PDHonline Course C705 (5 PDH)

Mr. Holland's Tunnel

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2020

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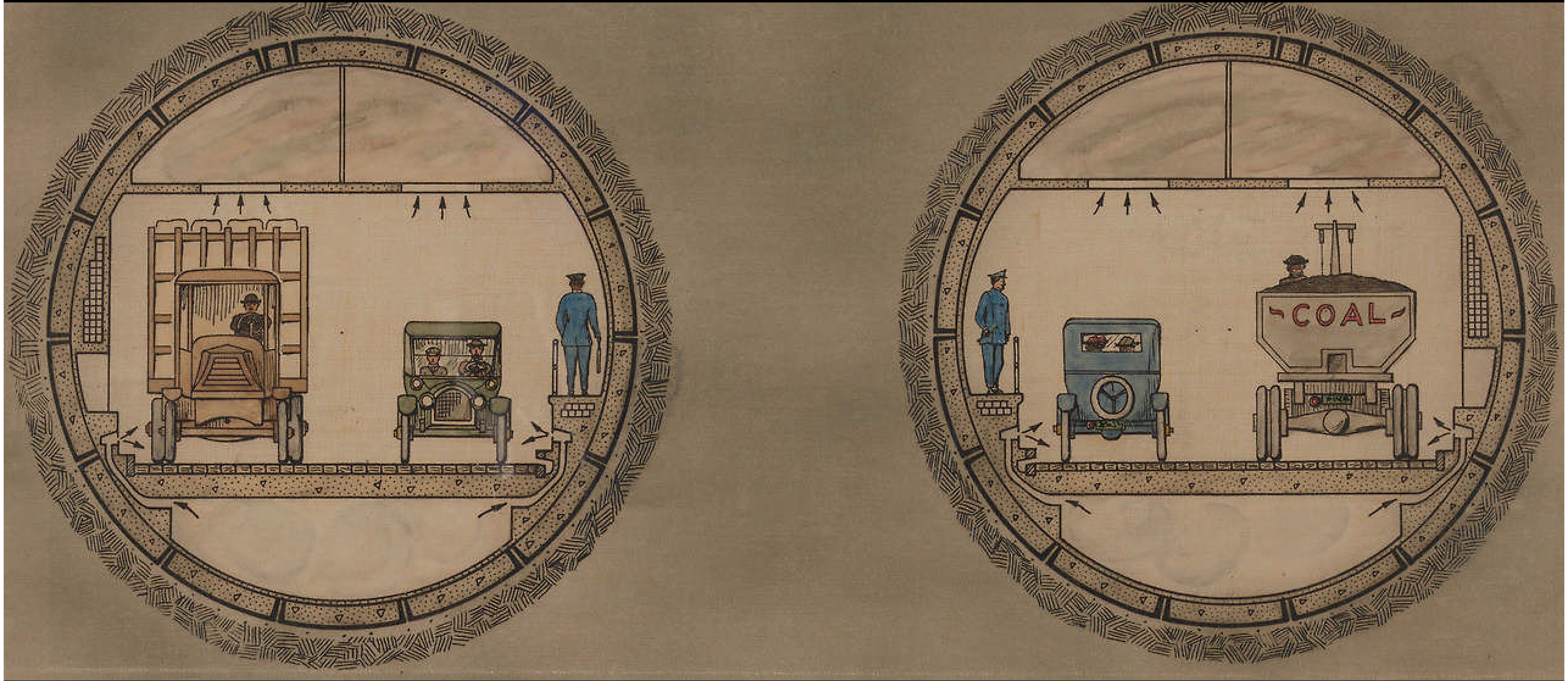
Mr. Holland's



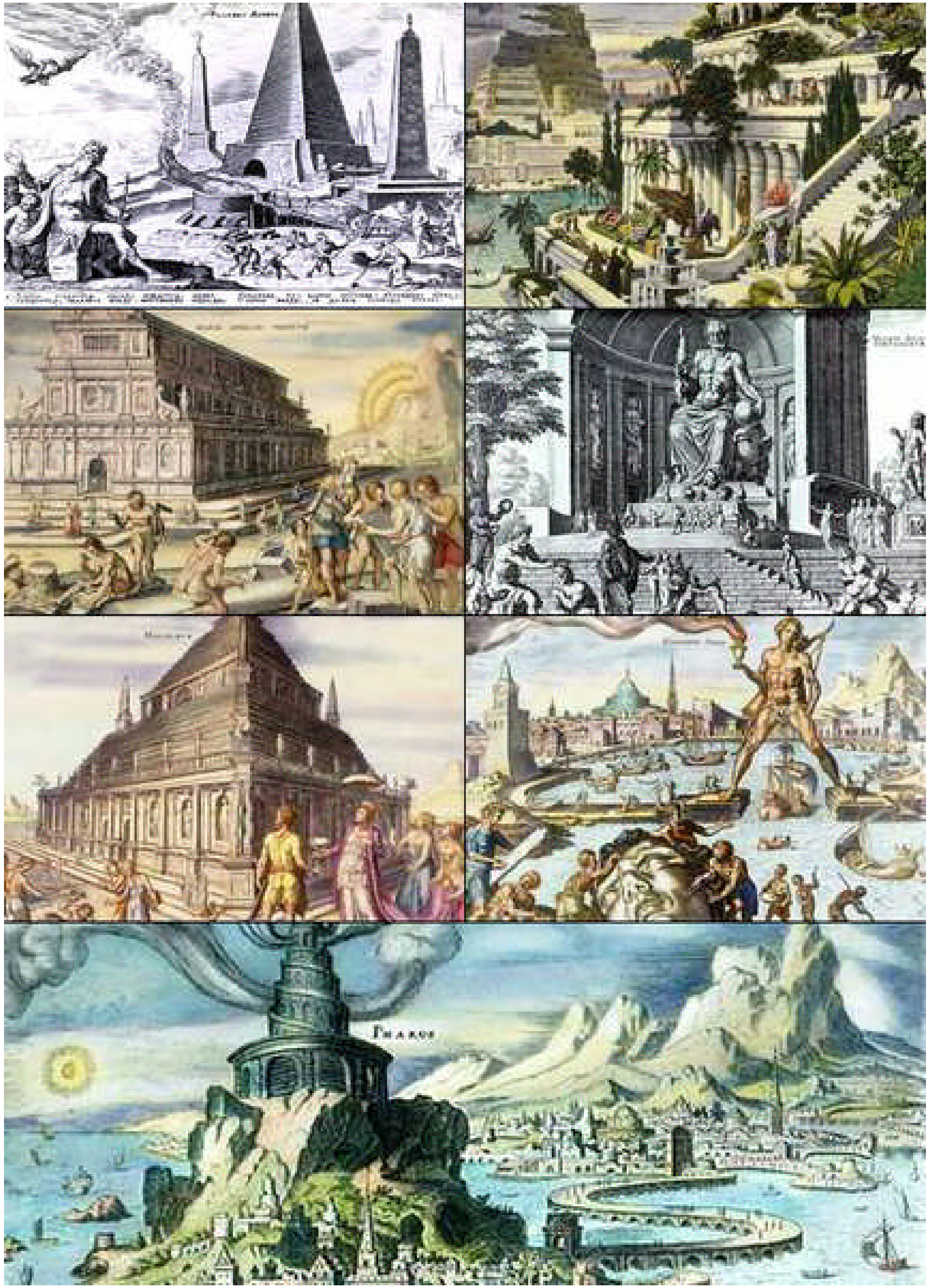
Tunnel

Table of Contents

Part 1

Eighth Wonder

The Seven Wonders of the World



“Back in the second century B.C., a certain Antipater of Sidon composed an epigram in which he enumerated what he termed the ‘Seven Wonders of the World.’ They were the walls of Babylon, the statue at Olympia by Phidias, the hanging gardens at Babylon, the Colossus of Rhodes, the pyramids of Egypt, the mausoleum at Halicarnassus, and the temple at Ephesus…”

RE: excerpt from *The Eighth Wonder*

<u>Left</u>: caption: “The Seven Wonders of the Ancient World (from left to right, top to bottom): Great Pyramid of Giza, Hanging Gardens of Babylon, Temple of Artemis at Ephesus, Statue of Zeus at Olympia, Mausoleum at Halicarnassus, Colossus of Rhodes, and the Lighthouse of Alexandria.”

"…Today any similar list of wonders, no matter by whom compiled, would doubtless include the Pyramids, not merely because they alone have survived the ravages of time, but because they still represent a marvelous achievement of man's handiwork. What the other wonders would be might afford material for a contest sponsored by some newspaper columnist. But surely there would be a place in such a list for the Holland Tunnel, as the longest sub-aqueous tunnel in the world, a stupendous project, magnificently conceived and executed. And surely old Antipater himself, however wedded he might be to his own wonders, would today be glad to add the Holland Tunnel to his list, as an eighth wonder of the world…"

RE: excerpt from *The Eighth Wonder*

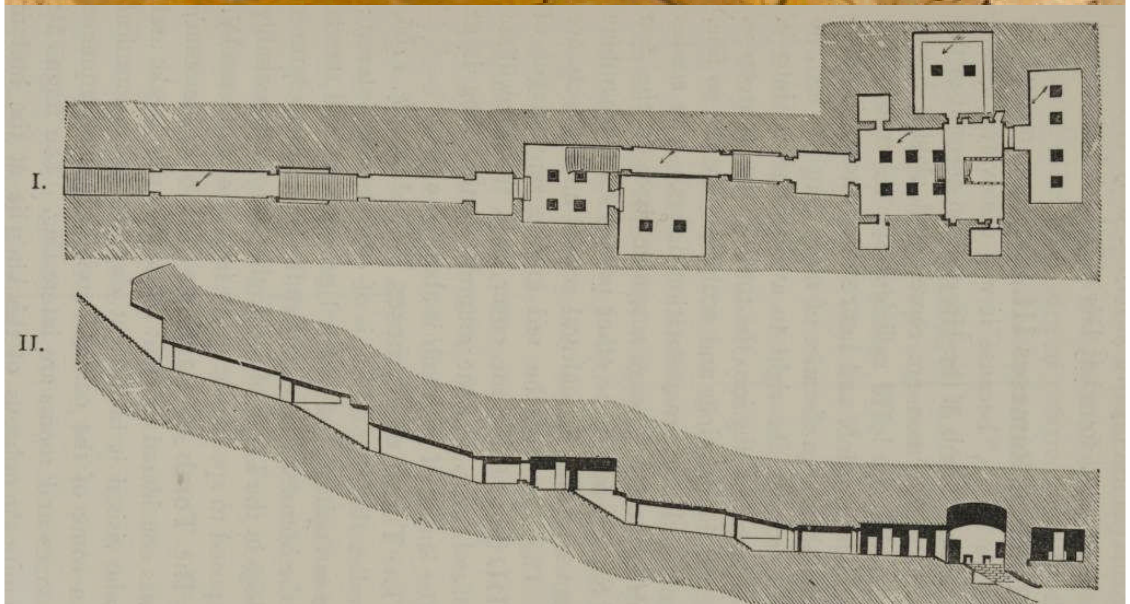

HUDSON RIVER VEHICULAR TUNNEL
MODEL OF METAL LINING 1/15 ACTUAL SIZE
EACH RING IS 29 FT. 6 IN.
IN DIAMETER.
TUBES ARE 65 FT. FROM
CENTRE TO CENTRE.
110,000 TONS OF
CAST IRON & STEEL
SEGMENTS & KEYS ARE REQUIRED.
BETHLEHEM STEEL COMPANY, INC.
WILL FURNISH 60,000 TONS OF IRON & 10,000 TONS STEEL CASTINGS.

