speed routes, block protection for all obscure points on the low-speed routes and to operate all switches both for line movements and in yards by power from central points. This involved the interconnection of the block and switch movements at many locations and made the adoption of the most flexible and compact appliances essential.

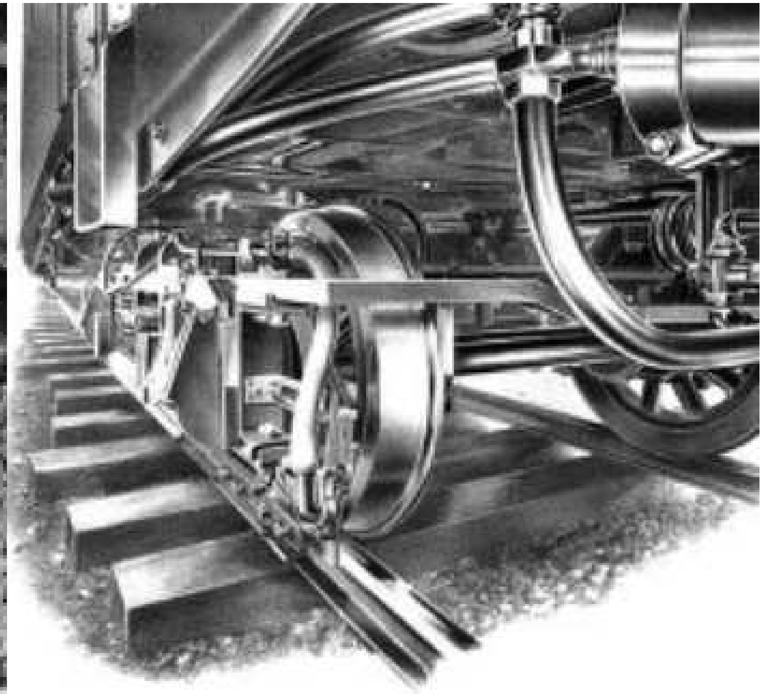
Of the various signal systems in use at the time, it was found that the most promising was the electro-pneumatic block and interlocking system by which varying power could be conducted in small conduit any distance and utilized in compact apparatus in restricted space/s. The train movements could be made promptly and with certainty and interconnected for safety. Moreover, all essential details of the system had been worked out in years of practical operation on important trunk lines of railways so that its reliability and efficiency were proven. The application of such a system to the IRT Subway involved an elaboration of detail not before attempted on a railway line of similar length and the contract for its installation was the largest single order ever given to a signal manufacturing company. In the application of an automatic block system to an electric railway where the rails are used for the return circuit of the propulsion current, it was necessary to modify the system (as applied to a steam railway) and introduce a track circuit control that would not be adversely affected by the propulsion current. This had been successfully accomplished for moderately heavy electric railway traffic in the *Boston* elevated installation which was the first electric railway to adopt a complete automatic block signal system with track circuit control.

The IRT Subway operation contemplated traffic of unprecedented volume and consequent magnitude of the electric currents employed. Experience with existing track circuit control systems led to the conclusion that some modification in apparatus was essential to prevent occasional traffic delays. The proposed operation contemplated a possible maximum of two tracks loaded with local trains at one minute intervals and two tracks with eight car express trains at two minute intervals, the latter class of trains requiring at times as much as 2K-HP for each train in motion. It was apparent that combinations of trains in motion could, at certain times, occur which would require enormous demands for power upon a given section of the line. The electricity conveying this power flowed back through the track rails to the power station and in so doing was subject to a "drop" or loss in the rails which varied in its amount according to the power demands. This caused disturbances in the signal-track circuit in proportion to the amount of drop and, it was believed, that under extreme conditions the ordinary form of track circuit might prove unreliable and cause traffic delays. A solution was suggested consisting of the use of a current in the signal track circuit which would have such characteristic differences from that used to propel the trains that it would operate selectively upon an apparatus which would in turn control the signal. Alternating current was chosen on account of its inductive properties and was adopted after a demonstration of its practicability under similar conditions elsewhere.

After a decision was reached as to the signal system to be installed, the arrangement of the block sections was considered from the standpoint of maximum safety and maximum traffic capacity. It was realized early that the rapidly increasing traffic of *Greater New York* would almost at once tax the capacity of the line to its fullest. The usual method of installing automatic block signals in the *United States* at the time was to provide home and distant signals with the block sections extending from home signal to home signal; that is, the block sections end at the home signals and did not overlap each other. This was also the arrangement of block sections where the telegraph block or controlled manual systems were in use. However, the English block systems all employed overlaps. Without the overlap, a train in passing from one block section to the other would clear the home signals for the section in the rear as soon as the rear of the train had passed the home signal of the block in which it was moving. It was thus possible for a train to stop within the block and within a few feet of this home signal. If a following train should for any reason overrun this home signal, a collision would result. However, with the overlap system a train could stop at any point in a block section and still have the home signal at a safe stopping distance in the rear of the train.



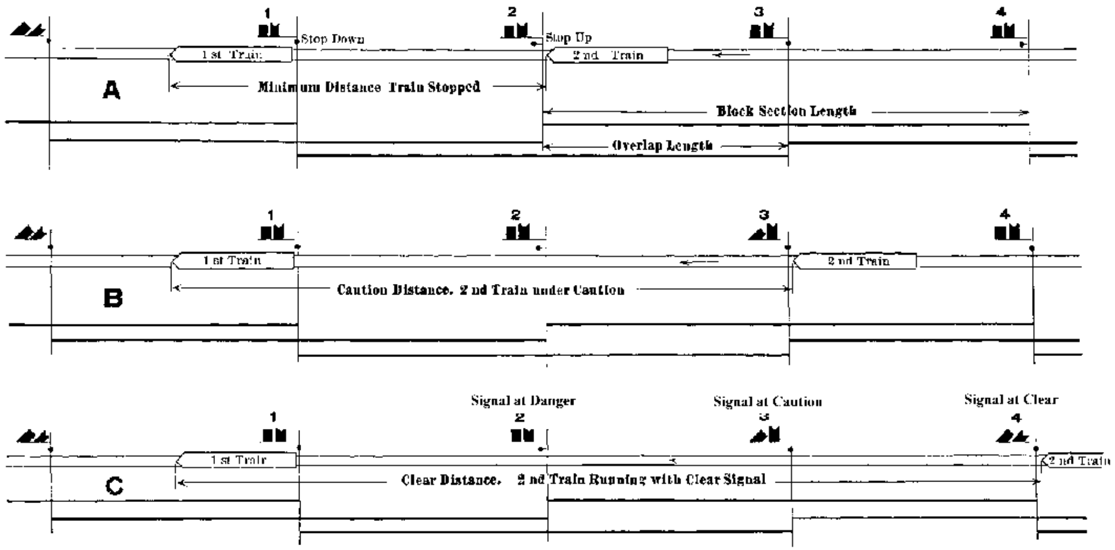
Block section lengths were governed by speed and interval between trains. Overlap lengths were determined by the distance in which a train can be stopped at a maximum speed. Usually, the block section length was the distance between signals plus the overlap. Where maximum traffic capacity was desired, the block section length could be reduced to the length of two overlaps and this was the system adopted for the IRT. The three systems of blocking trains with overlaps (B & C) and/or without overlaps (A), is shown diagramatically above, where two successive trains are shown at the minimum distances apart for "clear" running for an assumed stopping distance of 800-feet. The system adopted for the IRT Subway is shown in "C" (giving the least headway of the three methods).



Conservative signaling was all in favor of the overlap on account of the safety factor (in case the signal was accidentally overrun). Another consideration was the use of automatic train stops. These stops were placed at the home signals thus it was essential that a stopping distance be maintained in advance of the home signal to provide for stopping the train to which the brake had been applied by the automatic stop. Ordinarily, the arrangement of overlap sections increased the length of block sections by the length of the overlap and since the length of the section fixed the minimum spacing of trains, it was imperative to make the blocks as short as was consistent with safety in order not to cut down carrying capacity. This led to a study of the special problem presented by subway signaling and a development of a blocking system specific to its special needs.

Left: caption: "Pneumatic track stop, showing trigger in upright position"
Right: caption: "View under car, showing trigger on truck in position to engage with track stop"

The length of the overlap was given very careful consideration by the IRTC who instituted a series of tests of braking power of trains. From these tests and others made by the *Pennsylvania Railroad Company*, curves were computed to determine the distance in which trains could be stopped at various rates of speed on a level track, with corrections for rising and falling of grades up to 2%. Speed curves were then plotted for the trains on the entire line showing at each point the maximum possible speed. A joint consideration of the speeds, braking effort and profile of the route were then used to determine at each and every point on the line the minimum allowable distance between trains so that the train in the rear could be stopped by the automatic application of the brakes before reaching a train which might be standing at a signal in advance. In other words, the length of the overlap section was determined by local conditions. In order to provide for adverse conditions, the actual braking distances were increased by 50%. For example, the braking distance of a train moving at 35 mph was 465-feet. This would be increased by adding 50% (232-feet) thus the overlap would be no less than 697-feet. With this length of overlap the home signals could be located 697-feet apart and the block section length would be double this or 1394-feet. The average length of overlaps, as laid out, was about 800-feet and the length of block sections double this, or 1,600-feet.

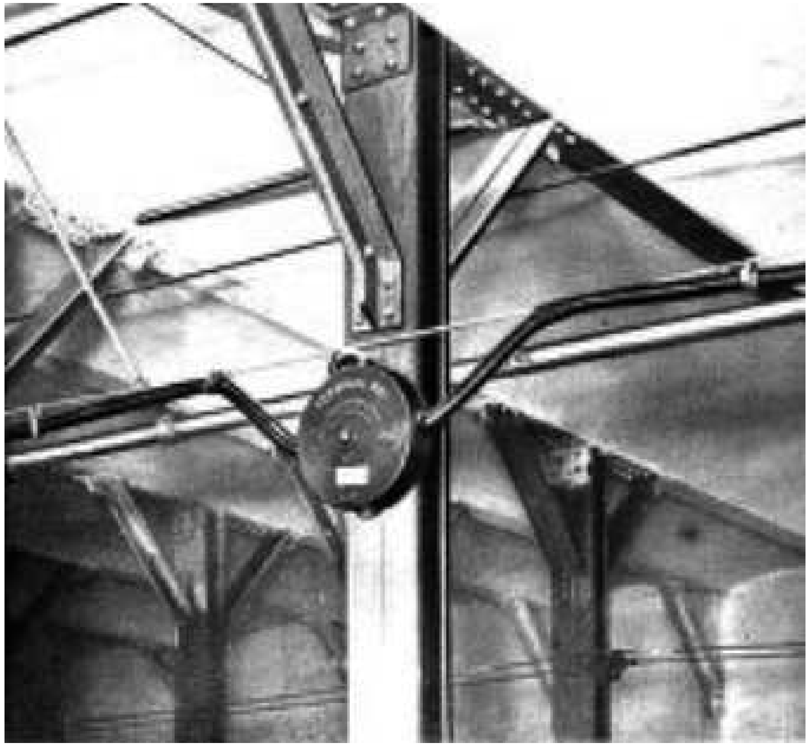


The protection provided by this unique arrangement of signals is illustrated above:

A. MINIMUM distance between trains: The first train has just passed the home signal, the second train is stopped by the home signal in the rear; if this train had failed to stop at this point, the automatic stop would have applied the air brake and the train would have had the overlap distance in which to stop before it could reach the rear of the train in advance; therefore, under the worst conditions, no train could get closer to the train in advance than the length of the overlap and this was always a safe stopping distance.

B. CAUTION distance between trains: The first train in same position as in <u>A</u>, the second train at the third home signal in the rear; this signal could be passed under caution and this distance between trains was the caution distance and was always equal to the length of the block section, or two overlaps.

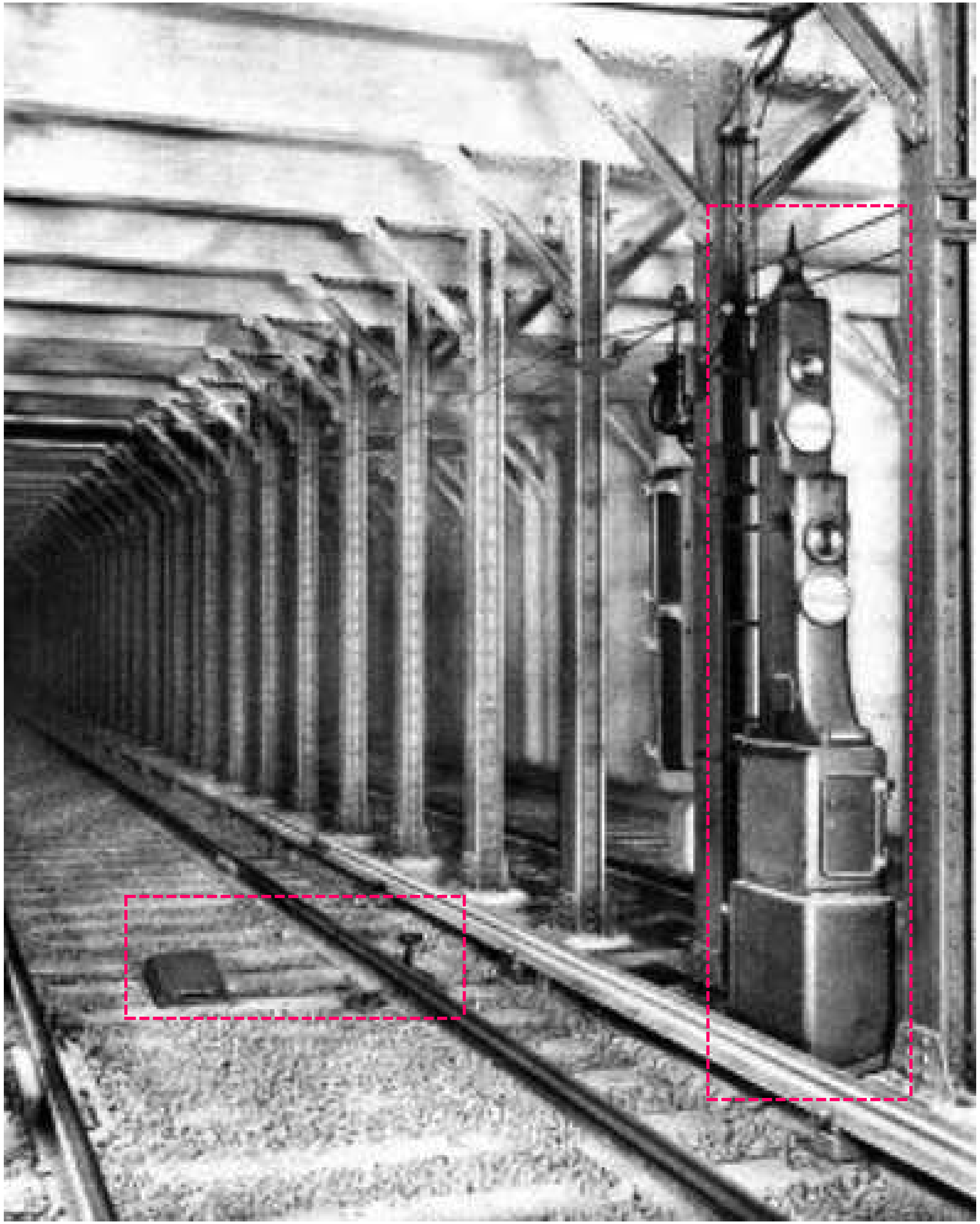
C. CLEAR distance between trains: First train in same position as in <u>A</u>, second train at the fourth home signal in the rear; at this point both the home and distant signals are clear and the distance between the trains is now the clear running distance; that is, when the trains are one block section plus an overlap apart they can move under clear signal and this distance was used in determining the running schedule. Note that in <u>C</u> the first train has the following protection: Home signals 1 and 2 in stop position, together with the automatic stop at signal 2 in position to stop a train, distant signal 1, 2, and 3 all at caution, or, in other words, a train that has stopped was always protected by two home signals in its rear and by three caution signals. In addition to this, an automatic stop was placed at a safe stopping distance in the rear of the train.