Nothing New

"…Of course, a tunnel is no new thing. Primitive man, living close to nature, could hardly have failed to observe evid-ences of tunneling by animal life about him, and soon made tunnels for his own purposes…"

RE: excerpt from *The Eighth Wonder*

<u>Left</u>: caption: "Stone Age man created a massive network of underground tunnels criss-cro-ssing Europe from Scotland to Turkey, a new book on the ancient superhighways has claimed"



I. Ground plan of the Tomb of Seti I., B.C. 1366.
II. Section of the Tomb of Seti I.
(From Lepsius, *Denkmäler*, Abth. I., Bl. 96.)

"…We know that in ancient Egypt a king, upon ascending the throne, began at once to excavate the long narrow passage leading to the rock-hewn chamber at Thebes which was his tomb…"

RE: excerpt from *The Eighth Wonder*

<u>Top</u>: caption: "Illustration of the underground structure of ancient Egyptian Pharaoh Seti I's tomb"

<u>Bottom</u>: caption: "Ground plan and section of the Tomb of Seti I, B.C. 1366"

"…From Egypt, too, comes the first record of a sub-aqueous tunnel – constructed under the dry bed of the river Euphrates, which had been temporarily diverted from its channel. It was 12 feet wide, 15 feet high, and was lined with brick masonry…"

RE: excerpt from *The Eighth Wonder*

Left: caption: "3,000-foot-long tunnel under the Euphrates River"

"…In the time of Cesar Augustus, or perhaps even earlier, the Romans built a notable tunnel through the Posilipo hills between Naples and Pozzuoli, about 3,000 feet long and 25 feet wide. In order to light this tunnel, its floor and roof were made to converge gradually from the ends to the middle: at the entrances it was 75 feet high. The Romans were the greatest tunnel builders of antiquity…"

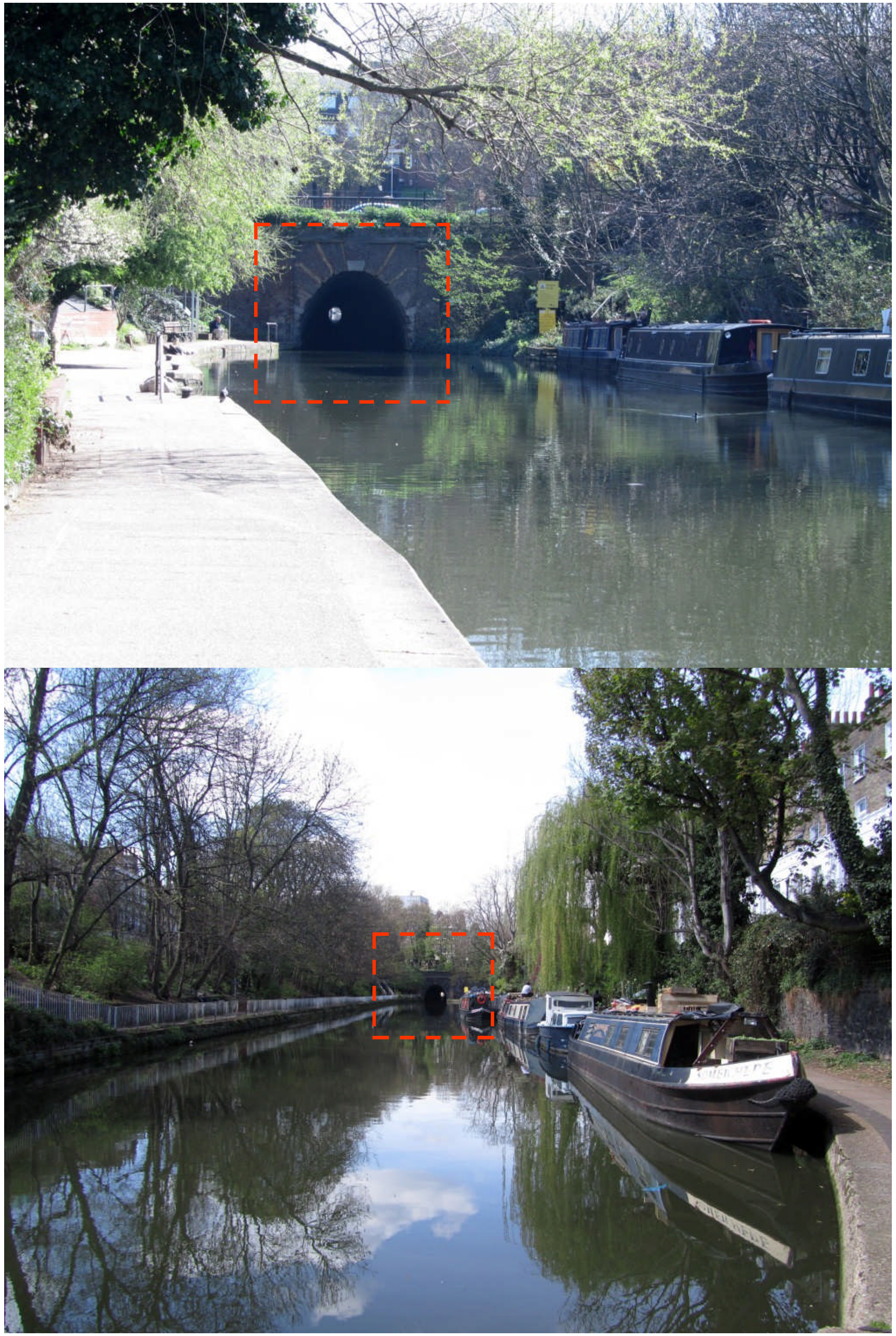
RE: excerpt from *The Eighth Wonder*

Left: caption: "1846 print titled 'Grotta di Posilipo.' Perhaps the largest tunnel in ancient times was a 4,800-foot-long, 25-foot-wide, 30-foot-high road tunnel (the Pausilippo) between Naples and Pozzuoli, executed in 36 BC."

"…During the Middle Ages, tunnel building was chiefly for military purposes. Every great castle had its private underground passage from the central tower or keep to some distant concealed place, through which to make sorties, receive supplies, or escape in time of need…"

RE: excerpt from *The Eighth Wonder*

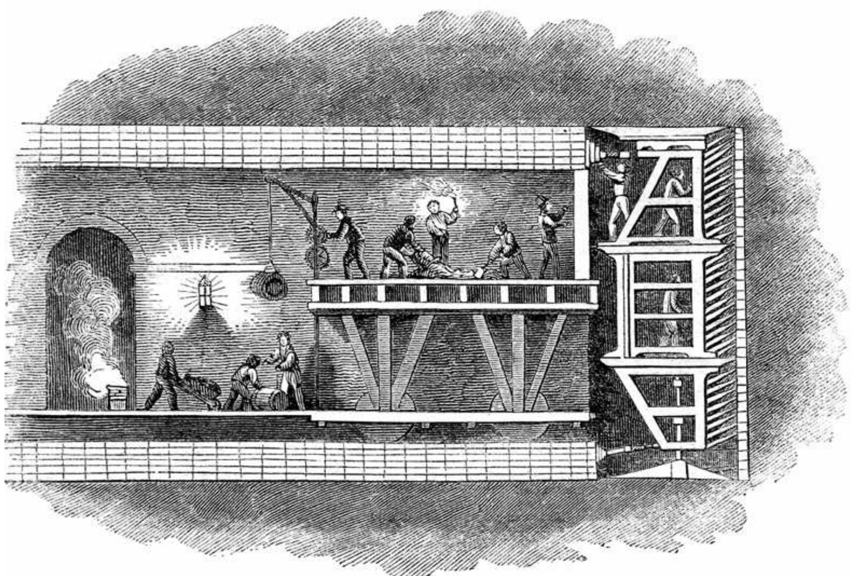
<u>Above</u>: caption: "Medieval subterranean tunnel below Dover Castle"

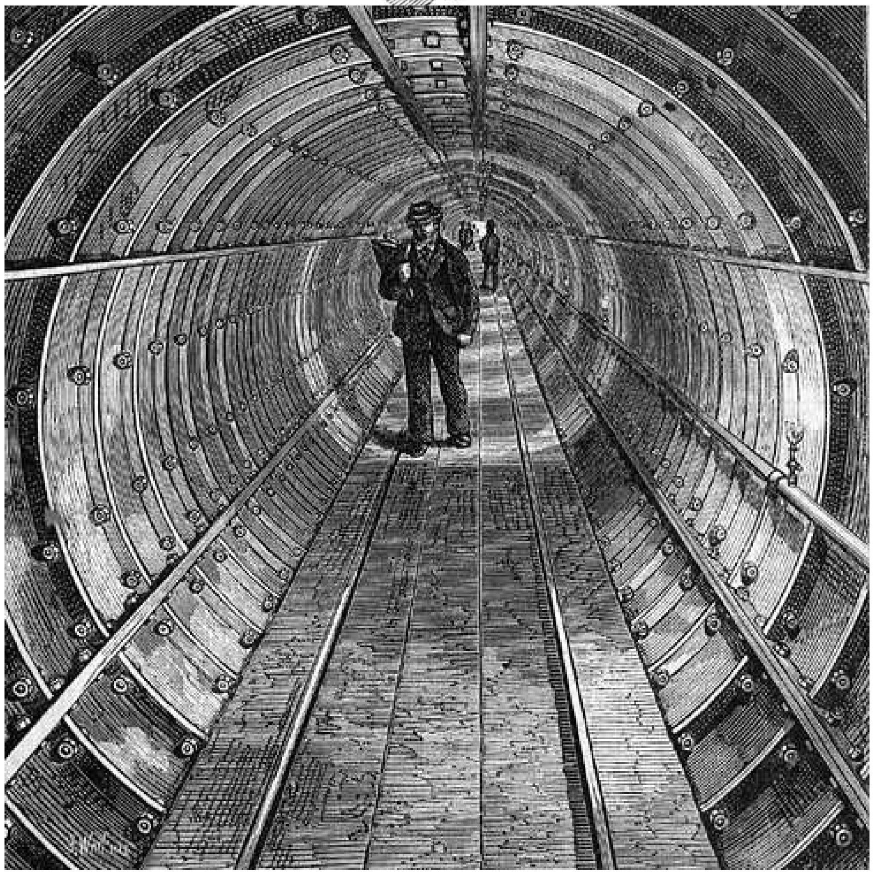


"…With the advent of gunpowder and of canal construction, a strong impetus was given to tunnel building in its more modern aspect of commercial or public utility. Previous to 1800, canal tunnels were all through rock or hard ground. Then, in 1803, a soft-ground tunnel 24 feet wide was excavated for the Saint Augustine Canal in France. Timbers were laid to support the roof and walls as fast as earth was removed, and the masonry lining built closely following. From this experience the various systems of soft-ground tunneling since employed have developed…"

RE: excerpt from *The Eighth Wonder*

<u>Left T&B</u>: caption: "Two views of the Islington Tunnel on the Regent's Canal, London"



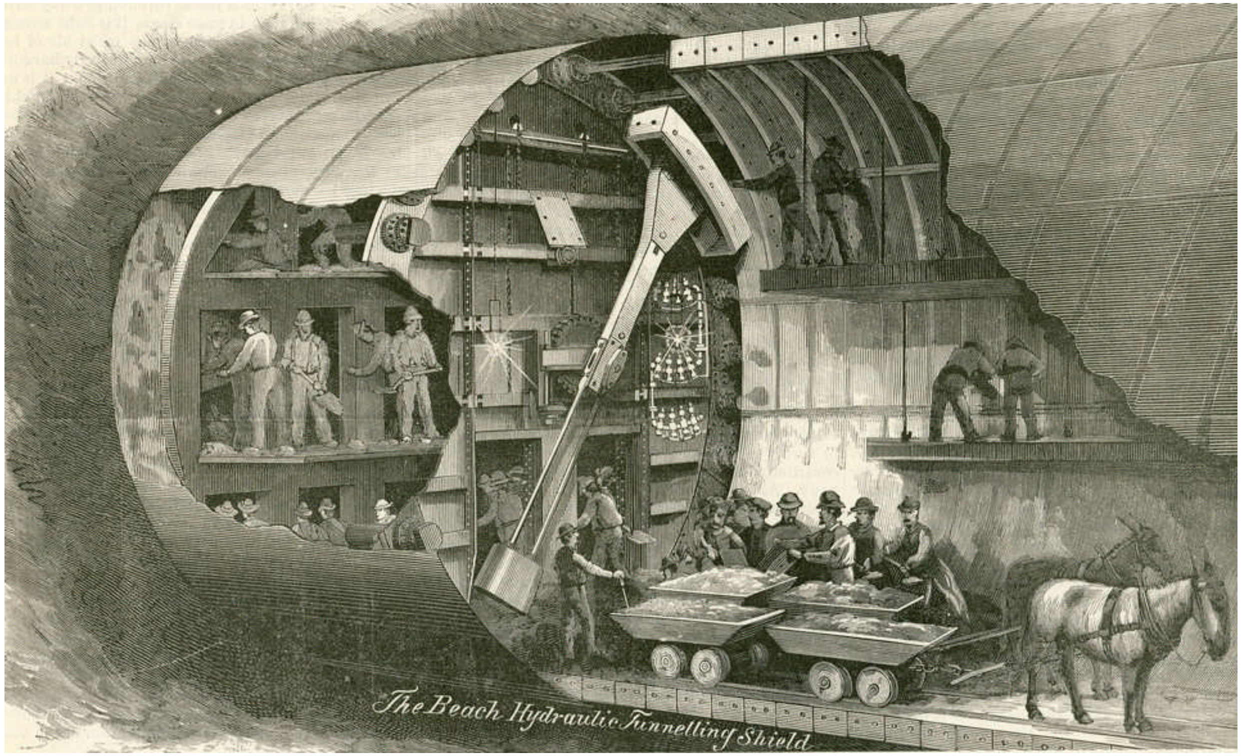


"…The use of shield and metal lining marks the greatest development in the art of soft-ground submarine tunneling. The shield was invented and first used by Sir Marc Isambard Brunel in excavating the first tunnel under the river Thames at London, begun in 1825 and opened in 1843. In 1869 Peter William Barlow used an iron lining in connection with a shield in driving the second tunnel under the Thames at London…"

RE: excerpt from *The Eighth Wonder*

<u>Top</u>: caption: "Diagram of the tunneling shield used to construct Marc Brunel's Thames Tunnel, London"

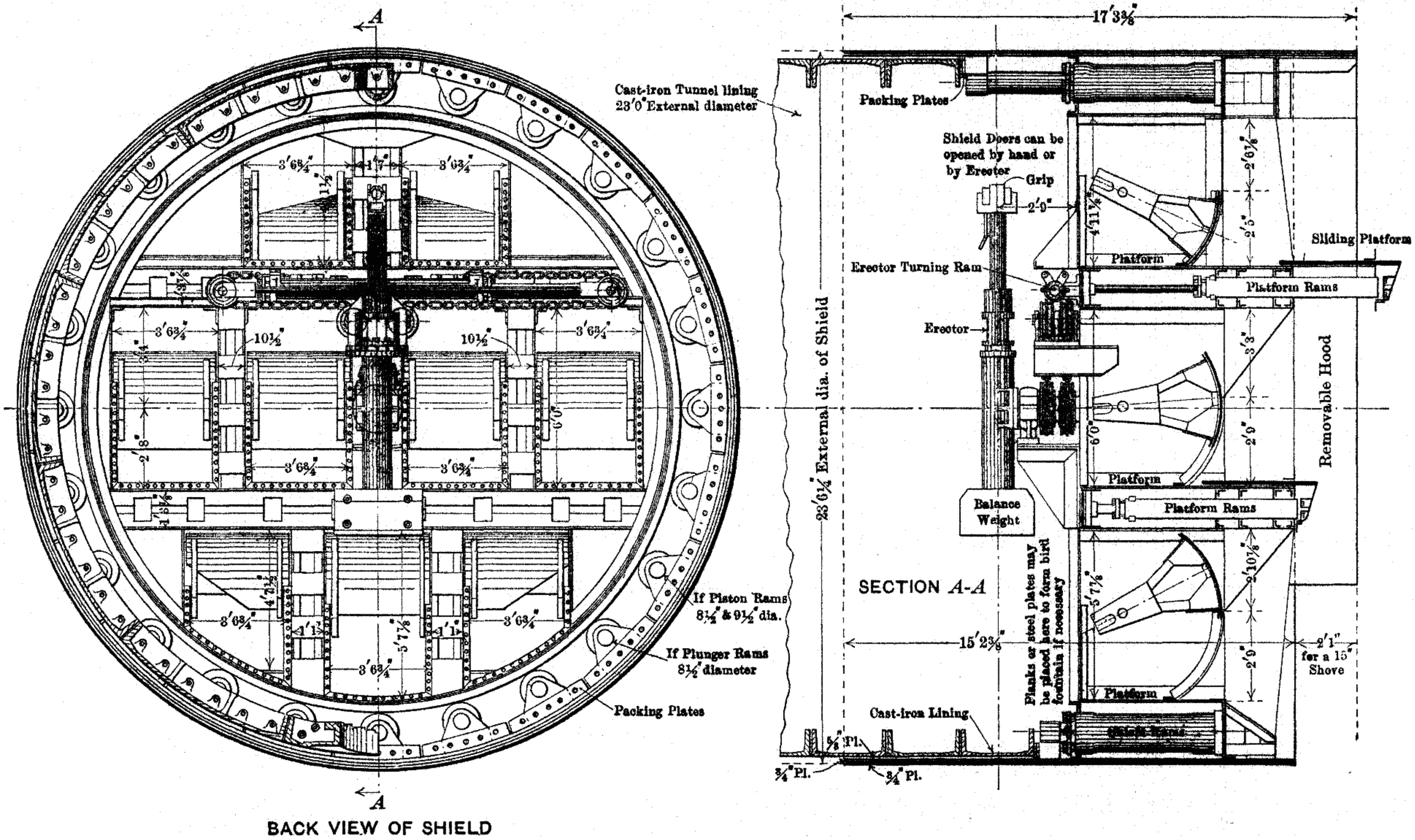
<u>Bottom</u>: caption: "In 1864 Peter Barlow patented a method of tunneling using a circular wrought iron shield and filling the gap between the tunnel's iron lining with lime or cement to prevent settling of the ground above"



"…The modern tunnel shield is a steel-plate cylinder whose forward edge acts as a cutting edge. Its rear end, extending backward, overlaps the tunnel lining of cast-iron rings. Inside the shield, hydraulic jacks act against the tunnel lining as a thrust block so as to push the shield ahead when pressure is applied. A partition prevents earth from entering the shield except as permitted through suitable openings. As the shield moves forward, the lining is erected under the protection of its rear. In submarine tunneling compressed air pumped into the forward end of the tunnel counter-balances the pressure of the water which tries to enter…"