The block signaling system as installed consisted of an automatic overlapping system applied to the two express tracks between *City Hall* and *96th Street*, a distance of 6.5 miles or thirteen miles of track, and to the third track between 96th and *145th Street/s* on the *Western Branch*, a distance of 2.5 miles. This third track was placed between the two local tracks and was used for express traffic in both directions; trains moving toward City Hall in the morning and in the opposite direction at night. Also, the two tracks from *145th Street* to *Dyckman Street*, a distance of 2.5 miles or five miles of track. The total length of track protected by signals was 24.5 miles.

<u>Left</u>: caption: "Main-line, piping and wiring for Block and Interlocking System showing junction box on column"

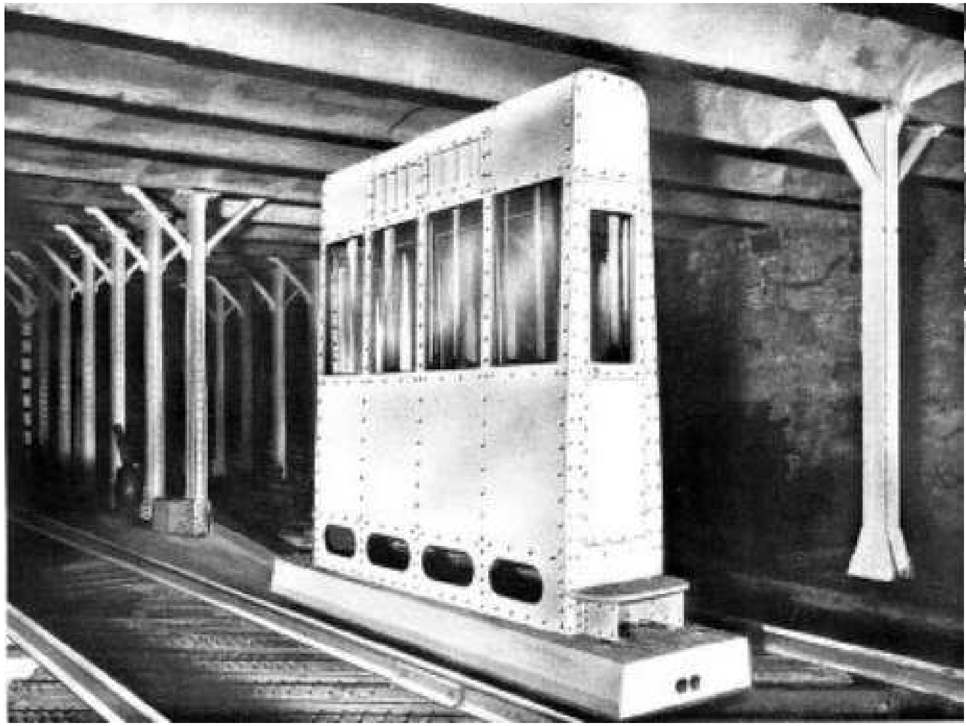
The small amount of available space in the Subway made it necessary to design a special form of the signal itself. Clearances would not permit a "position" signal indication. Besides, a position signal purely was not suitable for the poor lighting conditions of the Subway tunnels. A color signal was therefore adopted conforming to the adopted rules of the *American Railway Association*. It consisted of an iron case fitted with two white lenses, the upper being the home signal and the lower the distant signal. Suitable colored glasses were mounted in slides which were operated by pneumatic cylinders placed in the base of the case. Home and dwarf signals presented a red light for the danger or "stop" indication. Distant signals displayed a yellow light for the "caution" indication. All signals displayed a green light for the "proceed" or clear position. Signals in the Subway were constantly lit by two electric lights placed in back of each white lens. On the elevated structure, semaphore signals of the usual type were used. The signal lighting was supplied by a special alternating current circuit independent of the power and general lighting circuits.

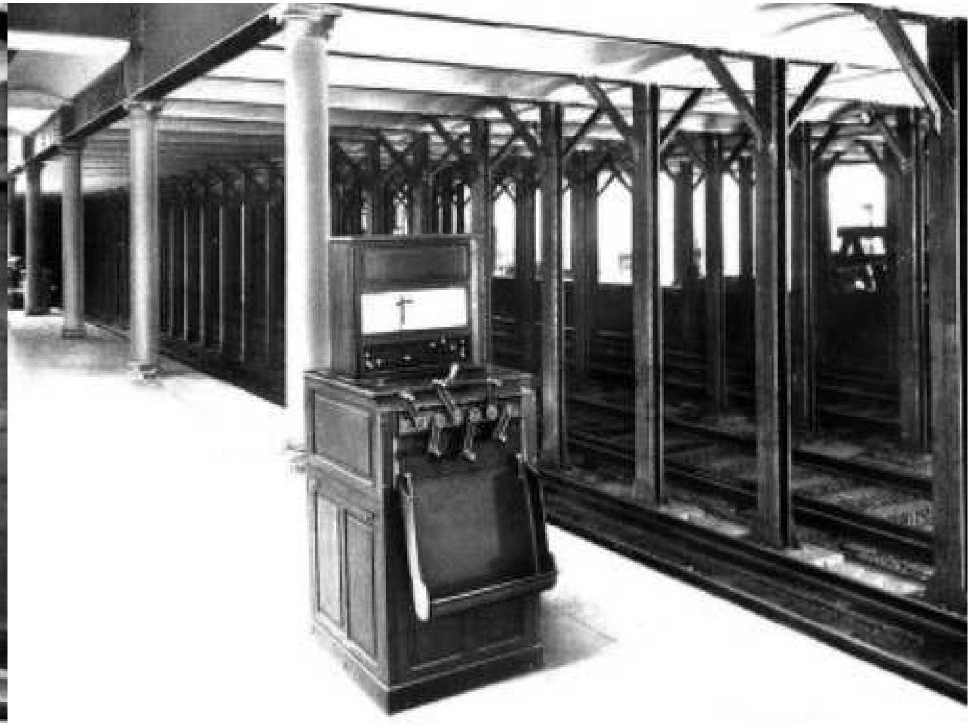


A train stop or automatic stop of the *Kinsman* system was used at all block signals and at many interlocking signals. This was a device for automatically applying the air-brakes to the train if it should pass a signal in the stop position. This was an additional safeguard only to be brought into use when the danger indication had, for any reason, been disreg-arded and insured the maint-enance of the minimum distance between trains as provided by the established overlaps.

<u>Left</u>: caption: "Front view of Block Signal Post, showing lights, indicators and track stop"

Two novel safety devices were included in the signal system. The first was an emergency train stop. It was designed to allow station attendants (or others) the emergency control of signals. In application, It was similar in principle to the emergency brake handle found in all passenger cars but operated to warn all trains of a dangerous condition. Signal controls were looped into an emergency box-set in a conspicuous position on each station platform. The pushing of a button on this box would set all signals to red (danger) immediately adjacent to the station such that all traffic would be stopped until the danger condition was removed. The second safety feature was "section break" protection. This consisted of a special emergency signal placed in advance of each separate section of the third rail. That is, at points where trains moved from a section fed by one sub-station to that fed by another. Under such conditions, the contact shoe/s of a train temporarily spanned the break in the third rail. In case of a serious overload or ground on one section, the train wiring would momentarily act as a feeder for the section and thus possibly blow the train fuses and cause delay. Therefore, in order to prevent trains passing into a dangerously overloaded section, an overload relay was installed at each section break to set a "stop" signal in the face of an approaching train which held the train until the abnormal condition was removed.





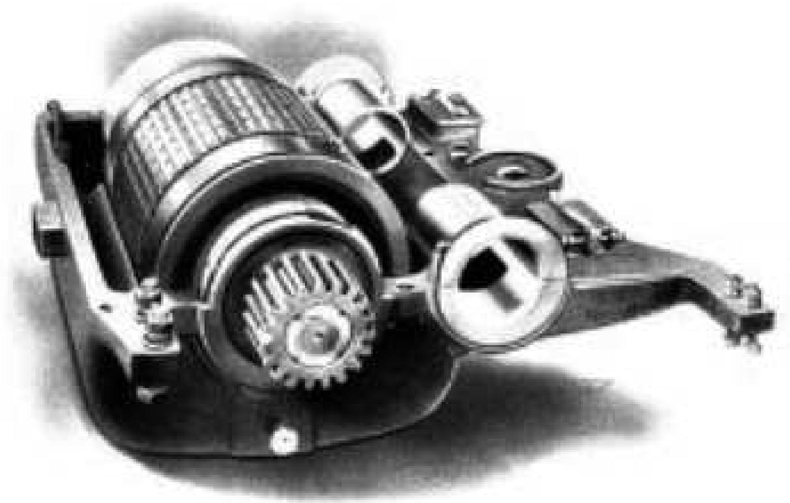
The movement of dense traffic on a four-track railway required a large amount of switching, especially when each movement was complicated by junctions of two or more lines. Practically every problem of trunk line train movement including two, three and four-track operation had to be provided for in the switching plants of the IRT Subway. Furthermore, the problem was complicated by the restricted clearances and vision inherent in tunnel construction. The utmost flexibility of operation had to be provided and every train movement be certain, quick and safe. This demanded that all switching movements be made through the medium of power-operated interlocking plants. These plants in the Subway portions of the line were in all cases electro-pneumatic while in the elevated portions of the line mechanical interlocking was provided. The interlocking machines were housed in steel "towers" in order that the operators be properly protected.

Left: caption: "Special Interlocking Signal Cabin South of Brooklyn Bridge Station"
Right: caption: "Electro-Pneumatic Interlocking Machine on Station Platform"

Rolling Stock

The IRTC's engineers were determined to improve upon the best devices known in electrical railroading of the day and to provide equipment unexcelled on any interurban line. This led to a careful study of the types of rolling stock used on other lines before a selection was made of those to be used on the IRT Subway. All of the existing rapid transit railways in the country, and many of those abroad, were visited and the different patterns of cars in use were considered in the investigation which included a study of the relative advantages of long and short cars, single and multiple side entrance cars and end entrance cars and all of the other varieties which had been adopted for rapid transit service. The service requirement of the IRT Subway introduced a number of unprecedented conditions and required a complete redesign of all the existing models. The general considerations to be met included the following:

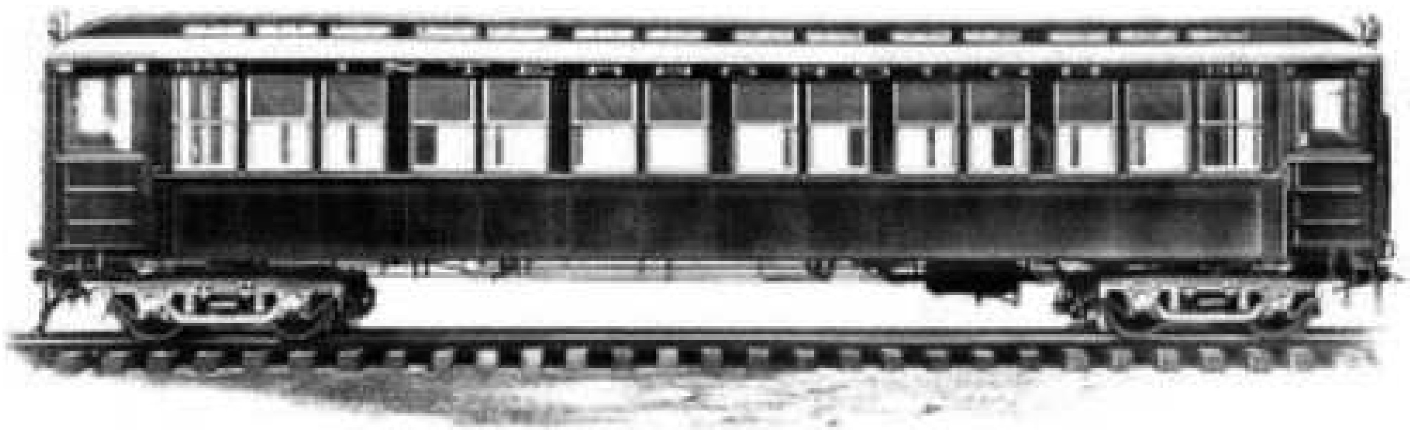
- High schedule speeds with frequent stops;
- Maximum carrying capacity for the Subway, especially at times of rush hours (morning and evening);
- Maximum strength combined with lowest permissible weight;
- Adoption of all precautions calculated to reduce possibility of damage from either the electric circuit or from collisions;
- The clearance and length of the local station platforms limited the length of trains and tunnel clearances limited the length, width and height of the individual cars



The speeds called for by the contract with the city introduced motive power requirements which were unprecedented in any existing railway service, either steam or electric, and demanded a minimum weight consistent with safety. As an example, an express train of eight cars, in order to conform to the schedule speed adopted, required a nominal motive power of 2K-HP with an average accelerating current at 600 Volts in starting from a station stop. This rate of energy absorption, which corresponds to 2,500-HP, was not far from double that taken by the heaviest trains on trunk line railroads when starting from stations at the maximum rate of acceleration possible with the most powerful steam locomotives of the day. Such exacting schedule conditions necessitated the design of rolling stock of equivalent strength to that found in steam railroad car and locomotive construction so that while it was essential to keep down the weight of the train and individual cars to a minimum, owing to the frequent stops it was equally as essential to provide the strongest and most substantial type of car construction throughout.

Above: caption: "200 Horsepower railway motor"

After having ascertained the general type of cars which would be best adapted to the subway service, and before placing the order for car equipment, it was decided to build sample cars embodying the approved principles of design. From these, the IRTC believed that the details of construction could be better determined than in any other way. Consequently, in the early part of 1902, two sample cars were built and equipped with a variety of appliances and furnishings so that the final type could be intelligently selected. From the tests conducted on these cars the adopted type of car evolved. After the design had been worked out, a great deal of difficulty was encountered in securing satisfactory contracts for proper delivery on account of the overflow of orders at car-building works at the time. However, contracts were finalized in December 1902 for five-hundred cars and orders were distributed between four car-building firms. Of these cars, two-hundred; as fast as they were delivered, were placed in operation on the *Second Avenue* line of the *Elevated Railway* in order that they might be thoroughly tested during the winter of 1903/04.



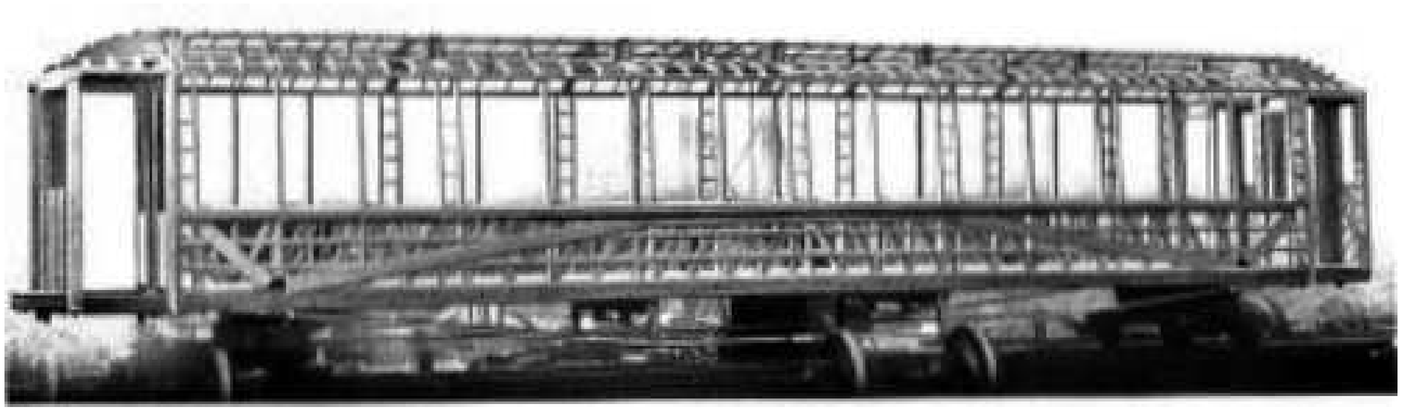
At the time of placing the first contract for the rolling stock of the Subway, the question of using an all-steel car was carefully considered by the IRTC management. In many respects, such a car presented desirable features for subway work (i.e. incombustibility). However, certain practical reasons prevented the adoption of an all-steel car in the spring of 1902 when it became necessary to place the orders for the first five-hundred cars. Principal among these reasons was the fact that no cars of this kind had ever been constructed and as the car building works of the country were in a very congested condition, all of the larger companies declined to consider any standard specifications for a short-time delivery. For cars involving the extensive use of steel, the option did not exist. There were a number of serious mechanical difficulties to be studied and overcome in the construction of such a car such as avoidance of excessive weight, insulation from the extremes of heat and cold and the prevention of undue noise in operation. Therefore, it was decided to produce a hybrid; a wooden car with sufficient steel framing/reinforcing for strength and protection.