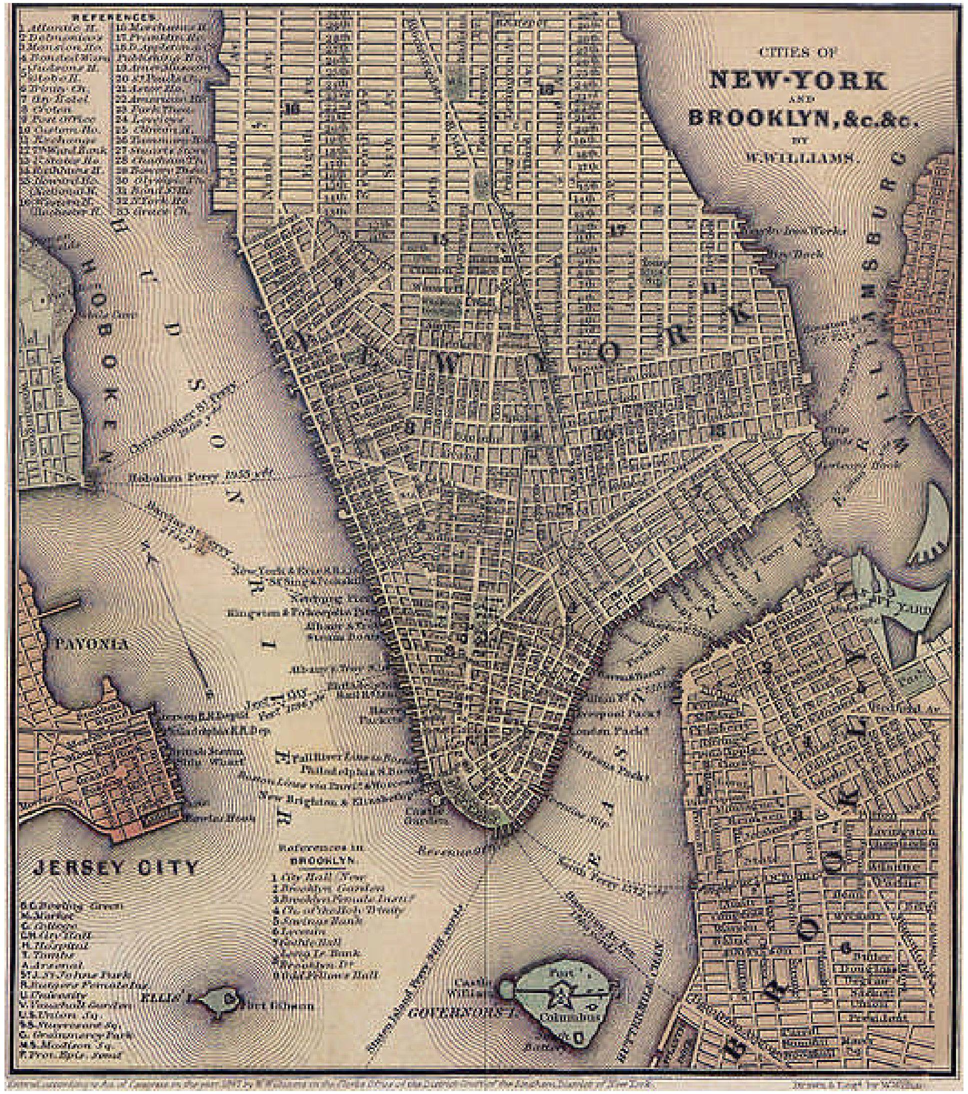
RE: excerpt from *The Eighth Wonder*

Above: caption: "The Beach Hydraulic Tunneling Shield"



<u>Above</u>: caption: "Back Elevation and Vertical Section of Hydraulic Shield"

Bridge or Tunnel?

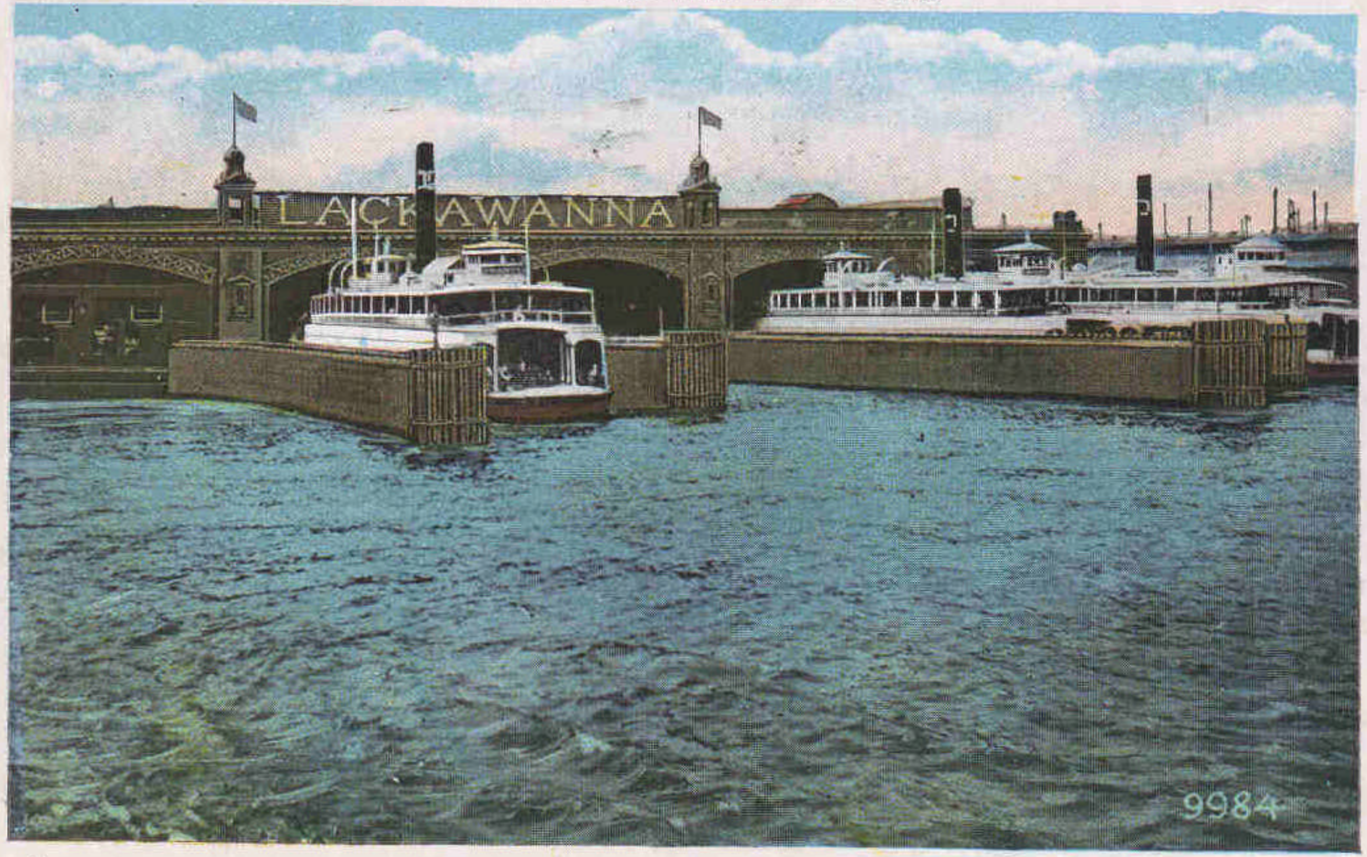


"…In 1906 the legislatures of the states of New York and New Jersey created for each state a Bridge Commission to investigate the feasibility of constructing a bridge over the Hudson River, uniting New York City with Jersey City. Legislative recognition was thus given to an increasingly vital problem – some means to supplement the ferries plying between these two ports…"

RE: excerpt from *The Eighth Wonder*

<u>Left</u>: caption: "Map of ferry service between lower Manhattan and Brooklyn on the East River, and Hoboken and Jersey City, N.J. on the Hudson River"

Lackawanna Ferries from Hoboken to New York.

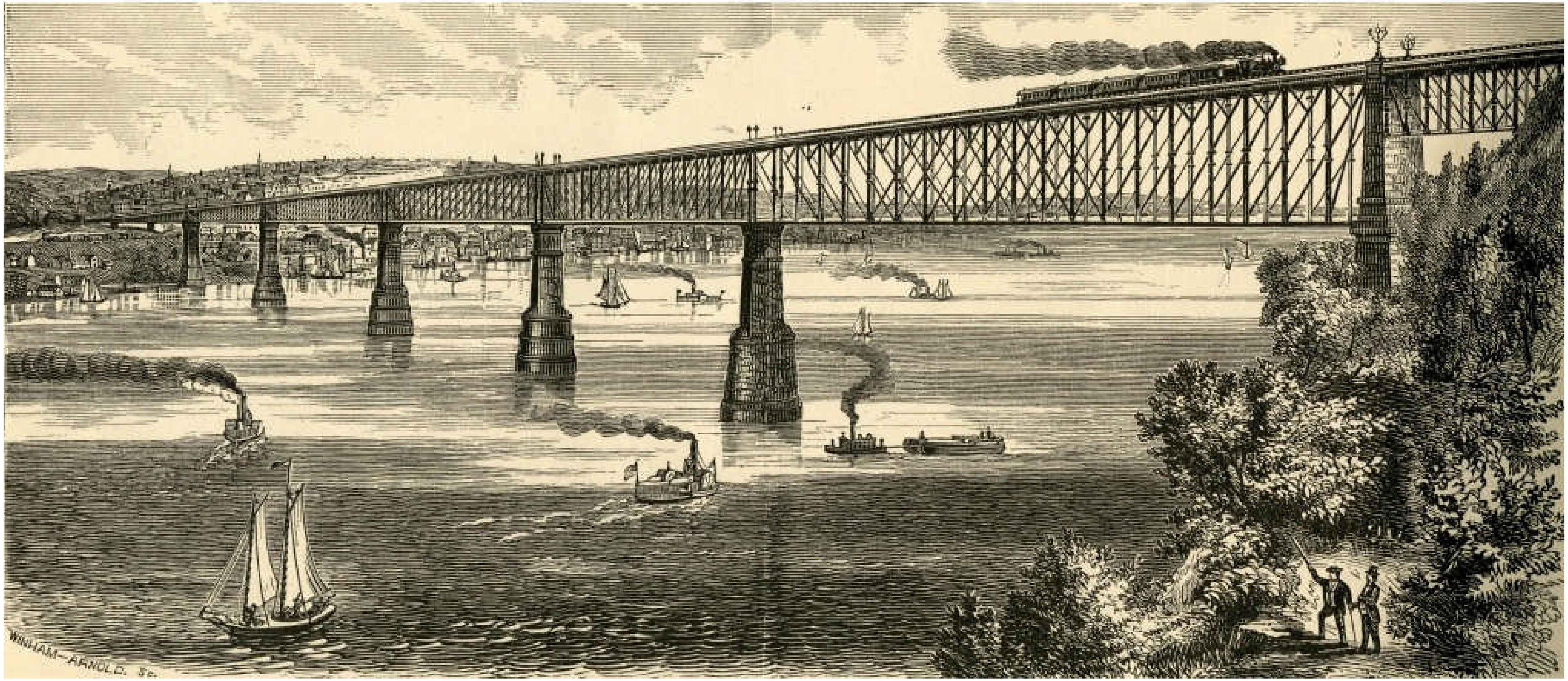


With the rapid rise of automobile and truck transport during the first decades of the *20th Century*, *Hudson River* ferries were carrying thirty million vehicles per year between *New York* and *New Jersey*. In 1906, a coalition of the *New York State Bridge and Tunnel Commission* and the *New Jersey Inter-state Bridge and Tunnel Commission* had begun feasibility studies for a bridge from lower *Manhattan* to *Jersey City, New Jersey*. However, there were drawbacks to the choice of a bridge crossing. A Hudson River bridge would require a minimum clearance of 200-feet. Since the Manhattan side of the Hudson did not meet the 200-foot elevation requirement for a bridge, long approaches (longer than that required by a tunnel) would have to be built on the New York side, consuming valuable real estate. Also, a bridge would be more vulnerable to inclement weather than a tunnel.

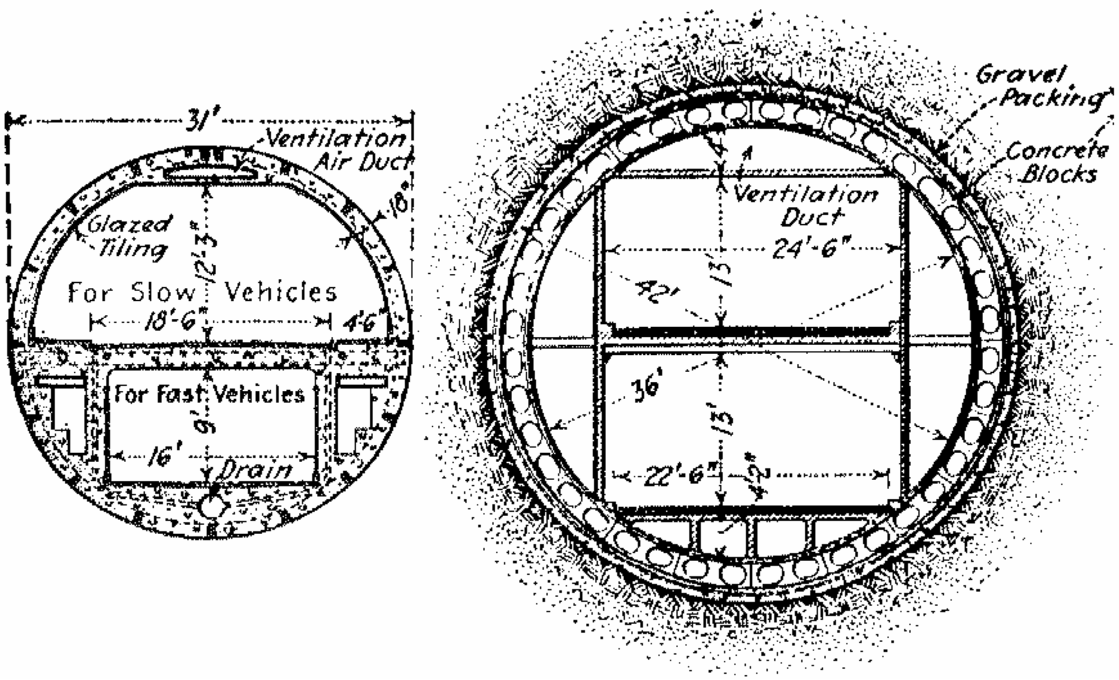
"A highway tunnel under the Hudson River at New York City, connecting the highway system of New York and New Jersey, is proposed by the Bridge and Tunnel Commissions of the two states instead of a bridge. There is but one bridge across the Hudson, south of Albany. That is at Poughkeepsie, 75 miles above New York City. The project for a bridge from Manhattan Island to the New Jersey shore has been agitated for a hundred years, but the great height at which it would have to be built to give sufficient clearance for shipping, and the value of the land that would have to be taken for terminals, would make a serviceable bridge cost $50,000,000, the commissions estimate, while a tunnel with two tubes, each having a 17-ft. roadway, could be built for $11,000,000. The average number of vehicles crossing the Hudson in ferry-boats is 19,660 per day. All but 2,000 of these cross below Twenty-third Street, and to make the highway tunnel accessible to this traffic it will have to be built below that point. A tunnel such as proposed would have a capacity of 5,000,000 vehicles a year, or about the number now crossing the river. Mechanical ventilation and means for maintaining perfect cleanliness are included in the plans."

***Popular Mechanics,* 1914**

RE: as early as 1906, the governors of the states of *New York* and *New Jersey* proposed a bridge over the *Hudson River*. That year, the governors appointed an *Interstate Bridge Commission* for the purpose of constructing one or more trans-Hudson bridges at the joint expense of the two states. Alternately, they considered vehicular tunnel below *23rd Street* as a more economical conveyance. Ultimately, in 1913, they chose a tunnel over a bridge as the first vehicular trans-Hudson crossing, but the outbreak of WWI and America's entry into the conflict (in April 1917) would delay the project.

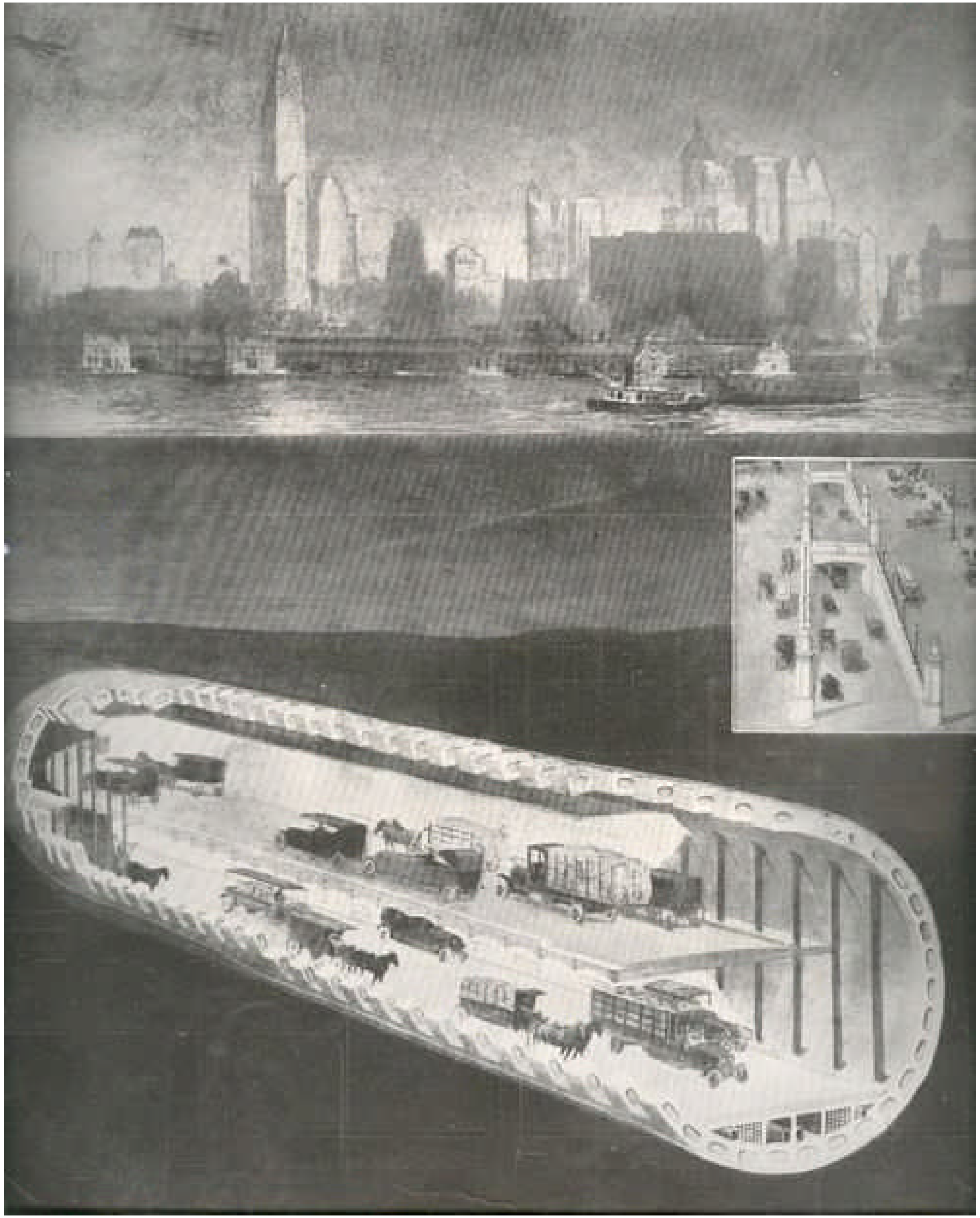


<u>Above</u>: caption: “Hudson River Bridge at Poughkeepsie, New York.” The *Poughkeepsie Highland Railroad Bridge* spans the *Hudson River* connecting *Poughkeepsie* and *Highland, New York*. Designed by *John F. O’Rourke*, it was built as a double track railroad bridge by the *Union Bridge Company* of *Pennsylvania*. Construction began in 1886 and the bridge operated from 1889 until 1974. At the time, it was the only fixed railroad crossing of the Hudson River between *New York City* and *Albany*, providing freight trains a more direct route between *New England* and the *Midwest*. Today, the bridge is operated by the *New York State Historic Park System* and is open to pedestrian and bicycle traffic only.



Two proposals were initially floated for the "Hudson River Vehicular Tunnel" (a.k.a. "Canal Street Tunnel"). The first proposal, presented by the firm of *Jacobs & Davies*, called for a bi-level tunnel measuring 31-feet in diameter. The upper level, which was to carry slower vehicles, was to have an 18-foot-wide roadway and a clearance of 12-feet, flanked by sidewalks 4-feet wide. The lower level (to be reserved for express vehicles) was to have a 16-foot-wide roadway and a nine-foot clearance. Both levels were to carry two-way traffic. The second proposal, presented by army engineer *George Goethals,* was a bi-level design measuring 42-feet in diameter. Each level was to carry opposing lanes of traffic, two lanes in each direction. The roadway was to measure 23-feet wide and was to have 13-feet of clearance.

<u>Above</u>: caption: "Two unrealized proposals for Hudson River vehicular tunnels, by the firm of Jacob & Davies in 1910 (left) and by O'Rourke & Goethals in 1919"



<u>**Left**</u>**: caption: "Image from *The Illustrated London News* (5 April 1919) presents a cross-section of a proposed Hudson River tunnel connecting the Jersey City and New York City"**

"…Further legislation, enacted from time to time, continued the life of these Commissions. In 1913 they were authorized to consider the possibility of a vehicular tunnel. Finally, on April 10, 1919, authority was granted them to proceed with the construction of a tunnel, or tunnels, between a point in the vicinity of Canal Street on the island of Manhattan and a point in Jersey City…"

RE: excerpt from *The Eighth Wonder*

Left: caption: "Hudson River Vehicular Tunnel"

"…Those who had the project closest at heart felt that the tunnel would:

1. ***Shorten the time of transit across the Hudson River and afford a continuous means of communication between New York and New Jersey, unaffected by climatic or other interference;***
2. ***Relieve traffic congestion, already serious;***
3. ***Accelerate the movement of necessary supplies into the city of New York, and thereby relieve conditions of distress;***
4. ***Increase the tax value of real property within a considerable radius of the tunnel terminals;***
5. ***Pay its cost three times over within twenty years;***
6. ***Reduce the high cost of living by reducing the cost of trucking;***
7. ***Increase the facilities of commerce in the port of New York by removing from the surface of the harbor many lighters and other floating equipment, and;***
8. ***Furnish means for the uninterrupted movement of troops and supplies to and from the city of New York in case of need.***

RE: excerpt from *The Eighth Wonder*

<u>Above</u>: caption: “The signing of the Interstate Treaty between the New York State Bridge & Tunnel Commission, representing the State of New York, and the New Jersey Interstate Bridge & Tunnel Commission, representing the State of New Jersey, for the construction of the Hudson River Vehicular Tunnel, at the office of the Commissions in the Hall of Records, New York City, on December 30, 1919.”