<u>Above</u>: caption: "Side view of steel passenger car"

"…Special precaution has been taken to safeguard the passengers. The wooden cars have steel underbodies, and these will gradually be replaced by all-steel cars, built with a view to rendering them both fireproof and collision proof, the cars being of a modified vestibuled type, with special construction at the ends to prevent telescoping…"

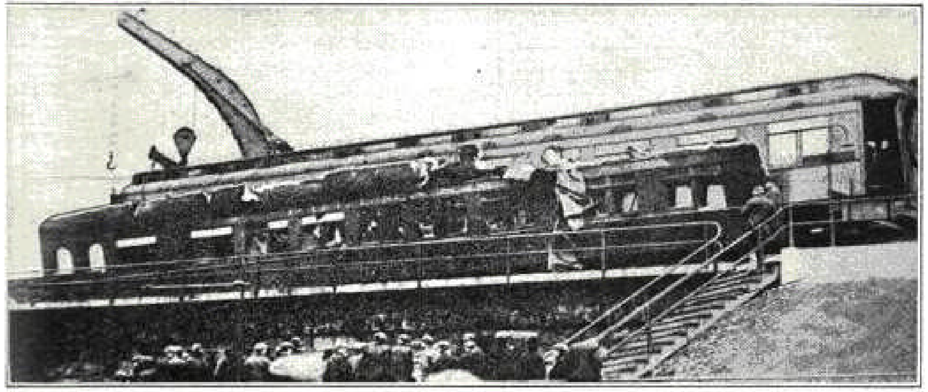
***Scientific American*, October 29th 1904**

<u>Left</u>: caption: "Metal Underframe of Protected Wood Car"



The side framing of the hybrid car was of *White Ash*, doubly braced and heavily trussed. There were seven composite wrought-iron carlines forged in shape for the roof, each sandwiched between two White Ash carlines and with White Ash intermediate carlines. The platform posts were of compound construction with "anti-telescoping" posts of steel bar sandwiched between White ash posts at corners and centers of vestibuled platforms. These posts were securely bolted to the steel longitudinal sills, the steel anti-telescoping plate below the floor and to the hood of the bow which served to reinforce it. This bow was a heavy steel angle in one piece, reaching from plate to plate and extending back into the car six-feet on each side. In case of accident, if one platform should ride over another, eight square inches of metal would have to be sheared off the posts before the main body of the car would be reached which would afford an effective means of protection. The IRTC's engineers believed that the construction of the car rendered it practically indestructible.

Above: caption: "Framing of Protected Wooden Car"

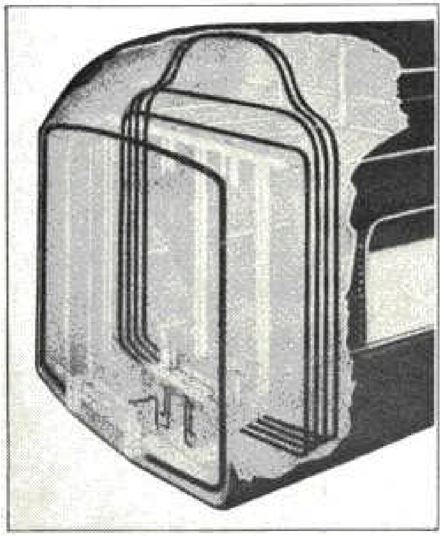


A TYPICAL "TELESCOPE" ACCIDENT. EIGHTEEN PERSONS WERE KILLED WHEN A "PREFERRED" FREIGHT CRASHED INTO THE REAR OF AN EXPRESS TRAIN NEAR ALTOONA, PENNSYLVANIA

Non-Telescoping Car Minimizes Danger in Rail Collisions

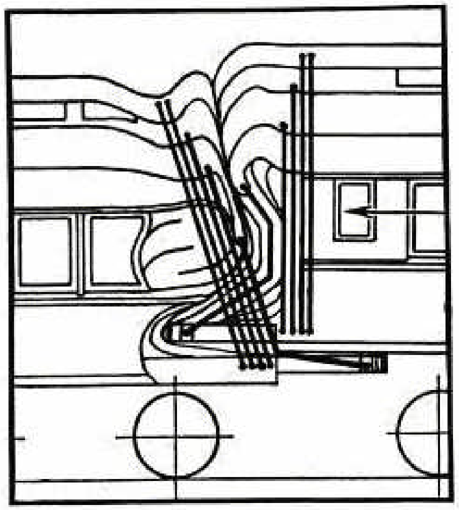
OF all the perils and dangers of railroad travel, the most dreaded is the fatal telescoping of cars. When the engineer is guilty of negligence, when a fog or a storm obstructs the view; when the man in the signal tower falls asleep or throws the wrong switch, the special, speeding ahead a mile a minute, crashes headlong into the rear end of a slowly moving passenger train, and plows through car after car, killing scores and wrecking both trains. It is a "telescope" accident. For many years construction engineers have been working to solve this problem.

The first step was taken fifteen years ago when the steel coach replaced the old wooden one. In order to insure a fair amount of speed, however, a steel coach is necessarily constructed of a heavy underframe, and a comparatively light body. The cars designed in this fashion proved to be much safer than the old wooden ones, but telescoping still remained a constant danger. When two cars would collide, the one traveling at the greater rate of speed would "override" the other, its heavy underframe crashing over and splintering the body of the invaded car.



Arrangement of Loops in Vestibule, Showing Double Defense Against an On-Coming Car

Frank M. Brinckerhoff, consulting engineer of New York, offers a solution to this fatal type of accident in his description of a car that will not telescope. He explains that there are two conditions or reactions which must be taken into consideration in order to estimate the effect of a collision: first, the distance the standing car is driven ahead by the crash, and secondly, the depth to which the on-coming car penetrates. The substance to withstand these two reactions must have two qualities, resistance and flexibility.

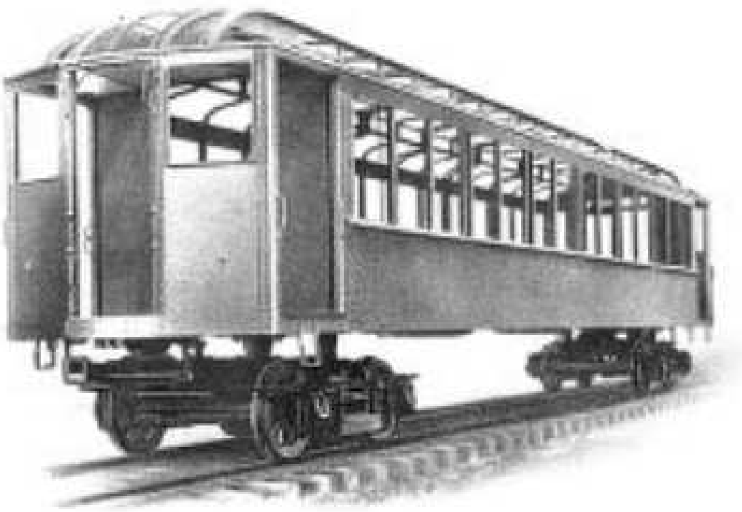


How the Wire Cables Act When the Cars Collide

Wire cable seems to be the material best suited to this particular use. Two protectives are required at the end of each non-telescoping car. The first is a single loop of wire cable, anchored to the underframe of the car, passing up one vestibule corner post, across the hood, and down the other corner post, as is shown in the illustration. This is so constructed that the initial shock of the invading train will be met by the vestibule corner posts, and the vestibule of the invading train will be "caught" in the loop. As the invading body progresses, the cable loop is drawn in and down, crushing the vestibule of the on-coming car.

The group of four bands of wire cables immediately behind this loop is provided as a secondary defense or precaution. It is estimated that the single loop at the end will be sufficient to withstand the majority of shocks. If the vestibule posts and the first cable are not sufficient to stop the forward motion of the invading car, the four loops behind will provide much higher resistance. By comparing the strength of the cables with the relative force of a collision, it has been demonstrated that the vestibule of an invading car would be completely crushed, thus limiting the area of possible severe damage to the space enclosed by the cable loops. The only possible danger to passengers will be the sudden jolt, as the trains collide, while the typical railroad wreck, with the embankments strewn with human bodies, will be eliminated.

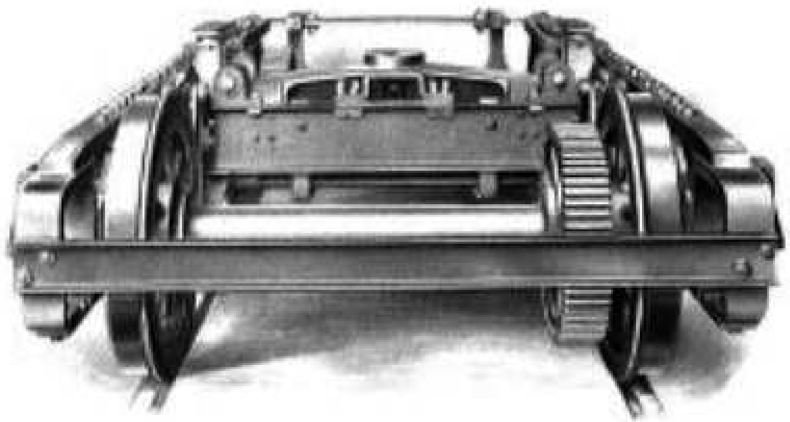
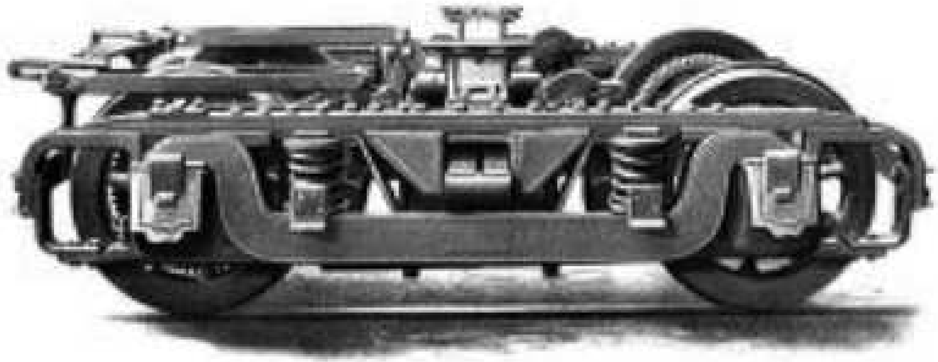
RE: article appearing in *Illustrated World* (ca. 1920s) concerning the problem of "telescoping" in railway accidents. This system used wire cable rather than rigid steel posts.



The plan of an all-steel car was not abandoned and although none was in use in passenger service anywhere in the world, steps were taken to design a car of this type and conduct the necessary tests to determine whether it would be suitable for railway service. None of the car-building companies was willing to undertake the work, but with the cooperation of the *Pennsylvania Railroad Company* which placed its *Altoona, PA* manufacturing facilities at the disposal of the IRTC, plans were prepared for an all-steel car and after about fourteen months of work, a sample type was completed in December 1903. The sample car embodied some faults, the principal one being that the car was not only too heavy for use on the elevated lines of the company but attained an undesirable weight for Subway operation as well. However, from this original design a second design involving very original features was worked out and a contract was issued by the IRTC for two-hundred all-steel cars.

Left: caption: "Exterior view – steel car framing"
Right: caption: "Interior view – steel car framing"

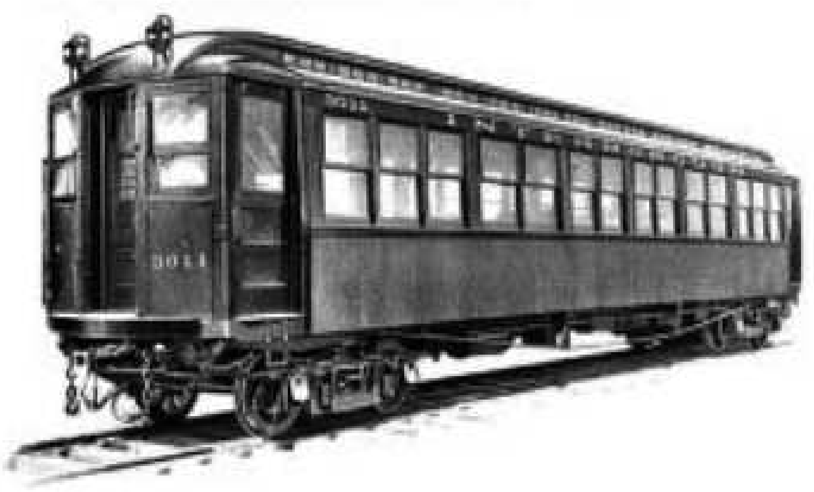

WHY THE SUBWAY IS THE SAFEST RAILROAD IN THE WORLD No. 8
Our Men KNOW Their Jobs
Subway Sun
Published now and then by the Interborough Rapid Transit Company
Eternal Vigilance
VOLUME VI
FEBRUARY
NUMBER 3
Fire Proof
Every part of the Subway from stairways to roadbed is fireproof
The first Fire-proof train ever built was used in the Subway
Interborough Rapid Transit Co.

In view of the atypical traffic conditions existing in *New York City* and the restricted siding and yard room available in the Subway, the IRTC decided that one standard type of car for all classes of service would introduce the most flexible operating conditions and would best suit the public demands at different times of the year and hours of the day. In order to provide cars, each of which would be as safe as the others, it was essential that there should be no difference in construction strength between the motor cars and the trail cars. All cars were therefore made of one type and could be used interchangeably for either motor or trail-car service. The motor cars carried both motors on the same truck; that is, they had a motor truck at one end carrying two motors, one geared to each axle; the truck at the other end of the car was a "trailer" and carried no motive power.

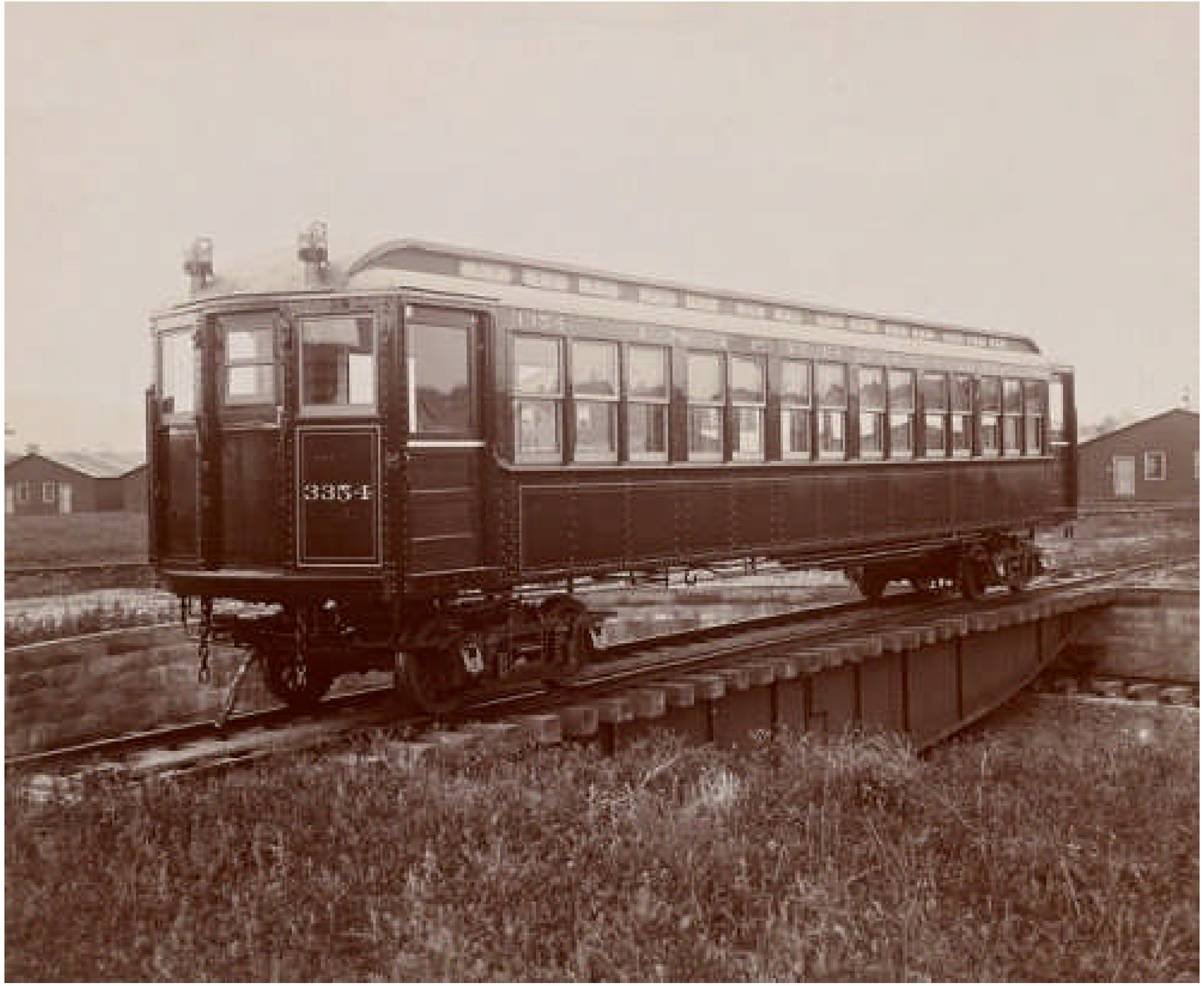
Left: caption: "End View of Motor Truck"

Right: caption: "Side View of Motor Truck"

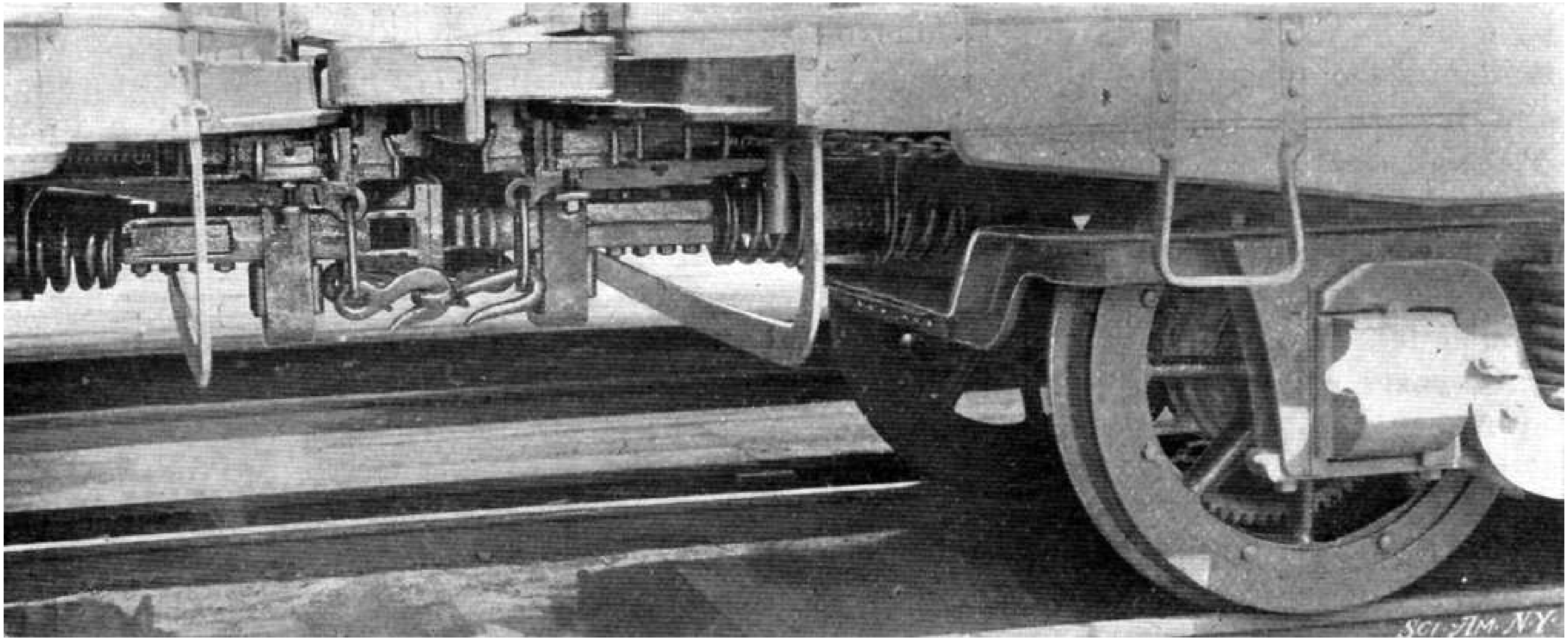


A novel feature in the construction of the cars was the patented (IRTC) motorman's compartment and vestibule. The cab was located on the platform so that no space within the car was required. At the same time, the entire platform space was available for ingress and egress (except on the front platform of the first car). The side of the cab was formed by a door which could be placed in three positions. When in mid-position, it enclosed a part of the platform so as to furnish a cab for the motorman, but when swung parallel to the end sills it enclosed the end of the platform and this would be its position on the rear platform of the rear car. The third position was when it was swung around in an arc of 180-degrees whereby it could be locked in position against the corner vestibule post enclosing the master controller. This would be its position on all platforms except on the front of the front car or the rear of the rear car of the train. The platforms themselves were not equipped with side gates but, rather, with doors arranged to slide into pockets in the side framing thereby giving up the entire platform to the passengers. These doors were closed by an overhead lever system. The sliding door on the front platform of the first car could be partly opened and secured in this position by a bar and thus serve as an arm-rest for the motorman. The doors closed against an air-cushion stop, making it impossible to clutch the clothing or limbs of passengers in closing.

Above: caption: "Exterior view – protected wooden car, showing copper sides"


3354

The average speed of express trains between *City Hall* and *145th Street* would be 25mph, including stops. The maximum speed of trains would be 45mph. Thus, the average speed of local and/or express trains exceeded the speed of trains on any elevated railroad. To attain these speeds without exceeding maximum safe limiting speeds between stops, the equipment accelerated trains carrying maximum load at a rate of 1.25mph per second in starting from stations on level track. To obtain the same acceleration by locomotives, a "draw-bar pull" of 44K pounds would be necessary; a pull equivalent to the maximum effect of six steam locomotives and equivalent to the pull which could be exerted by two passenger locomotives of the *Pennsylvania Railroad* type. By the use of the multiple unit system of electrical control, equivalent results in respect to rate of acceleration and speed were attained. The total addition to train weight aggregating only fifty-five net tons (the two *Pennsy* steam locomotives weighed about 250 net tons). Therefore, if the locomotive principle of train operation were adopted it was obvious that it would have been necessary to employ a lower rate of acceleration for express trains. This could have been attained without sacrifice of average speed, since the average distance between express stations was nearly two miles. However, in the case of local trains which averaged nearly three stops per mile, no considerable reduction in the acceleration was possible without a material reduction in average speed. Thus, the multiple unit system adopted possessed material advantages over a locomotive system.



In an eight-car multiple-unit express train, the first, third, fifth, sixth and eighth cars were "motor cars" while the second, fourth and seventh were "trail cars." An eight-car train could be reduced to a six-car train by uncoupling two cars from either end; to a five-car train by uncoupling three cars from the rear end or to a three-car train by uncoupling five cars from either end. In each case, a motor car remained at each end of the reduced train. In like manner, a five-car local train could be reduced to three cars still leaving a motor car at each end by uncoupling two cars from either end since in the normal five-car local train the first, third, and fifth cars were motor cars. Pantograph safety gates for coupling between cars were provided. They were constructed so as to adjust themselves to suit the various positions of adjoining cars while passing in, around and out of curves of ninety-foot radius.

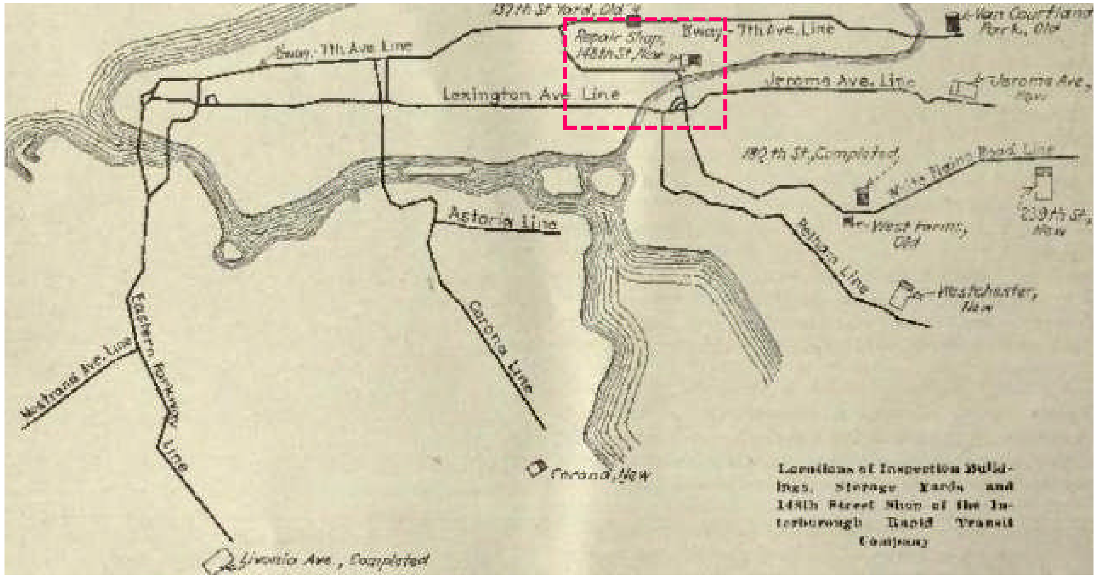
<u>Above</u>: caption: "Platforms and couplings of cars"

All cars were heated and lit by electricity. The heaters were placed beneath the seats and special precautions were taken to insure uniform distribution of heat. The wiring for heaters and lights was safeguarded to avoid, as far as possible, all risk of short-circuit and/or fire. The wire used for the heater circuits was carried on porcelain insulators separated from all woodwork by large clearances while the wiring for lights was carried in metallic conduit. All lamp sockets were specially designed to prevent the possibility of fire and were separated from the woodwork of the car by air spaces and by asbestos. The interior of each car was lit by twenty-six ten-candle power lamps, in addition to four lamps provided for platforms and markers. The lamps for lighting the interior were carefully located, to ensure uniform and effective illumination.

Repair and Inspection

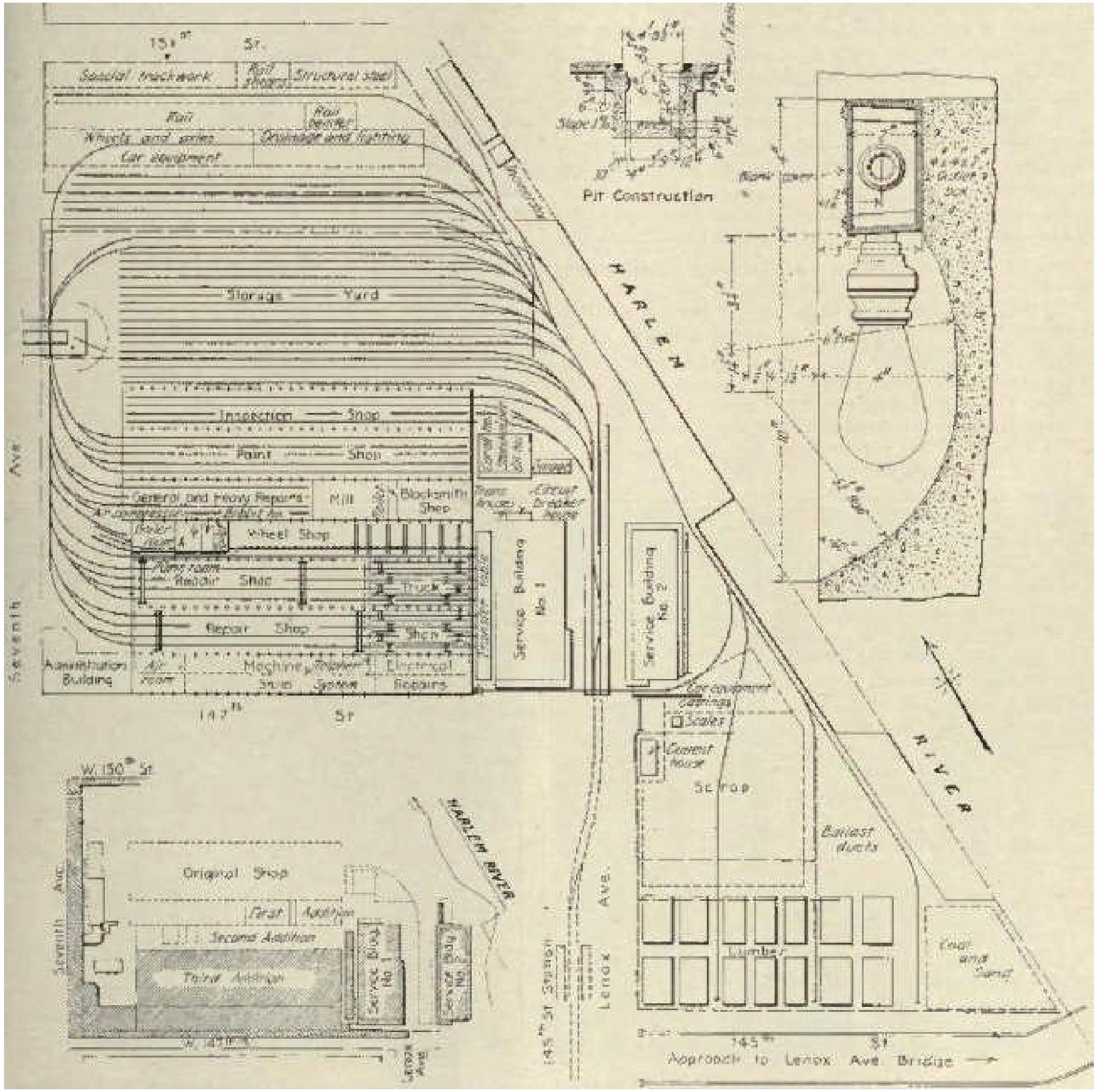
“…The immensity of the task of maintaining the rolling stock of the Interborough Rapid Transit Company can be gathered from a few statistics of the traffic conducted, as compared with trunk-line railroads. During the calendar year of 1922, the last year for which statistics of this kind are available, the entire revenue-passenger business on the steam railroads or trunk-line railroads of the country (Classes I, II, and III) reporting to the Interstate Commerce Commission amounted to exactly 989,509,000 passengers, and it is estimated that the few small roads outside the jurisdiction of the commission would not be sufficient to make an aggregate of 1,000,000,000 passengers. During the same year, however, the twelve months ended Dec. 31, 1922, the number of passengers carried by the Interborough Rapid Transit Company was 1,001,730,481. This number was divided approximately two-thirds on the subway division and one-third on the elevated division. Yet this number was carried practically without accident…The extent of the operations of the Interborough Rapid Transit Company can be indicated in another way. Each month this company operates between 15,000,000 and 17,000,000 car-miles. This mileage is more than that which would be taken by the operation of a subway car 20 times around the circumference of the earth at the equator every day for a month…”