Coal Famine

"…was due almost entirely to the city's inability because of the ice-choked river to transport thousands of tons of coal that were literally in sight on the other side of the river, and yet as unattainable as if they were still in the mines"

Lt. Col. *George Goethals*

RE: the "coal famine" during the winter of 1918 in NYC

"A rising temperature yesterday brought no general relief in the desperate coal situation in New York. County Fuel Administrator Schley estimated that about 25,000 tons were brought in – a bit more than half of the normal consumption of the city. To make matters worse, the Weather Bureau at Washington sent out a storm warning last night, predicting a heavy snowfall here today or tomorrow, which may tie up all lines of land transportation. Each day draws New York closer to an absolute coal famine and makes the situation more serious. It developed yesterday that a large portion of the thousands of tons of coal said to be nearing the city was bunker coal, and entirely unfitted for the use of anything but ships…Kill von Kull, the main waterway by which coal reaches the city, was blocked again last night by heavy ice floes, after remaining open for only twenty-four hours. Tugs are trying to clear it…"

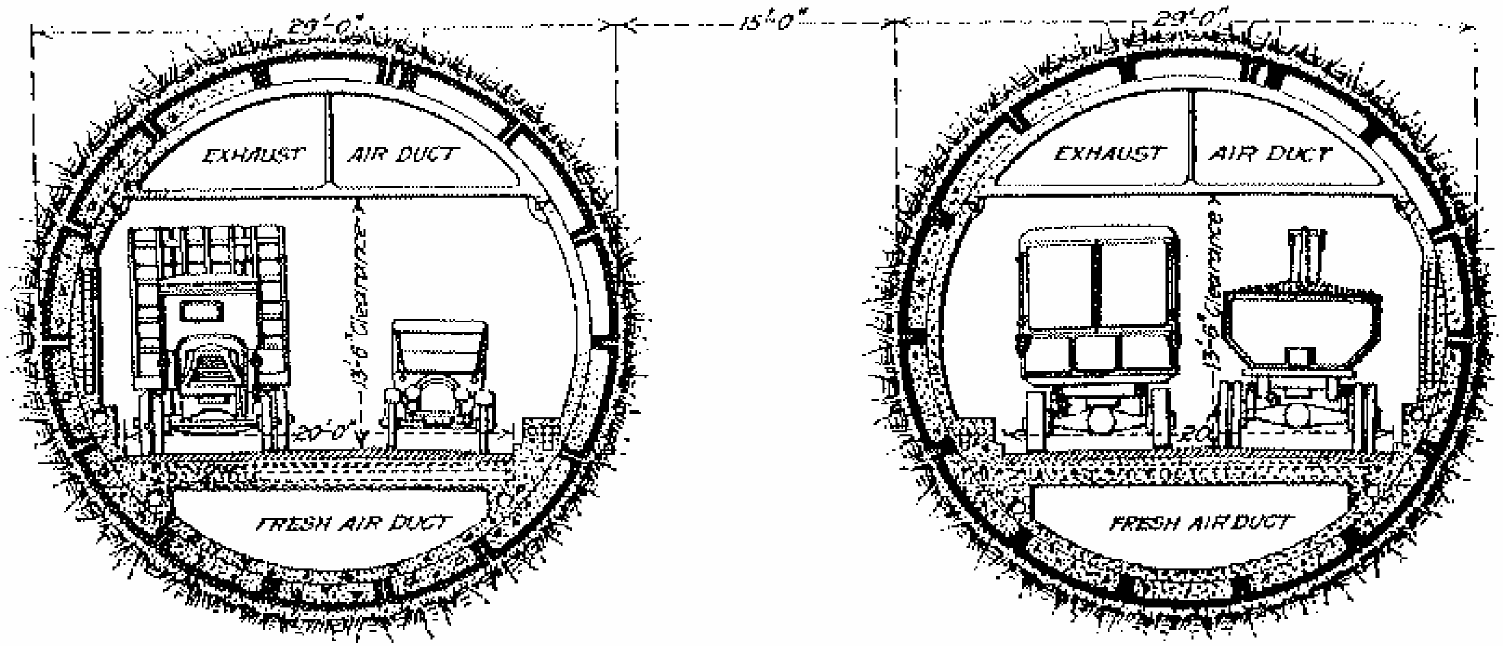
New York Tribune, **January 6th 1918**

<u>Left</u>: caption: "Ice-breakers in the Hudson"

“…Mayor Hylan, who has been vitally interested in the coal famine since entering office…yesterday undertook a personal tour of inspection to look for coal hoards…The Police Department, on orders from Mayor Hylan, yesterday began taking a coal census, making a house to house canvass to learn if there were any domestic reserves that could be drawn on to tide the poor over the coal shortage…At the end of a strenuous day, the police had collected and distributed 386 tons of coal and six loads of wood to 3,082 families that had no fuel…”

***New York Tribune*, January 6th 1918**

Chief Engineer



"When Clifford M. Holland talks tunnels, his listener is in danger of being convinced that tunnels are the only refuge for mankind; by the time he has finished his hearer sees in a tunnel all the allurement which a mole finds in a nicely constructed borrow. Because Mr. Holland does know tunnels, and he does build them safely."

***Brooklyn Daily Eagle,* February 19th 1920**

Above: caption: "Clifford Holland's design for a Hudson River vehicular tunnel made up of twin tubes." Holland's ventilated twin-tube design was selected to be built by the NY/NJ Commission/s in 1919.

"…The Commissions selected as chief engineer Mr. Clifford M. Holland, tunnel engineer of the Public Service commission, First District, State of New York, in immediate charge of the construction of all subway tunnels under the East River. He was regarded as having had a greater and more successful experience in the work of the sub-aqueous tunnel construction than any other member of his profession. A board of consulting engineers was appointed, and a contract or treaty between the two states was drawn up and approved by the Commissions and given the consent of Congress…"

RE: excerpt from *The Eighth Wonder*

Left: *Clifford M. Holland*, Chief Engineer. Holland gathered a team of experts from the *U.S. Bureau of Mines* (USBM), *Yale University* and the *University of Illinois* to design the world's first ventilated vehicular tunnel. *Ole Singstad* (who completed the tunnel and later went on to design the *Lincoln, Queens-Midtown* and *Brooklyn-Battery Tunnel/s*) led the design team.

"…Chief Engineer Holland took office on July 1, 1919, and at once began the organization of an engineering staff. His chief assistants were selected from those who had been associated with him in the construction of the East River subway tunnels. Having had not less than ten years' experience in sub-aqueous tunneling, they were well qualified both by technical training and by practical experience to meet the requirements of the work. Actual construction began October 12, 1920…"

RE: excerpt from *The Eighth Wonder*

The Martyr Engineer

“Things broke well for me: the choice of engineering, the good school, the right years – when work was booming, the perfect place – New York, the lucky first job – subway shafts to Brooklyn, then my life’s pinnacle and purpose – the great tunnel to New Jersey, and my wife, noble, strong. She knew what the project meant to me and the city.”

Clifford M. Holland, **Chief Engineer**

RE: when 41yo Clifford Holland died of exhaustion and heart failure on October 27th 1924 – before the completion of “the great tunnel to New Jersey” – he was eulogized on the press as the “martyr engineer” for his heroics and dedication. He was also acclaimed as “the most noted tunnel builder in the world” and the engineer of the “eighth wonder of the world.” Within two weeks of his death, the project was named in his honor: *Holland Tunnel*. In 1999, *Engineering News Record* (ENR) honored him as one of the ten most outstanding “Landmark Project Engineers” of the last 125 years. Born on March 13th 1883 to an old *New England* family, he told his high school classmates he was going to be a “tunnel man.” To that end, he entered Harvard University’s engineering program in 1902, earning his B.S. in *Civil Engineering* in 1906.

"If I had known it was tapping his strength so much, I would have urged him to be more careful, but he was so completely wrapped up in his work that I really do not know if any pleadings would have had any effect"

RE: comments made by the wife of Chief Engineer *Clifford M. Holland* upon his tragic death from nervous exhaustion at the age of 41

Above: caption: "Clifford Milburn Holland, 1919"

The Holland Tunnel

At Stated Meetings of the **New York State Bridge** and **Tunnel Commission** and the **New Jersey Interstate Bridge** and **Tunnel Commission** held Tuesday, November twelfth, nineteen hundred and twenty-four, the following resolution was adopted.

Whereas the untimely death on October twenty seventh, nineteen hundred twenty four of

Clifford Milburn Holland
Chief Engineer in the Construction
of the Hudson River Vehicular Tunnel

has caused a general expression of sorrow; and

Whereas, by comment in the public press as by resolutions of public bodies and societies and expressions from leading citizens and civic organizations, the opinion is general that Mr. Holland gave his life to the work of the planning and construction of this great public utility; and

Whereas, the members of the New York State Bridge and Tunnel Commission and the New Jersey Interstate Bridge and Tunnel Commission are in accord with the widespread suggestion that some fitting attribute be paid to the memory of the deceased Engineer; Therefore be it

Resolved, that the **Hudson River Vehicular Tunnel,** now being constructed between Canal and Broome Streets in the Borough of Manhattan, City of New York, and 12th and 14th Streets, Jersey City, New Jersey, be and it is hereby dedicated to the memory of Clifford Milburn Holland, and that the said Hudson River Vehicular Tunnel is hereby designated and named as

The Holland Tunnel

"…Upon the death of Mr. Holland on October 27, 1924, at Battle Creek Sanitarium, where he had gone in search of health after devoting all his strength and energy to the construction of the tunnel, the Commissions gave it his name. Under his direction all the more difficult portions had been completed and the remaining details planned, and on the very day his body was borne to his home there came a demonstration of his engineering skill and accuracy in the successful junction of the under-river headings of the north tunnel…"

RE: excerpt from *The Eighth Wonder*

<u>Left</u>: caption: "Contract No. 3. North Tunnel - New York and New Jersey shields - Upper cutting edges meeting. 12/28/24"

The Head Mole

Clifford Milburn Holland **devoted his life to the construction of tunnels under waterways in and around *New York City*. Holland's first engineering job was as tunnel engineer for New York City's *Public Service Commission*, which was then constructing the first New York Subway (IRT). In 1919, at the age of 36, he was appointed chief engineer on the project to connect *New York* and *New Jersey* by way of a tunnel under the *Hudson River*. He was a natural choice for the job, having successfully overseen several tunnels under NYC's *East River*, including the *Old Slip-Clark Street Tunnel* and the *Whitehall-Montague Street Tunnel*. Holland spent so much time directly overseeing the work on the tunnel named in his honor after his death that newspaper reporters began to refer to him as "the Head Mole." Despite having had a weak heart since childhood, he endured compression and decompression several times a day as he descended into the tunnel and returned to the surface. By October 1924, he was suffering from what was termed "nervous exhaustion" and retreated to a sanitarium for a rest cure. Two weeks later, his heart failed and he died just before the two headings of the north tunnel met.**

“Another Engineer Dies on Big Tunnel Job; M.H. Freeman Is Victim of Acute Pneumonia

Milton H. Freeman, chief engineer of the New York and New Jersey Vehicular Tunnel, died at 10 o’clock on Tuesday night at his home in Valhalla, N.Y., of acute pneumonia. Mr. Freeman succeeded Clifford M. Holland as chief engineer when the latter died on Oct. 27 last.”