***Electric Railway Journal*, March 21st 1925**



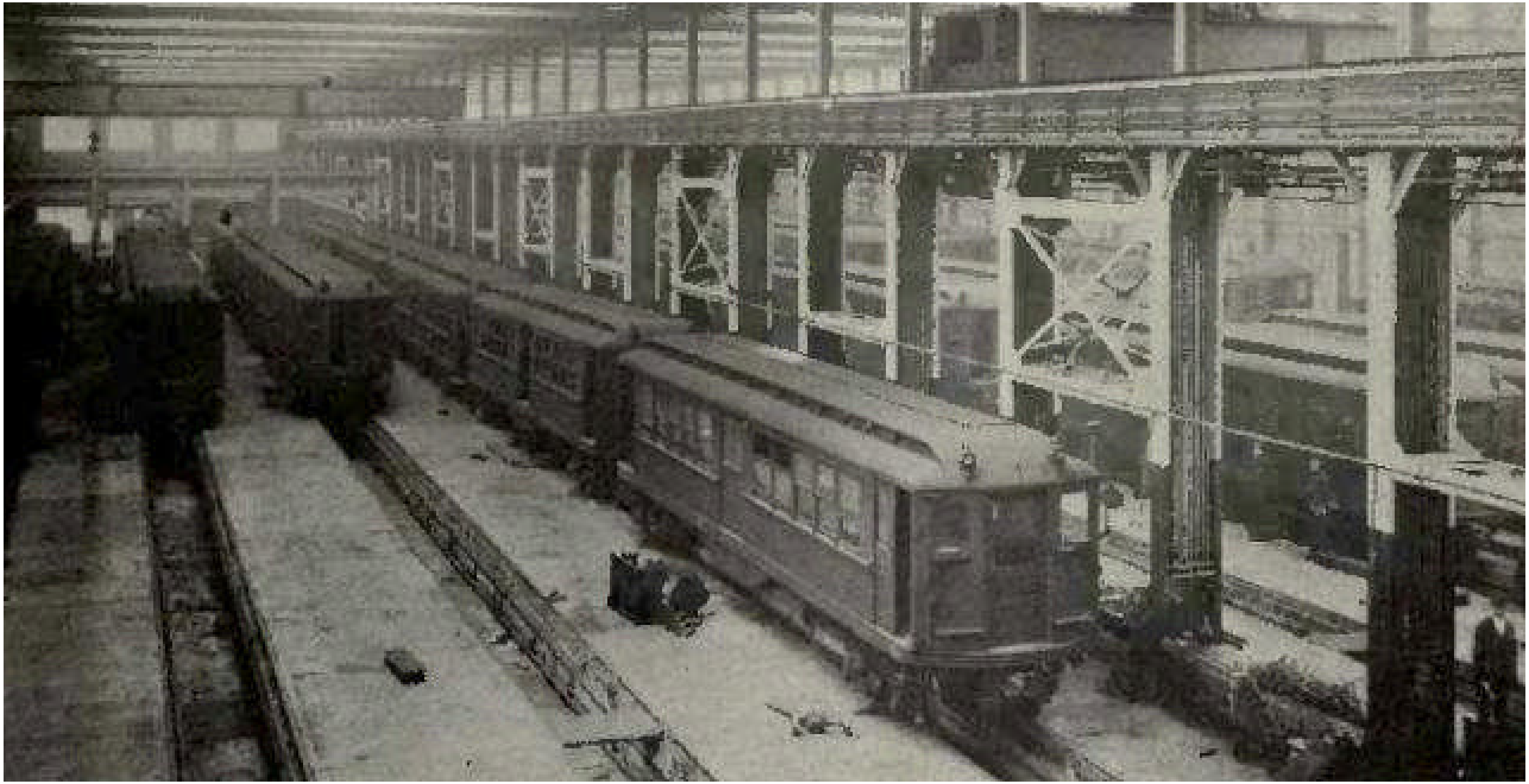
While popularly known as the "Subway System," the lines of the IRT comprised a large amount of track in the open air. A necessary corollary was the requirement of adequate inspection and repair shops so that all the rolling stock could be, at all times, maintained in a state of good repair and efficiency. In this regard, provision was made by the IRTC for a state-of-the-art repair and inspection shop. The repair and inspection shop of the IRTC adjoined the car yards and occupied the entire block between *Seventh Avenue* on the west-side, *Lenox Avenue* and the *Harlem River* on the east-side, *148th Street* on the south-side and *149th Street* on the north-side. The electric subway trains entered the shops and car yard by means of the *Lenox Avenue Extension* (spur), which ran directly north from the junction at *142nd Street* and Lenox Avenue of the *Bronx Park* (Eastern) main line. The spur left the main line at 142nd Street and gradually approached the surface, emerging at *147th Street*.

<u>Above</u>: caption: "Location of Inspection Buildings, Storage Yards and 148th Street Shop of the Interborough Rapid Transit Company"



<u>Above</u>: caption: "General Layout of the New Shops of the Interborough Rapid Transit Company. The Insert at Lower Left Shows Construction. Upper Right. Pit Construction and Arrangements for Lighting"

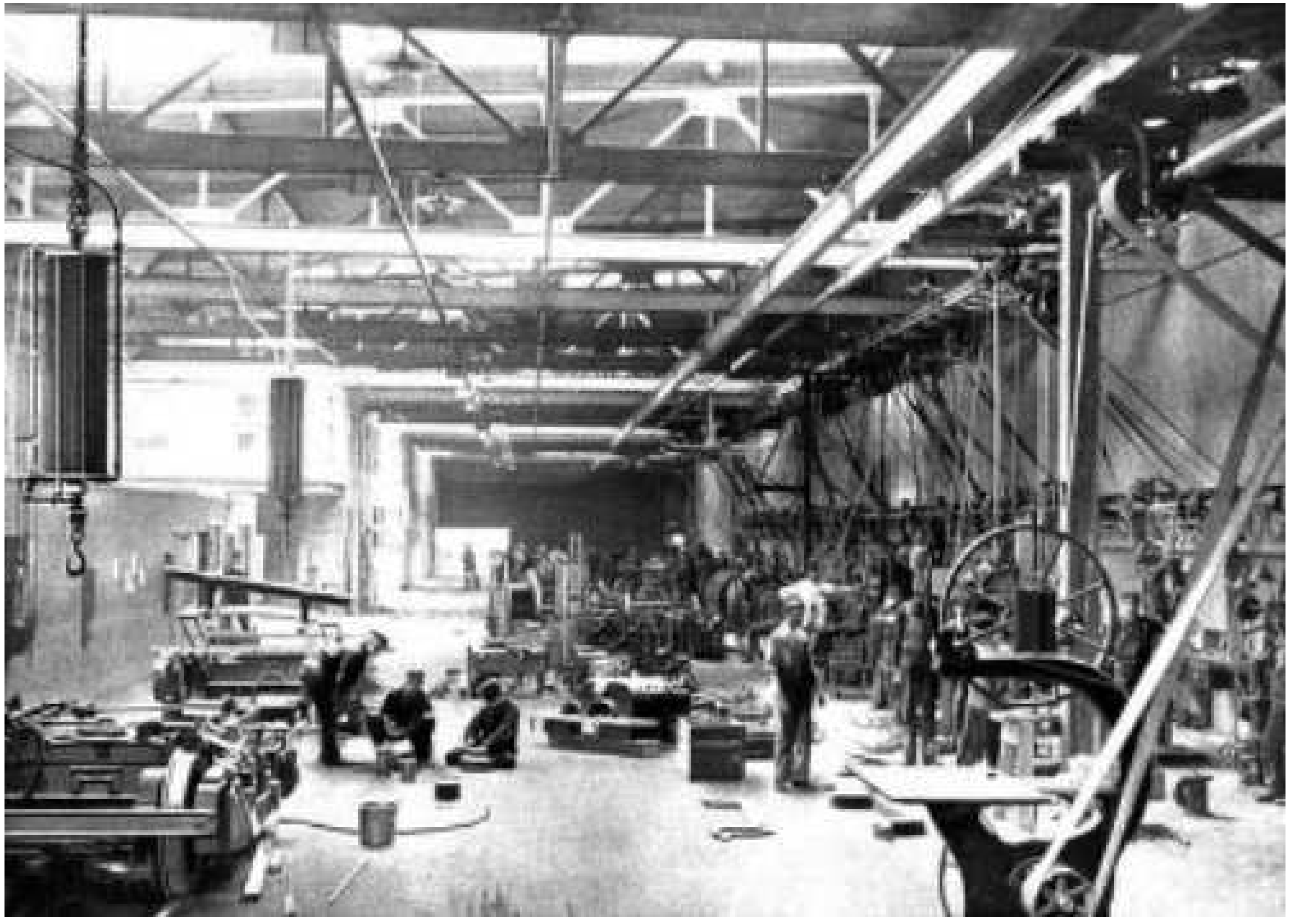
***Electric Railway Journal,* May 3rd 1924**



The inspection shed was at the southern end of the property and occupied an area of approximately 336-feet by 240-feet. It was divided into three bays of which the north bay was equipped with four tracks running its entire length and the middle bay with five tracks. The south bay contained the machine-tool equipment and consisted of eighteen electrically driven machines, locker and wash rooms, heating boilers, etc. and had only one track extending through it.

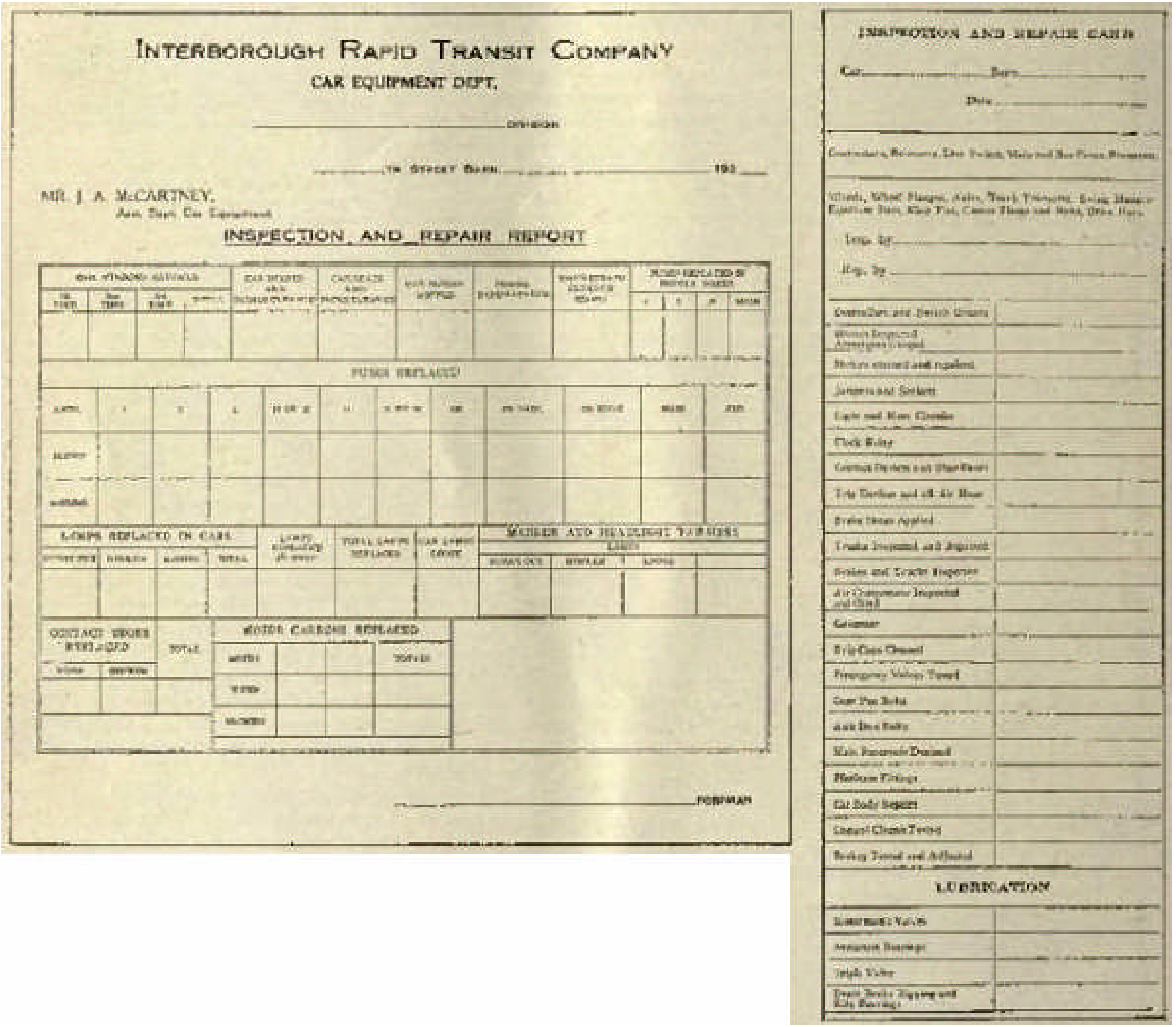
<u>Above</u>: caption: "One of the Inspection Bays at the 147th Street Shops"

As was usual in facilities of this kind, the third rail was not carried into the shops. Rather, the cars were moved about by means of a special trolley. In the middle bay this trolley consisted of a four-wheeled light-frame carriage which ran on a conductor located in the pit. The carriage had attached to it a flexible wire which could be connected to the shoe-hanger of the truck or to the end plug of the car in order that the cars could be moved around in the shops by means of their own motors. In the north bay (where the pits were very shallow) the conductor was carried overhead and consisted of an eight-pound T-rail supported from the roof girders. The middle bay was provided with a fifty-ton electric crane which spanned all of the tracks in the shop and was so arranged that it could serve any one of the thirty cars on the five tracks and could deliver the trucks, wheels, motors and other repair parts at either end of the shops where they could be transferred to the electric "telpherage" hoist; one of the most interesting features of the shops. The electric telpherage system ran the entire length of the north and south bays crossing the middle bay (a.k.a. "erection shop") at each end so that the telpherage hoist could pick up in the main room any wheels, trucks or other apparatus required and could take them either into the north bay for painting or into the south bay or machine shop for machine-tool work. The telpherage system extended across the transfer table pit at the west-end of the shops and into the storehouse and blacksmith shop at the *Seventh Avenue* end of the grounds.

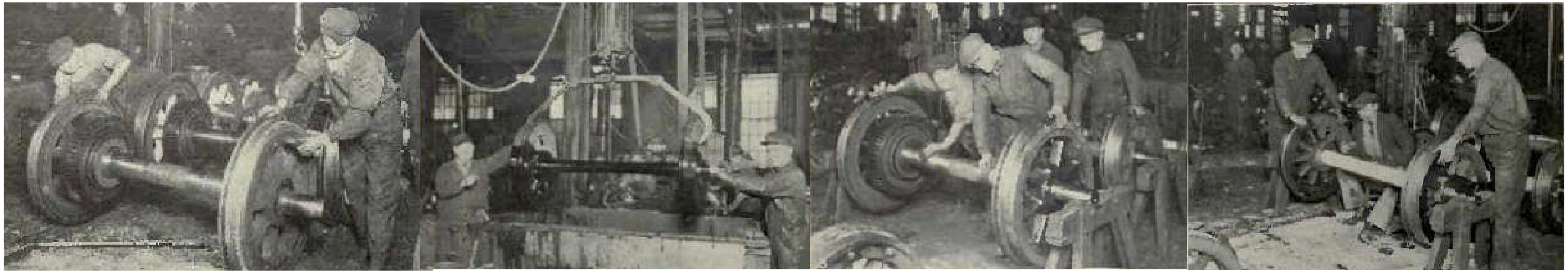


“...Each day the mileage clerk makes out a list, giving the numbers of the cars that are due for inspection, with the number of trips or mileage that each of the individual cars on the list has made since the date of its last inspection. A careful record is kept of the mileage made each day by each car, and motor cars are inspected every 1,000 miles and trail cars every 1,200 miles. After the mileage clerk makes out his list of cars to be inspected, one copy is sent to the shop department and another copy to the train dispatcher. As soon as a car is put in the inspection shed for inspection and repairs, the car checker compares the car numbers with his inspection list and puts a white inspection or work card on each car that is due for regular inspection...The back of the card contains space for record of the inspection of the storage batteries, as each car on the system carries a battery for emergency lighting. There are 26 cells, and the gravity, height of electrolyte, volts per cell, and total volts are recorded. The fact that the inspection card carries a list of the jobs to be done relieves the individual workman from a great deal of bookkeeping, because he has simply to make his entries on this card. On roads of the size of the Interborough where several hundred men are employed on inspection and repair, it is considered very essential that each individual should be held directly responsible for the work he performs. This the work card illustrated allows, because it has listed all of the various parts of the equipment with space for the signature of the man who does the work. No car is allowed to leave the pit until all items have been signed up. There are two other cards somewhat similar to the inspection card, one is blue and the other is red. This distinguishes them from the general inspection card because it is white…”

***Electric Railway Journal,* May 3rd 1924**



<u>Above</u>: caption: "At Left, One of the Blanks Used by the Inspection Force. At Right, Inspection Card Which Must Be Signed by the Man Doing the Work." [337]



1 2 3 4

"…The Four Illustrations on This Page Show the Methods of Inspecting Wheels by the Vibration Test and Magnifying Glass…a great deal of study has been given by the engineers of the Interborough Rapid Transit Company to methods of testing wheels, axles and pinions. The accompanying views show the processes used when the wheels come into the repair shop. (1) The dirt is scraped and wiped oft. The axle is then immersed in a lye tank for 30 or 35 minutes, and then thoroughly cleaned with waste; (2) It is then put in a hot bath of oil; (3) then wiped clean and dry again; (4) It is then carefully examined with a magnifying glass for evidence of detail fractures. Any crack is usually at the junction of the wheel and axle. Three of the views show a motor axle and two show a trailer axle. Both are treated in the same way…"

***Electric Railway Journal*, March 21st 1925**

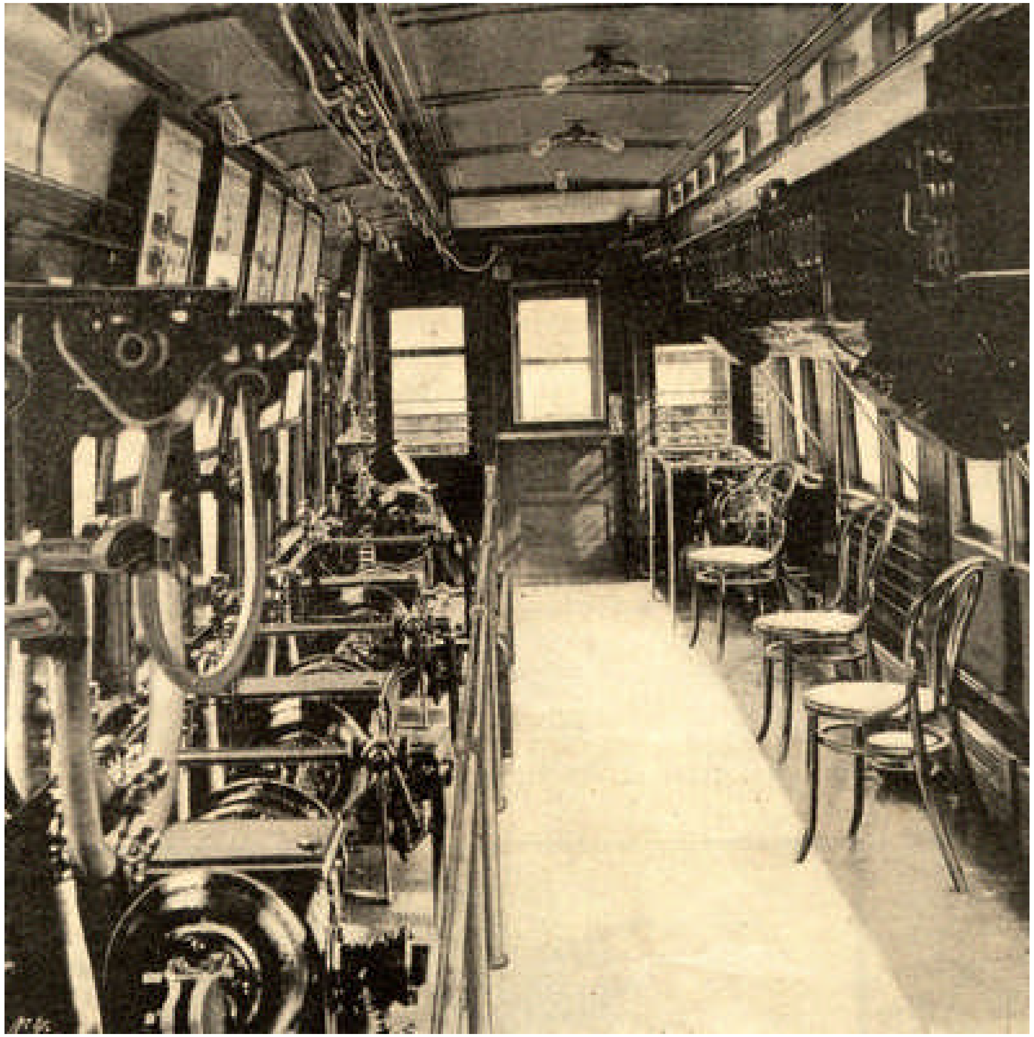
<u>Above</u>: caption: "Equipment for Wheel Turning at the 147th Street Shop. This powerful lathe for turning steel wheels has been of enormous help in keeping the cars used in New York rapid transit service supplied with wheels."

<u>Left</u>: caption: "Riveting a Roof Plate on a Car by a Pneumatic Riveter"

Part 5

The People Ride in a Hole in the Ground

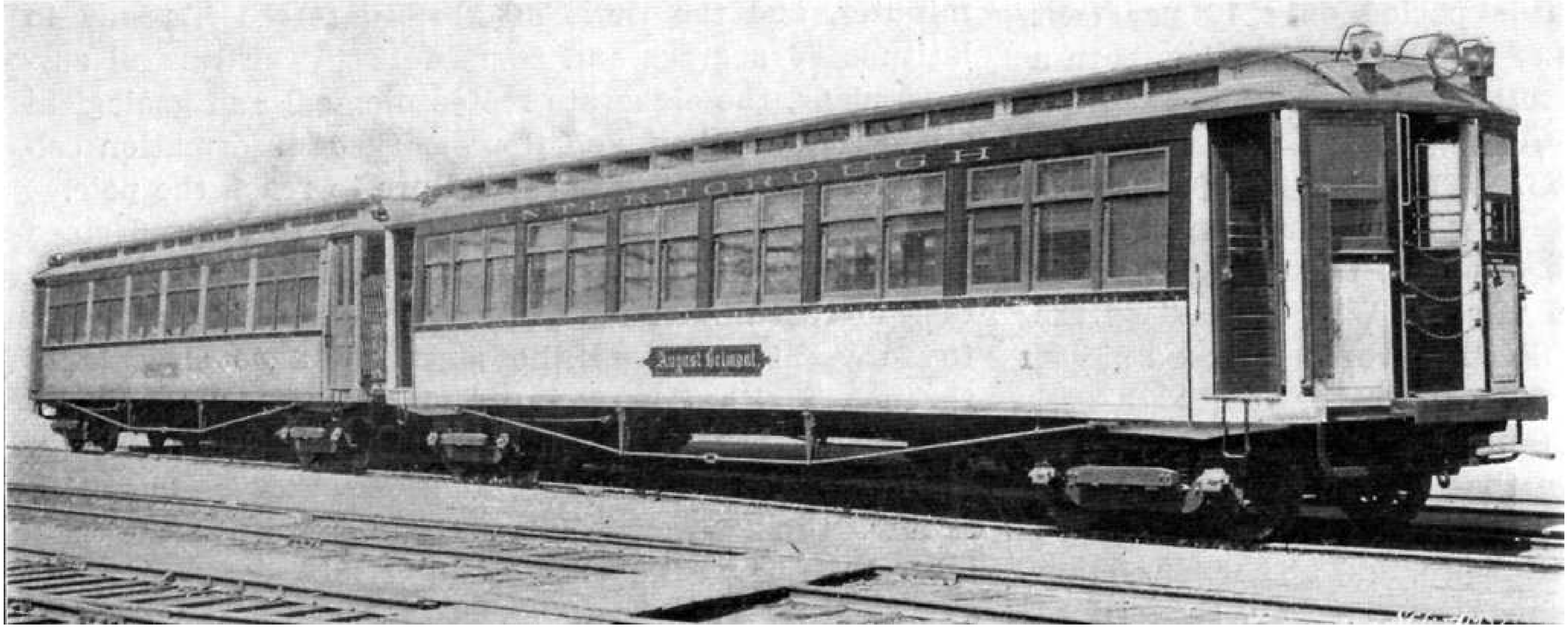
Training Days



"…As there was no other Subway in New York in which the men could be schooled in their vocation, it was, therefore, necessary to devote the period from July 20th to October 27th, 1904, to training the crews that were to operate the road, and, consequently, during this period the tunnel was practically nothing more than a training school for recruits…Following the operation of the first official train over the road, nine trains which were used as schools of instruction for the crews, which later on were to regularly operate the road, were run over the road each day. By September 18th, we had increased the number of trains operated from nine to twelve…"

Superintendent A.L. Merritt - *Interborough Bulletin*, 1914

Left: caption: "Interior of the car used for the Instruction of New York Subway motormen"



"…The prospective motorman is thoroughly drilled in the school car by a competent instructor not only in use of the mechanism but also how to act in cases of emergency. This personal teaching is supplemented by an excellent book of instructions containing about 150 questions and answers of a practical nature, with cuts and explanations of all the apparatus. This the motorman is expected to study closely and thoroughly. From time to time his knowledge of its contents is tested in examinations. Should he be of an inquiring turn of mind he is further allowed the privilege and opportunity of entering the shops and studying the entire system in detail, as much as he desires…"

***Scientific American,* August 24th 1904**

<u>Above</u>: caption: "Cars Submitted for Trial on the Rapid Transit Subway (No. 1, the August Belmont, and No. 2, the John B. McDonald)"

“With more than 1,500 men employed to work on the portion of the Subway opened yesterday, the Interborough Company starts out with the outlook favorable for at least three years of peace. Under an agreement with the employees, there will be no strike in that period. The wages which the train operatives are to obtain under the bargain are as follows: Motormen - $3.50 a day (nine hours’ work.) Conductors - $2 a day. Guards - $1.70 a day. The only electric railway motormen in the world who receive better pay are those on the Manhattan elevated lines. These men, who are old members of the Locomotive Engineers’ Union, get $3.50 for eight hours’ work…”

***The New York Times,* October 28th 1904**

"…On August 17th 1904, the first electric train was operated through the tube, Mr. August Belmont guiding it on its initial trip southbound, while Mr. Frank Hedley was the operator on the return trip northbound. The train started from Ninety-sixth Street, went south to Brooklyn Bridge and returned to Ninety-sixth Street. This first official round trip in the new Subway was a great success, outstripping the most sanguine anticipations of every one in the party, for we emerged from the tunnel unscathed and without having done any more damage than knocking down a few wires along the road and clipping off a couple of markers, which accidents were lightly regarded on that occasion as mere incidents of the trip. Of course, it is needless to say that the trip each way was not made in sixteen minutes as it is today. At that time the stations at Brooklyn Bridge, Grand Central, Seventy-second Street and Ninety-sixth Street were not completed. In addition to a parlor car, the 52 cars which were then ready for service formed the nucleus of the Subway equipment. On September 1st 1904, that part of the Subway which was practically completed and ready for operation, consisting of tracks and stations, from Brooklyn Bridge to One Hundred and Thirty-seventh Street and Broadway, in the West Side, and from One Hundred and Forty-fifth Street and Lenox Avenue, on the East Side, was formally turned over to the Interborough Rapid Transit Company…"

Superintendent A.L. Merritt - ***Interborough Bulletin*****, 1914**

"The schedule of trains in the rapid transit subway for the first days of operation has been arranged as follows:

LOCAL TRAINS, FIVE CARS EACH. 5:30 A.M. to 12 midnight, three-minute headway. 12 midnight to 5:30 A.M., from five to ten minute headway.

EXPRESS TRAINS, EIGHT CARS EACH. 6:30 to 7 A.M. five-minute headway. 7 to 9:30 A.M., four-minute headway. 9:30 A.M. to 2:30 P.M., varying from five to ten minute headway, the trains running most infrequently about noon time. 2:30 to 4:30 P.M., five-minute headway. 4:80 to 8 P.M., four-minute headway. 8 P.M. to 12 midnight, five and six minute headway, 12 midnight to 6:30 A.M. no express trains at all.

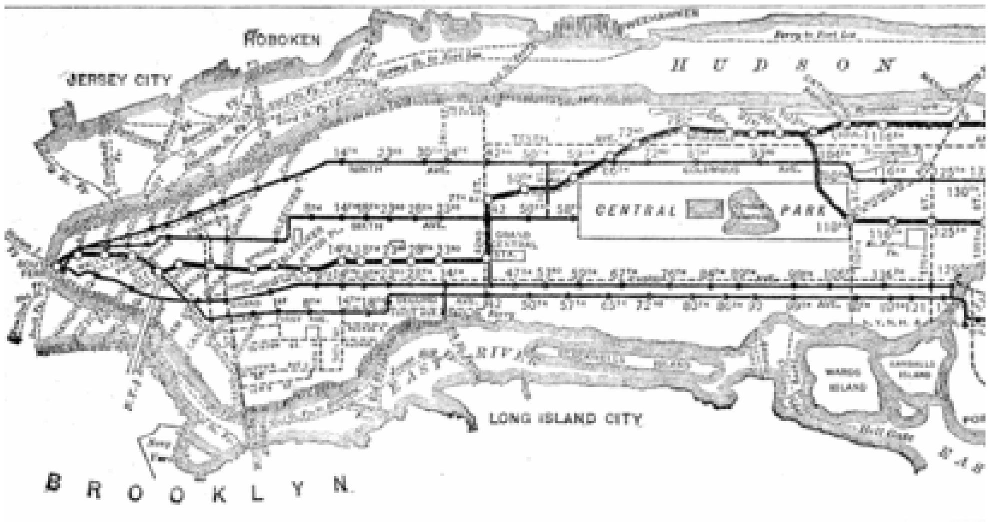
This schedule is subject to alteration at any time. General Manager Frank Hedley said when he was asked about time-table plans: 'Nobody knows how many people are going to patronize the road. I wish some one would tell me, so that I might know how to fix a permanent schedule. We shall be prepared to increase the number of trains to suit the demand. If it is necessary, we'll run them on a one-minute headway.' The express stations are at the Brooklyn Bridge, Fourteenth Street and Fourth Avenue, Forty-second Street and Park Avenue, Seventy-second Street and Broadway, and Ninety-sixth Street and Broadway. The last downtown express will leave Ninety-sixth Street at 11:30 P.M., and when it has completed its round-trip the express service for the day will be at an end…"

***The New York Times*, October 25th 1904**

54

INTERBOROUGH RAPID TRANSIT COMPANY

OPERATING SUBWAY AND ALL ELEVATED LINES IN NEW YORK CITY.



GENERAL OFFICERS.

AUGUST BELMONT, President. E. P. BRYAN, Vice-President. FRANK HEDLEY, General Manager.
H. M. FISHER, Secretary. D. W. McWILLIAMS, Treasurer. E. F. J. GAYNOR, Auditor.
GEO. H. PEGRAM, Chief Engineer. General Offices—13-21 Park Row, New York.

SUBWAY DIVISION.—NEW YORK CITY.

WEST BRANCH.