***New York Times*, March 26th 1925**

"…His successor, Mr. Milton H. Freeman, had been his Division Engineer. He, too, gave himself unsparingly to the work, and died on March 24, 1925. He was succeeded by Mr. Ole Singstad, who had been Engineer of Design under both Mr. Holland and Mr. Freeman. Under his direction the Holland Tunnel has been completed…"

RE: excerpt from *The Eighth Wonder*

<u>Left</u>: caption: "Ole Singstad, Chief Engineer. Under whose direction the Holland Tunnel was brought to successful completion."

"…Oddly enough, Ole Singstad began his career above ground - designing bridges. That was back in 1905, the year he arrived in the United States from his native Norway. He was virtually penniless but the engineering degree he had won before at the Polytechnic Institute of Trondheim landed him a job with the Central Railroad of New Jersey. He worked for several other railroads after that but in 1909 embarked on his mole-like profession as a designer for the Hudson River tunnels of the Hudson Manhattan Railroad in New York. There followed similar work on the I.R.T. subway tubes under the East River and then, in 1919, he got his first big break with the Holland Tunnel project…"

***Mechanix Illustrated,* June 1941**

Part 2

All Things Considered

Location, Location, Location

"…The Holland Tunnel is located in the vicinity of Canal Street, New York City, because that street is a wide east and west thoroughfare giving direct communication across the island of Manhattan. On the east, Canal Street connects with the East River bridges and Brooklyn; on the west, with the Hudson River water front, at approximately the center of downtown traffic over the Hudson ferries…"

RE: excerpt from *The Eighth Wonder*

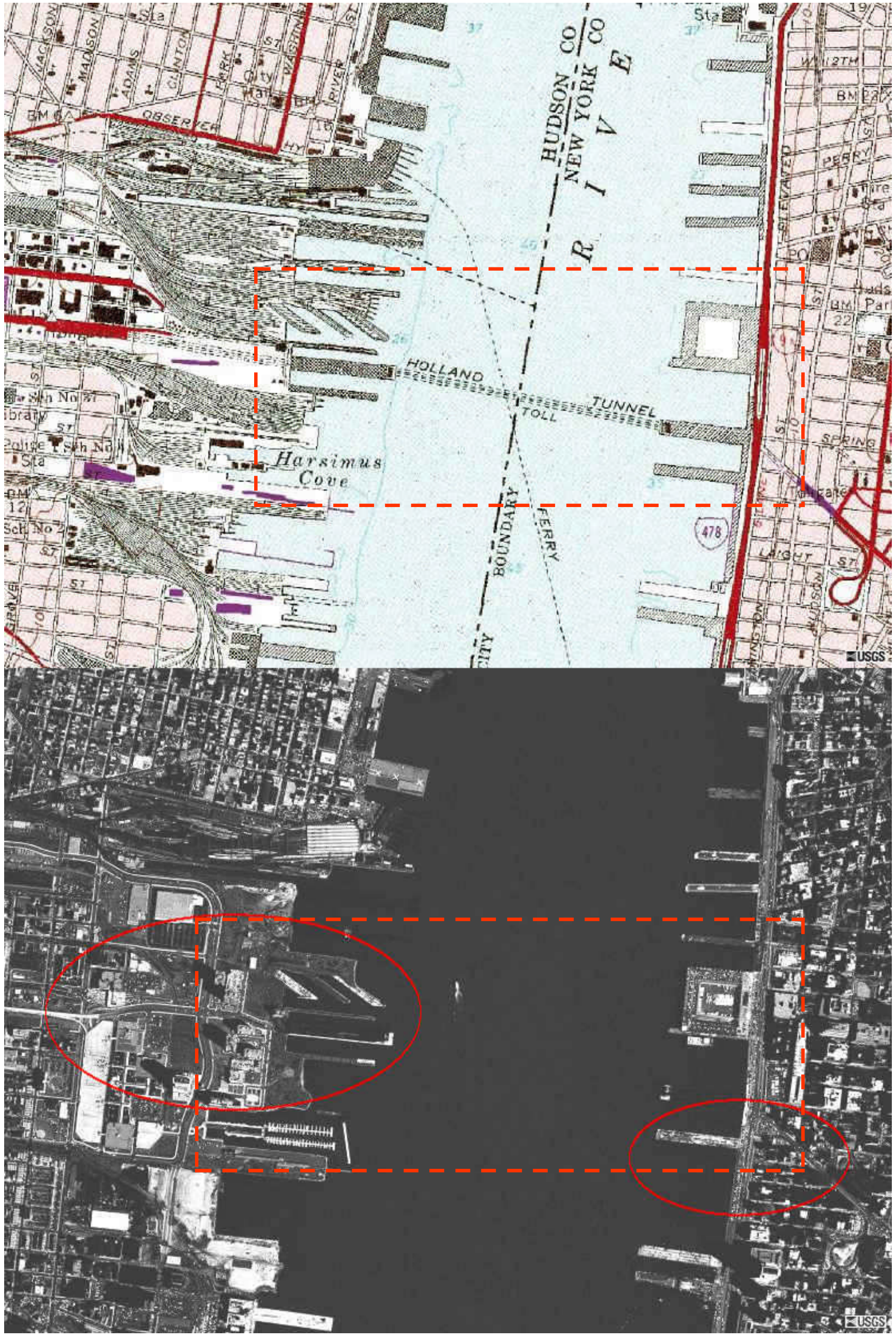
<u>Above</u>: caption: "Site of the Holland Tunnel, looking west from New York City"

"…Its location in Jersey City is at the logical point as nearly opposite Canal Street as is practicable, in order to obtain the shortest tunnel. This point is very near the center of traffic and is advantageously located. It gives direct communication to Jersey City Heights and points beyond by means of the Thirteenth Street Viaduct. The water front, with important railroad yards, is easily accessible and adequate communication is afforded with the low-lying parts of Jersey City and Hoboken through streets which parallel the river…"

RE: excerpt from *The Eighth Wonder*

<u>Left</u>: caption: "Aerial photograph of tunnel site, looking East from New Jersey 4/4/23" 51

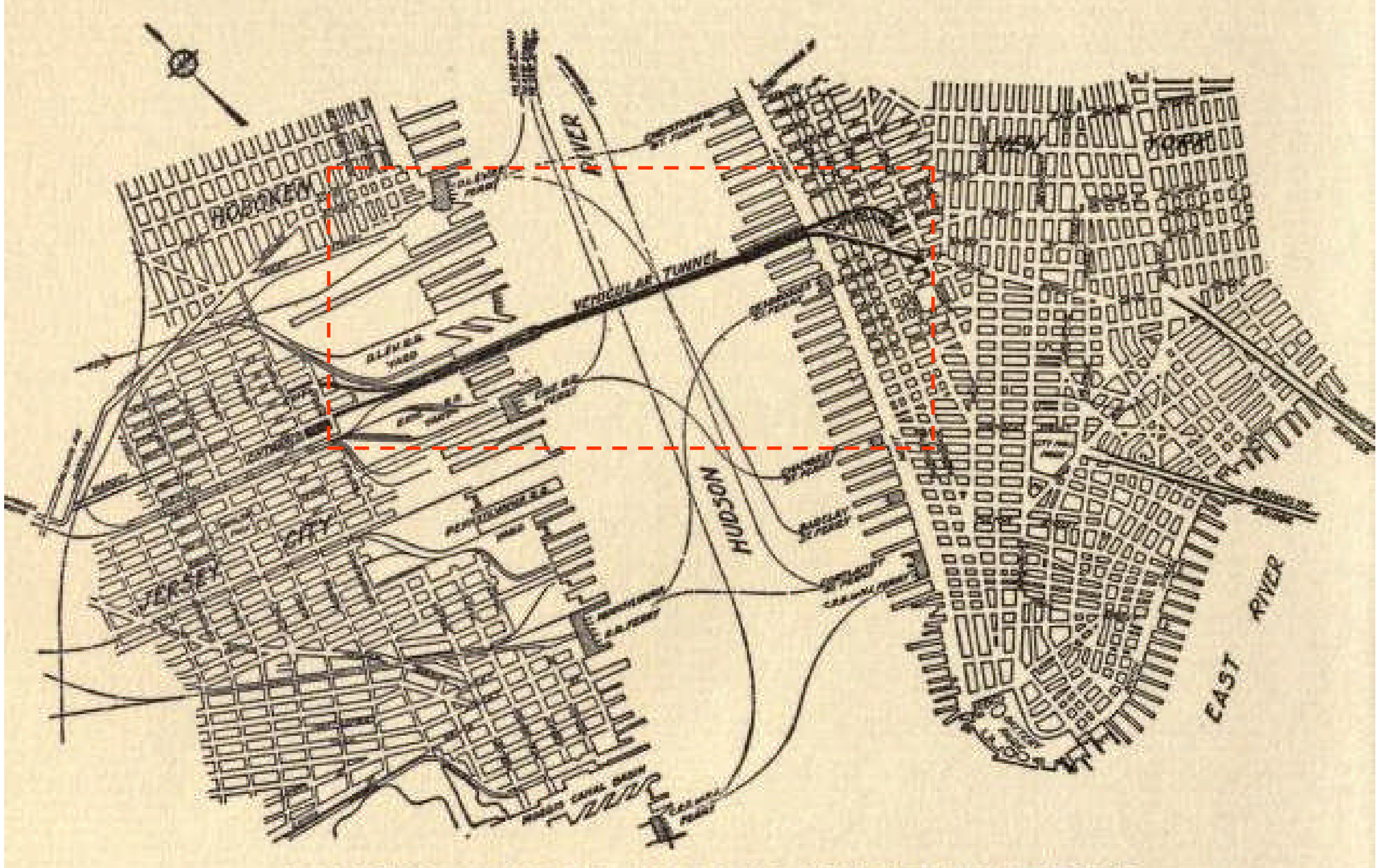
<u>Right</u>: caption: "The original two-way viaduct to the Holland Tunnel"