Mls.	Exp. Mins.	Local Mins.	BROADWAY LINE.	LOCATION.
0	0	0	South Ferry¹	Foot of Whitehall Street.
.27	1	1	Bowling Green	Foot of Broadway.
.52	2	2	Wall Street	Wall St. and Broadway.
.78	3	3	Fulton Street*	Fulton St. and Broadway.
.22	....	½	City Hall	City Hall Park.
1.05	4	4	**Brooklyn Bridge** ◎	Park Row and Centre St.
1.27	– –	5	Worth Street	Worth and Elm Streets.
1.52	– –	6½	Canal Street*	Canal and Elm Streets.
1.83	– –	8	Spring Street	Spring and Elm Streets.
2.11	– –	9½	Bleecker Street*	Bleecker and Elm Streets.
2.45	– –	11	Astor Place*	Eighth Street and 4th Ave.
2.70	8	12½	**Fourteenth Street*** ◎	14th Street and 4th Ave.
2.97	– –	13½	Eighteenth Street*	18th Street and 4th Ave.
3.21	– –	15	Twenty-third Street²*	23d Street and 4th Ave.
3.46	– –	16	Twenty-eighth Street*	28th Street and 4th Ave.
3.71	– –	17	Thirty-third Street²*	33d Street and 4th Ave.
4.22	12	18½	**Grand Cent. Station¹*** ◎	42d Street and 4th Ave.
4.67	– –	19½	Times Square*	42d Street and Broadway.
5.06	– –	21	Fiftieth Street	50th Street and Broadway.
5.59	– –	23	Columbus Circle*	60th Street and Broadway.
5.96	– –	24½	Sixty-sixth Street	66th Street and Broadway.
6.27	17	25½	**Seventy-second Street** ◎	72d Street and Broadway.
6.66	– –	27	Seventy-ninth Street	79th Street and Broadway.
7.08	– –	28	Eighty-sixth Street*	86th Street and Broadway.
7.26	– –	29	Ninety-first Street	91st Street and Broadway.
7.48	20	30	**Ninety-sixth Street** ◎	96th Street and Broadway.
7.88	22	31	103d Street	103d Street and Broadway.
8.23	23	33	110th Street	110th St. and Broadway.
8.53	24	34	116th Street*	116th St. and Broadway.
9.14	26	36	Manhattan Street*	Manhattan St. & Br'dway.
9.62	27	37	137th Street	137th St. and Broadway.
9.99	29	39	145th Street	145th St. and Broadway.
10.50	31	41	157th Street	157th St. and Broadway.
11.17	....	Shuttle Train	168th Street	168th St. and Broadway.
11.70	....	Shuttle Train	181st Street	181st St. and Broadway.
12.70	....	Shuttle Train	Dyckman Street	Dyckman St. & Broadway.
12.78	....	Shuttle Train	207th Street	207th St. and Broadway.
13.53	....	Shuttle Train	215th Street	215th St. and Broadway.
13.80	....	Shuttle Train	221st Street	221st St. and Broadway.

EAST BRANCH.

Mls.	Exp. Mins.	Local Mins.	LENOX AVE. AND WEST FARMS.	LOCATION.
0	0	0	South Ferry¹	Foot of Whitehall Street.
.27	1	1	Bowling Green	Foot of Broadway.
.51	2	2	Wall Street	Wall St. and Broadway.
.76	3	3	Fulton Street*	Fulton St. and Broadway.
.12	....	½	City Hall	City Hall Park.
1.05	4	4	**Brooklyn Bridge** ◎	Park Row and Centre St.
1.27	– –	5	Worth Street	Worth and Elm Streets.
1.54	– –	6½	Canal Street*	Canal and Elm Streets.
1.83	– –	8	Spring Street	Spring and Elm Streets.
2.11	– –	9½	Bleecker Street*	Bleecker and Elm Streets.
2.45	– –	11	Astor Place*	Eighth Street and 4th Ave.
2.70	8	12½	**Fourteenth Street*** ◎	14th Street and 4th Ave.
2.97	– –	13½	Eighteenth Street*	18th Street and 4th Ave.
3.21	– –	15	Twenty-third Street²*	23d Street and 4th Ave.
3.46	– –	16	Twenty-eighth Street*	28th Street and 4th Ave.
3.71	– –	17	Thirty-third Street²*	33d Street and 4th Ave.
4.22	12	18½	**Grand Cent. Station¹*** ◎	42d Street and 4th Ave.
4.67	– –	19½	Times Square*	42d Street and Broadway.
5.06	– –	21	Fiftieth Street	50th Street and Broadway.
5.59	– –	23	Columbus Circle*	60th Street and Broadway.
5.96	– –	24½	Sixty-sixth Street	66th Street and Broadway.
6.27	17	25½	**Seventy-second Street** ◎	72d Street and Broadway.
6.66	– –	27	Seventy-ninth Street	79th Street and Broadway.
7.02	– –	28	Eighty-sixth Street*	86th Street and Broadway.
7.26	– –	29	Ninety-first Street	91st Street and Broadway.
7.48	20	30	**Ninety-sixth Street** ◎	96th Street and Broadway.
8.29	21	32	110th Street	110th St. and Lenox Ave.
9.05	25	35	116th Street*	116th St. and Lenox Ave.
9.52	27	37	125th Street*	125th St. and Lenox Ave.
10.08	29	39	135th Street	135th St. and Lenox Ave.
10.52	31	41	145th Street	145th St. and Lenox Ave.
			Westchester Avenue and West Farms, via 135th Street.	
10.98	....	42	Mott Avenue	Mott Ave. and 149th St.
11.43	....	43½	Third Avenue*	149th St. and Third Ave.
12.08	....	45½	Jackson Avenue	Jackson & Westchester Avs.
12.37	....	47	Prospect Avenue	Prospect & Westch'ter Avs.
12.92	....	49	Simpson Street	Simpson St. & So. Boulev'd.
13.36	....	50	Freeman Street	Freeman St. & S. Boulev'd.
13.90	....	52	174th Street	174th St. & Boston Road.
14.38	....	53½	177th Street*	177th St. & Boston Road.
14.55	....	54	180th Street	180th St. & Boston Road.

◎ Express stations. South of Brooklyn Bridge and north of Ninety-sixth Street run on local time.

"…Notwithstanding the pessimistic prognostications contained in our preliminary report, on October 10th, 1904, a regular train schedule was inaugurated between One Hundred and Thirty-seventh Street and City Hall, both expresses and locals operating under a six minute headway. Though we carried no passengers on those trains, a full crew was aboard each one, and stations were announced, doors opened and closed, and bells passed to the motorman just as though we carried people. By Friday, October 21st 1904, the entire schedule as it was to be operated on the opening day - 25 local trains and 15 express trains - was placed in operation. And it was 'some' schedule, too, particularly when we first attempted to spread it out evenly over the road…However, after many nerve trying experiences, we gradually unraveled the innumerable knotty problems which we encountered and on October 27th 1904, at 2:38 o'clock in the afternoon, three special trains carrying Mayor McClellan with a party of City officials, the General Manager of the road and other officials of the Company and their friends, were run over the line, formally opening the road to the public…"

Superintendent A.L. Merritt - *Interborough Bulletin*, 1914

Left: caption: "Map of the 1906 IRT system in Manhattan"


ENTRANCE TO SUBWAY, NEW YORK
CITY HALL DECORATED

Growing Pains

“…On November 23rd 1904, the One Hundred and Forty-fifth Street spur of the Lenox Avenue line was opened, and a few days afterwards the Westchester Branch (that is the section between Brook Avenue and One Hundred and Eightieth Street) was opened and operated by the Elevated Division, the section from One Hundred and Forty-second Street junction to the Third Avenue portal not being completed. The Broadway line was opened as far as One Hundred and Fifty-seventh Street on the 4th of December. The temperature in the open air on that day was 32 degrees, but down in the tunnel it was 50 degrees and much more comfortable than on the street, consequently many more people used the Subway than on any day previously…January 16th 1905, saw the south end of the road extended down from Brooklyn Bridge to Fulton Street. While but half of the Fulton Street station, the up side, was ready for business, the General Manager said that half a station was much better than no station at all, therefore the Fulton Street, up side, platform and station was opened a full six months before the downtown side…We gradually pushed along, progressing step by step, toward either terminal, and by March 15th 1905, the East side of the Brooklyn Bridge station was opened up for business…The downtown platforms of both the Wall and Fulton Street stations were opened on June 12th…”

Superintendent A.L. Merritt - *Interborough Bulletin*, 1914

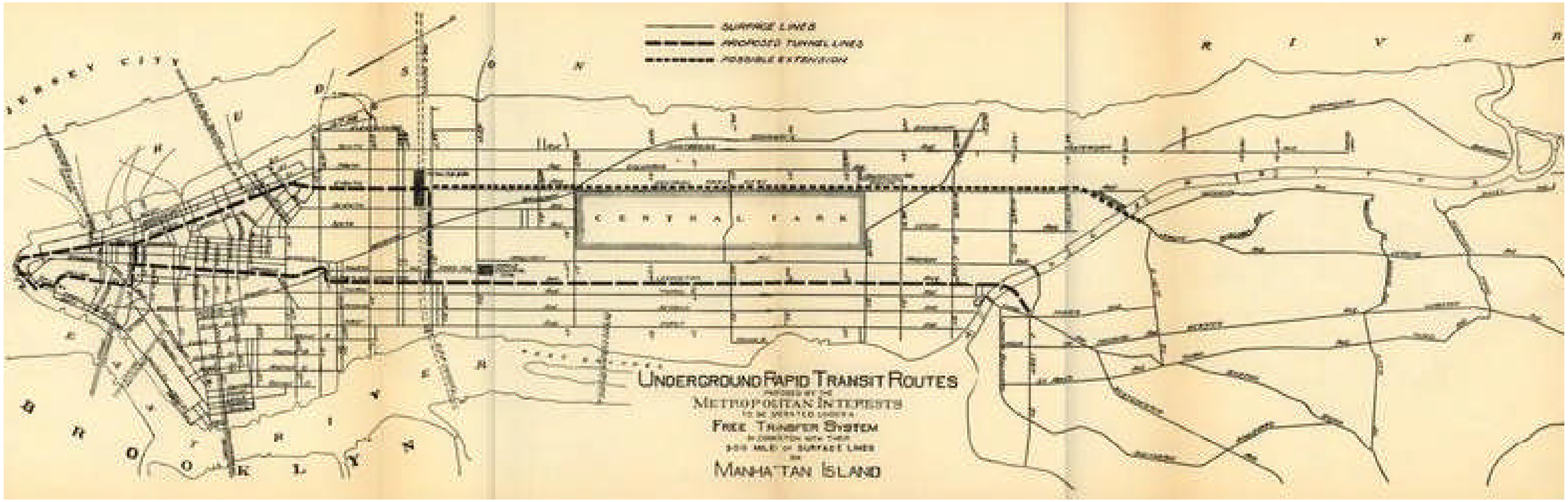
"…Our first really serious operating difficulty was encountered on December 14th 1904 when a city water main located at Eighty-first Street and Broadway burst and flooded our tracks, putting us out of business for the first time since we began operation. As a consequence of the flood from Seventy-second Street to Ninety-sixth Street all trains were discontinued from 10:15 A.M. until 1:15 P.M. Without even giving the matter so much as a thought that snow storms would involve the operation of Subway trains in any material way, we were suddenly confronted with our first blizzard on January 4th 1905. During the storm the temperature on the streets above registered 10 degrees, and in the tunnel it was 35 degrees above zero. Naturally there was a great rush for the Subway which was much warmer than the open and not subject to interruption by the raging storm outside. On that day we hung up our first record for a big day's business, having safely transported 360,000 people, and without losing any time…Just as we were forgetting about our first blizzard and the big business we did as a result of it, along came blizzard No. 2 on the 26th of January. Recalling the record crowds we carried on the occasion of the first blizzard, we at once prepared for a similar rush on that day, and were surprised in tallying up the day's business to find that we had again broken our record, carrying 411,000 passengers as against 360,000 on January 4th. The day following we did even better, carrying 425,000, and on the third day of the blizzard established a new high record of 446,000 passengers transported without a single mishap. Those three record days were conspicuously marked on our ledger with several asterisks to emphasize the big business done…on June 12th 1905, the road was again crippled with a second flood, this one occurring just below Grand Central station. As a result of this inundation, the road was cut in two from Sunday night until Tuesday morning, the longest interference with our operation we had thus far encountered…"

Superintendent A.L. Merritt - *Interborough Bulletin*, 1914

"…The West Farms Division of the Subway, north of One Hundred and Forty-second Street, was placed in operation on July 10th 1905, and on the same day the South Ferry loop station was opened. On March 12th 1906, the Broadway line, with the exception of the stations at One Hundred and Sixty-eighth Street, One Hundred and Eighty-first Street and Two Hundred and Seventh Street, which were not quite ready at the time, was opened up as far as Two Hundred and Twenty-first Street. On April 14th the One Hundred and Sixty-eighth Street station was opened, and on May 30th the One Hundred and Eighty-first Street station was also opened. The Two Hundred and Twenty-fifth Street station of the Broadway line was opened on January 14th 1907, and on January 27th 1907, the Two Hundred and Thirtieth Street station of the same line was also opened. On April 1st 1907, the Two Hundred and Seventh Street station of the Broadway line was opened. The Brooklyn extension of the Subway to Borough Hall was formally opened on January 9th 1908. That was a big gala day for Brooklyn, as the extension supplied the kind of rapid transit which the districts it tapped had been clamoring for many years past…On May 1st 1908, the Brooklyn extension was completed and opened to the Atlantic Avenue station, at the southern terminus, and on August 1st, 1908, the extension to Van Cortlandt Park, at the northern terminus, was placed in operation…"

Superintendent A.L. Merritt - *Interborough Bulletin*, 1914

Expansion



"…A glance at the enclosed map will show how admirably the routes which we suggest are adapted to meet the requirements which you have laid down. Under the transfer system which we propose, by which the underground lines and our three hundred miles of surface lines on Manhattan Island would be operated as one system, almost every person on Manhattan Island would be able to ride from his place of residence to his place of business for a single fare of five cents and at a rate of speed which would be possible only with underground lines operated in connection with a complete system of surface lines. In other words, our plan would practically bring rapid transit to the door of every citizen…the routes which we suggest represent the most careful study of the engineering problems presented and of the needs of the six hundred million passengers who annually ride upon the Metropolitan lines…our primary motive in undertaking the construction of underground lines would be the expectation of additional business and relief from the overcrowding which now makes it impossible for the surface lines to give satisfactory service. The public, on the other hand, would have, without any increase in fares, a vastly improved and extended service…"

RE: excerpt from a letter from *Thomas F. Ryan* to *Alexander E. Orr*, President of the RTC, Feb. 25th 1904

"…The northern terminus of the proposed route is at a point in the Bronx, near Third Avenue and 138th Street, at the principal business center of the Bronx, where seven of our surface lines converge. From this point the route extends under the Harlem River to Lexington Avenue; down Lexington Avenue past the Grand Central Station to Fifteenth Street; along Fifteenth Street and under Union Square to Broadway (passing under the present subway at Union Square); down Broadway to Chambers Street; along Chambers Street to William Street (passing under the present subway and the proposed bridge loop); along William Street to Hanover Square; and thence to the Battery through Coenties Slip and South Street; through the Battery (passing outside of the Battery loop of the present subway and over the Brooklyn extension thereof) to Greenwich Street; along Greenwich Street, West Broadway and Hudson Street to Eighth Avenue; along Eighth Avenue to Thirty-fourth Street (passing above the Pennsylvania tunnel and through the center of the new Pennsylvania Station at a grade which has been approved by The Pennsylvania Railroad Company) and along Thirty-fourth Street (passing under the Interborough tunnel at Park Avenue) to a junction with the main route at Lexington Avenue. It is also proposed to add a loop connection on Chambers Street between the East Side line and the West Side line. The plan contemplates the ultimate extension of the West Side line from Thirty-fourth Street along Eighth Avenue to the Harlem River…"

RE: excerpt from letter from *H.H. Vreeland*, President of *The New York City Railway Company* (lessee, *Metropolitan Street Railway System*) to *William Barclay Parsons*, Chief Engineer of the RTC, February 25th 1904.

"…The rapid transit routes which we recommend, in addition to offering the special advantages due to their operation in connection with the surface lines, to which I have called attention, offer the following additional advantages which seem to be of controlling importance:

1. The lines which we propose contemplate two exceptionally direct north and south rapid transit routes for Manhattan Island, following, in the main, the lines of travel where the congestion is now the greatest, and provided with such loop connections as will most efficiently distribute the train service where it may be needed at the various hours of the day.

2. They would furnish means of reaching every part of the city to the 35,000,000 passengers who are expected to pass annually through the new Pennsylvania Station, as well as direct communication between that station and the Grand Central Station.

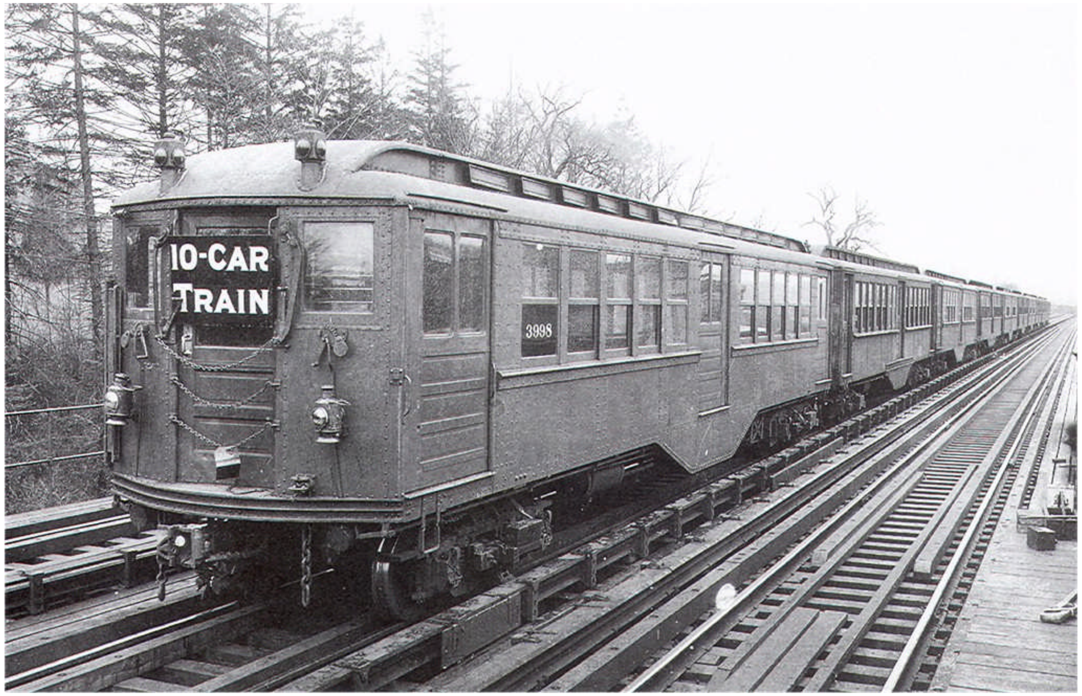
3. They would afford direct underground connection with the proposed trolley tunnels under the Hudson River which are to have their termini at Christopher Street and Cortlandt Street, respectively, and connections could readily be made with all the East River Bridges.

4. By utilizing the cross-town subway lines on Chambers Street and Thirty-fourth Street, an underground belt line is provided for the lower end of the Island which would furnish the much-needed rapid transit connections between the east and west side of the City, including means for the residents of the upper east side to reach the lower west side without congesting the cross-town surface line.

5. In short, the plan provides a belt line for the southern part of the City which could receive by underground connections the traffic from the three Hudson River tunnels (at Cortlandt, Christopher and Thirty-fourth Streets) from The Long Island Railroad Company's tunnel under the East River and from two and perhaps three of the bridges from Brooklyn, and distribute this traffic to every part of the City largely by underground routes…"

RE: excerpt from letter from *H.H. Vreeland*, President of *The New York City Railway Company* (lessee, *Metropolitan Street Railway System*) to *William Barclay Parsons*, Chief Engineer of the RTC, February 25th 1904.

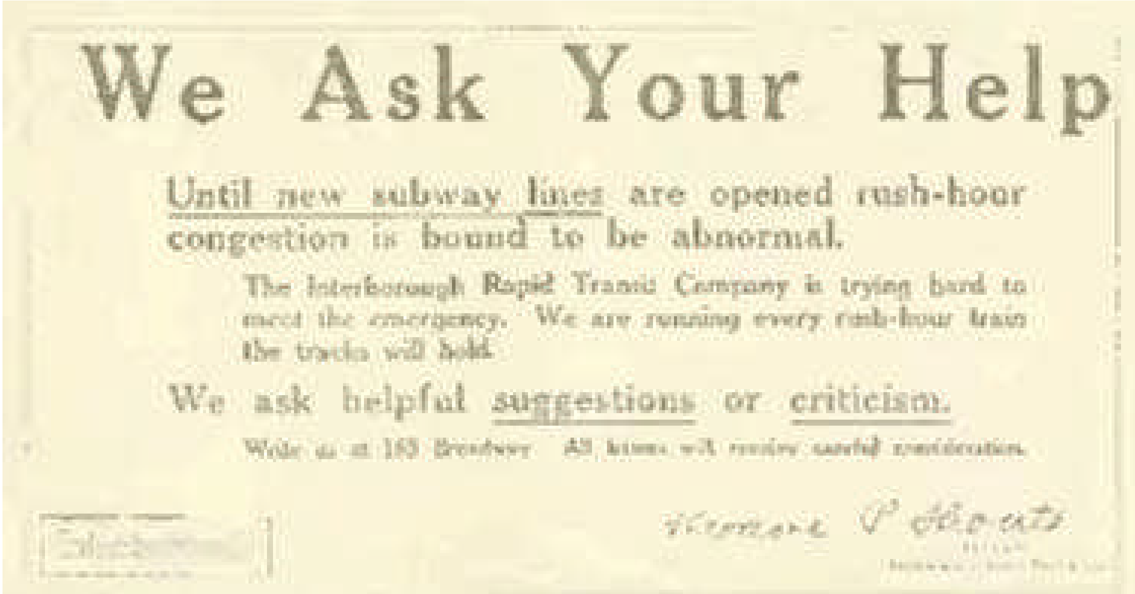
Ten Car Service



"The above is a picture of a ten-car, side-door, all-steel subway train such as is run on the express tracks of the subway. The company started this ten-car service January 23d 1911, continuing the interval of one minute and forty-eight seconds previously run by the eight-car trains. This adding of two cars to the express trains increased the capacity of the subway express tracks 25 per cent in commission hours. A ten-car train consists of seven motor cars and three trailers, providing seats for 500 passengers. The total length of these trains is 510 feet and the total weight is about 350 tons. As there are seven motor cars in each train, each motor car having two motors of 200 horse-power, there is, therefore, on a ten-car train, 2,800 horse-power. This is about 40 per cent greater horse-power, than is required on the limited trains on the trunk line roads. These trains are fully equipped with the latest improvements in the way of car equipment, and represent an expense of $110,000 per train. The transportation furnished by these trains is unequalled within any city in the world."

Interborough Bulletin, **April 1911**

We Ask Your Help



"…the company posted on the windows of every car in the subway and on the elevated placards entitled, 'We Ask Your Help.' It was a frank appeal for public assistance, the beginning of a definite campaign to enlist the good-will of the people of New York on behalf of the Interborough company. During the last two or three years the Interborough has had to face traffic conditions, on both the subway and elevated, unparalleled, perhaps, on any other railroad in the world. The original subway lines, approximately 96 miles in length, had been built by the city to care for a daily capacity of approximately 400,000 passengers. Yet within five years these lines were carrying 1,000,000 each day. Frequently during the past year the 1,500,000 mark has been touched. To relieve this congestion as well as to extend the rapid-transit system to all parts of the city New York is now building nearly 300 miles of additional underground routes. Until these are ready for operation, however, existing lines must continue to carry their present burden. Here was a situation which was difficult for the company as well as the public. It was important that the public should understand the nature of the problems which had to be solved…"

***Electric Railway Journal,* April 7th 1917**

Above: car poster, IRTC

"…The public's response exceeded all expectations, both in the number of replies and in the generally appreciative attitude toward the company's efforts. More than 7000 letters were received…Every section of New York's varied social and business life was represented…Lawyers, architects, merchants, civil, electrical and mining engineers, policemen, former Interborough employees, railroad men, stenographers, clerks, telephone operators, advertising men — all outlined various ways for dealing with congestion, or made suggestions for improving many minor points of service as they related to the particular line or station they used most frequently…Suggestions that seemed practicable were referred to a special committee from the operating department. On this committee President Shonts placed men who were experts in transportation problems, men who had studied the subway lines of London and Paris, who represented the best railroad brains in America, and who had spent years in making New York's subway one of the safest and most efficient railroads in the world…Some of the Suggestions…

1. The use of end doors on subway cars for exit, with entrance through the center doors, or vice versa, with exit at the center doors and entrance at the ends.

2. To use both express tracks during the rush hours in the same direction. In other words, to run trains downtown in the morning over three tracks, with uptown service only over the one local track. In the evening this arrangement would be reversed.

3. To operate both express and local trains, eliminating or 'skipping' certain stations. Thus it was proposed to operate certain rush-hour trains in the morning past Ninety-sixth Street without stopping or past Brooklyn Bridge at night…

The predominant tone of all the letters was fairness. Nine out of every ten who wrote to President Shonts were earnest and sincere in their desire to help the company in its efforts to render service that, first of all, was absolutely safe, then comfortable and efficient. The amount of study and concentration displayed by the public on the subway and elevated problems was extraordinary…"

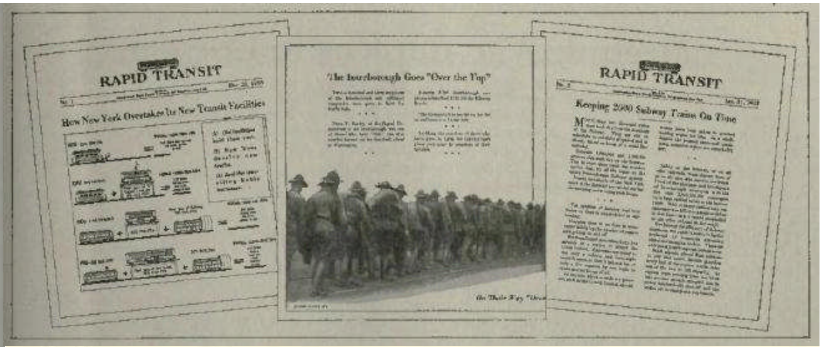
***Electric Railway Journal,* April 7th 1917**


TRAINS RUN AT THE CO'S CONVENIENCE
INTER BOROUGH
RATTLED TRANSIT
THREE HOURS TO HARLEM
W. A. Rogers

Don’t

- **Don’t try to stick your head out of the window of a subway train. The lower windows are fastened down;**
- **Don’t rush for the front car to get a look at the track ahead. The front windows are curtained;**
- **Don’t walk across the tracks between station platforms. You would have to cross four deadly third rails;**
- **Don’t take a local train if you are in a hurry. It’s quicker to take an express and transfer to the local at the express station nearest to your destination;**
- **Don’t stand on the platforms (between the cars);**
- **Don’t try to ride in the tunnel between 2:30 and 6:00 today unless you have a special pass. Five-cent tickets will be sold after 7:00;**
- **Don’t lower the top window unless you have to. The draughts are bad in the tunnel;**
- **Don’t wait for an express train after midnight. They do not run between then and 6:30AM;**
- **Don’t move from your seat if there is an accident. You cannot improve your position and you might be the cause of a panic;**
- **Don’t deface the stations or trains. If you do, you are likely to be arrested**

***The New York Times,* October 28th 1904**



Danger Warnings

Every day our guards warn you more than 150,000 times to "watch your step."

They speak for your safety.
Won't you listen?

Don't Block a Closing Door

More than 2,800 persons were injured last year trying to squeeze through closing doors.

Why take the risk to save a few minutes?

Various IRTC publications and posters directed at the traveling public

A Tiresome Job

"'Mark my words,' said the observant citizen, 'the Subway is going to boom the newspaper business. When you get in, there's nothing to look at except the people, and that's soon a tiresome job.'"

***The New York Times,* October 28th 1904**

"…The people of New York do well to celebrate with trumpets and drums the opening of the subway for travel. The event begins the emancipation of the larger part of the city's population from an excessively cramped and uncomfortable manner of living. The emancipation will not be finally effected without many years of additional labor and the construction of other tunnels than the one now about completed…The existing situation, then, in regard to living accommodations in Manhattan may be summarized as follows: New private residences are being erected only for rich people. A great many families with fair incomes continue to live in them; but this number is actually, as well as relatively, decreasing, because of the constant displacement of the existing stock of residences by apartment-houses and business buildings. Had no relief been afforded, the result would undoubtedly be the complete destruction of private residences in Manhattan, except for very rich people, and the substitution in their place of huge apartment-houses and family hotels. The subway, which is now being opened, will, however, afford some relief, because its express tracks will make an unoccupied area like Washington Heights almost as accessible from the financial district as the lower West Side now is. Under the impulse afforded by these better accommodations, there will be a revival of the building of small residences on Manhattan Island, and during the next five years Washington Heights will be the scene of a speculative building movement of a greater volume and momentum than that which took place on the West Side in the middle years of the eighties. There is no doubt, however, that the existing subway will, like the elevated roads, create more traffic than it can satisfactorily accommodate, and unless supplementary tunnels are added, there will be a renewal, in a few years, of the congestion from which the city is now suffering. Within another six years, however, other subways will surely be opened; and they, together with the new bridges and the tunnels under the East and North rivers, will permit New York to expand more freely than it has done for a generation; with the result, undoubtedly, of increasing both its industrial efficiency and its general wholesomeness of life. They will restore cheap land to a large part of the inhabitants of the city, reduce the cost of living, and encourage on the one hand the distribution of population, and on the other the concentration of business. But just because this immense invigoration of the city's power of circulation will centralize business as well as distribute population, it will merely postpone the day when those only will occupy a private residence in Manhattan who are rich enough to afford a large price, and any man who lives anywhere or anyhow in Manhattan will have to pay in one way or another, if not in money, then in space, light, air, and comfort."

***Herbert Croly - The Review*, September 1904**

"…The actual work of construction amounted to about $37,000,000. The operating company has expended in its great power-house, equipment, and rolling stock a sum nearly equal to this. The road as it stands represents an expenditure of nearly $3,000,000 per mile, and is the most expensive ever built. At the end of fifty years it becomes the property of the city…"

***Outlook Magazine*, November 1904**

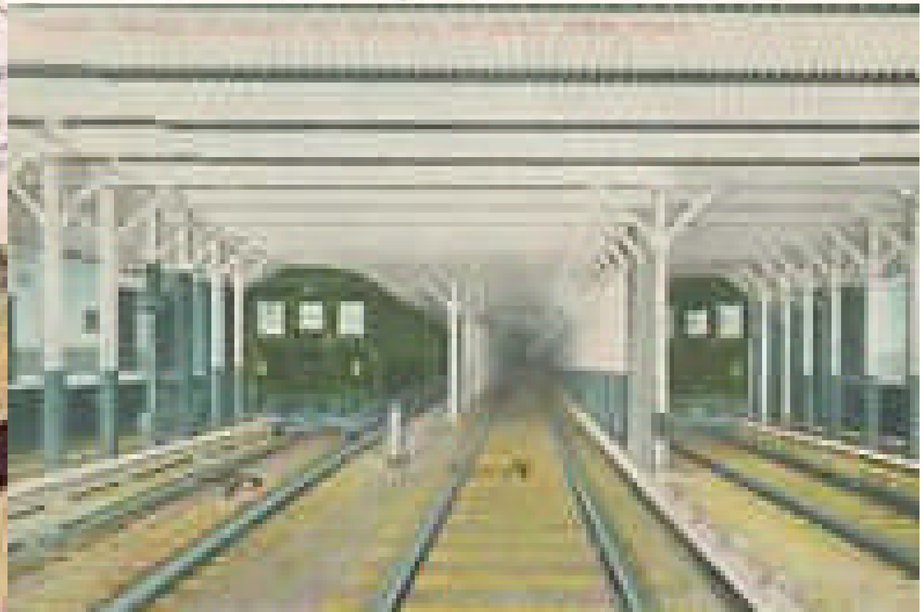
“In after years every man connected with the construction of the New York Subway will be proud to say that he was on this work. There have been no scandals of any kind, and no one has ever dared to insinuate that any official, from the highest to the lowest, has done other than hard, faithful and honest work on this vast contract.”

William Barclay Parsons

Postcards from the Platform Edge


TRAINS
UNCLE
SEEING THE


nothing like a ride on
New York's famous
SUBWAY
EXPRESS



It Has Been Done

"…The narrow island of Manhattan, bisected by its streets, filled with water, gas, and heating mains, electric ducts, pneumatic tubes, sewers, surface and elevated railways, and with its buildings constructed on foundations varying from shifting sand below the tide line to hard and seamy rock rising to high altitudes, and with the Harlem River interposing on its north line - all these were obstacles which the engineer had to meet and conquer. It has been done…"

John B. McDonald

RE: excerpt from his October 27th 1904 opening day speech