"…The southerly tube for east-bound traffic extends from Provost and Twelfth Streets, Jersey City, under the Erie Railroad yards, the Hudson River, and Canal Street to Varick Street, New York City. The northerly tube for westbound traffic extends from Broome Street mid-way between Varick and Hudson Streets and under Hudson Street and the Hudson River, the Erie, and the Delaware, Lackawanna and Western Railroad yards to Four-teenth Street at Provost Street, Jersey City…"

RE: excerpt from *The Eighth Wonder*

<u>Left</u>: caption: "Aerial Photograph and corresponding location map of Holland Tunnel Hudson River crossing between Manhattan and Hudson County, New Jersey"



LOCATION PLAN OF HOLLAND VEHICULAR TUNNEL

“…In planning a public undertaking of the magnitude of the Holland Tunnel, consideration had to be given to many features besides those of actually tunneling. The building of the structure itself was a great engineering problem, but many investigations beyond mere technical design were required…”

RE: excerpt from *The Eighth Wonder*

"…To secure the best location and arrangement of tunnel roadways, a survey of present and future traffic and the influence of the tunnel on the development of adjacent territory was called for, first of all. Traffic conditions had to be considered from many angles, such as capacity, congestion of the tunnel roadway, adequate approaches, congestion in adjoining streets, width of roadway, and the growth and development of vehicular traffic. A preliminary forecast of tunnel traffic, based chiefly on the yearly increase in traffic over the Hudson ferries, resulted in an estimate of the number of vehicles that would use the tunnel as follows:

- ***1924 (when tunnel was expected to be opened) 5,610,000***
- ***1935 . . . . 13,800,000***
- ***1937 . . . . 15,700,000***
- ***1943 . . . . 22,300,000***

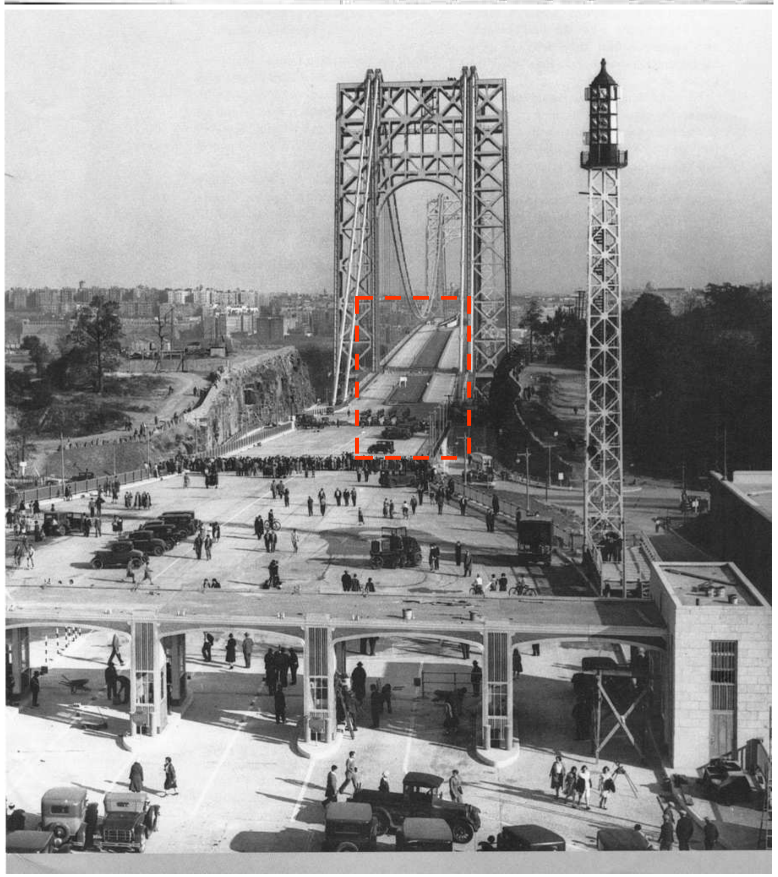
Further estimates indicated that a one-line tunnel would have a capacity about equal to the traffic demand at the opening of the tunnel. A two-line tunnel would have sufficient capacity to accommodate all traffic up to 1937, while a three-line tunnel would reach its capacity in 1943…"

RE: excerpt from *The Eighth Wonder*

Cost Effective

"…Obviously it would be unwise to construct a one-line tunnel whose capacity would be reached as soon as put in operations. As between a two-line and a three-line tunnel, it was found that the difference in cost, with interest, would be sufficient to pay for another two-line tunnel after the first two-line tunnel had outgrown its capacity. Of greater importance was the consideration that no street or section could accommodate the volume of traffic represented by a three-line tunnel. If a three-line tunnel was built, it could be operated at only two-line capacity. This would violate two of the main principles governing proper tunnel planning – the distribution of traffic so as to avoid undue congestion, and the investment of capital for construction only as facilities are needed, without the necessity of providing for the distant future. These are two of the most important features in which tunnel construction is held to be superior to bridge construction in crossing wide, navigable rivers…"

RE: excerpt from *The Eighth Wonder*



"…The cost of a long-span bridge does not vary directly with the span but increases about as the square of the span. On such a bridge no commensurate saving in the cost of con-struction is obtained by omitting some of its facilities. The tendency in bridge construction, therefore, is to provide facilities greatly in excess of immediate requirements, with a con-sequent expenditure of capital long before those facilities are needed. Then when there is sufficient traffic to utilize the bridge to full capacity, the resulting congestion in the vicinity of the bridge entrances becomes a serious matter. This is seen in the case of the East River bridges in New York City today…"

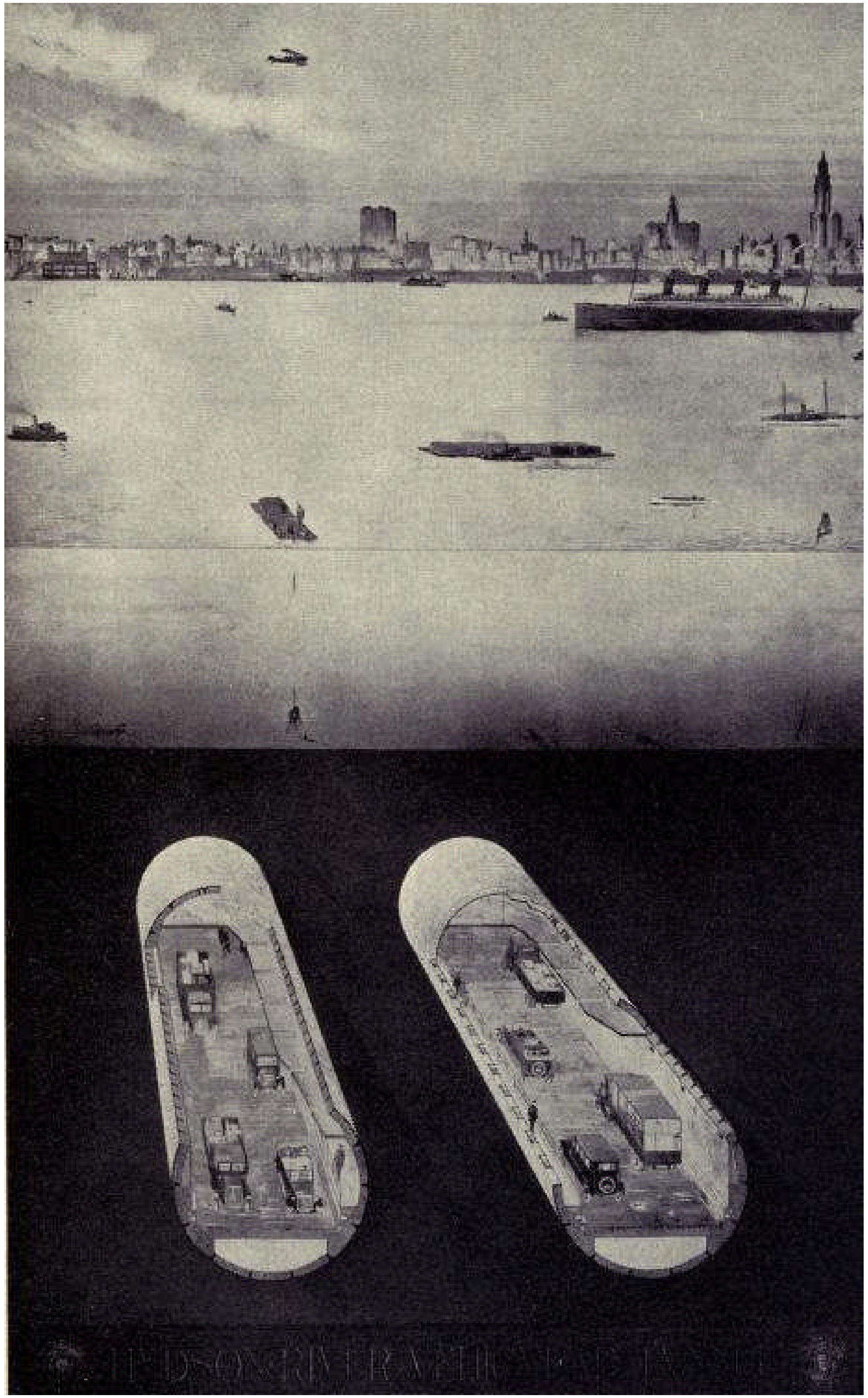
RE: excerpt from *The Eighth Wonder*

<u>Left T&B</u>: when the *George Washington Bridge* opened on October 25th 1931, it included only an upper deck with six traffic lanes. The center two lanes were left as open grating to be added when demand increased. With the post-war boom in automobile ownership, traffic increased dramatically and these two lanes were added in 1946. From 1959 to 1962, the lower level was added, opening to traffic on August 29th 1962.

On the Other Hand…

"…Tunnel construction, on the other hand, is more flexible than bridge construction, because the cost is a direct function of its length, with the volume of excavation increasing as a square of the diameter. Since the cost of excavation represents a large part of the total cost of a tunnel, any increase in the width of the roadway can be made only at considerable expense. The proper way to plan a tunnel is to avoid the disadvantages inherent in bridge construction, build only for the present and near future, and construct other tunnels at other locations when the facilities of the first tunnel are outgrown…"

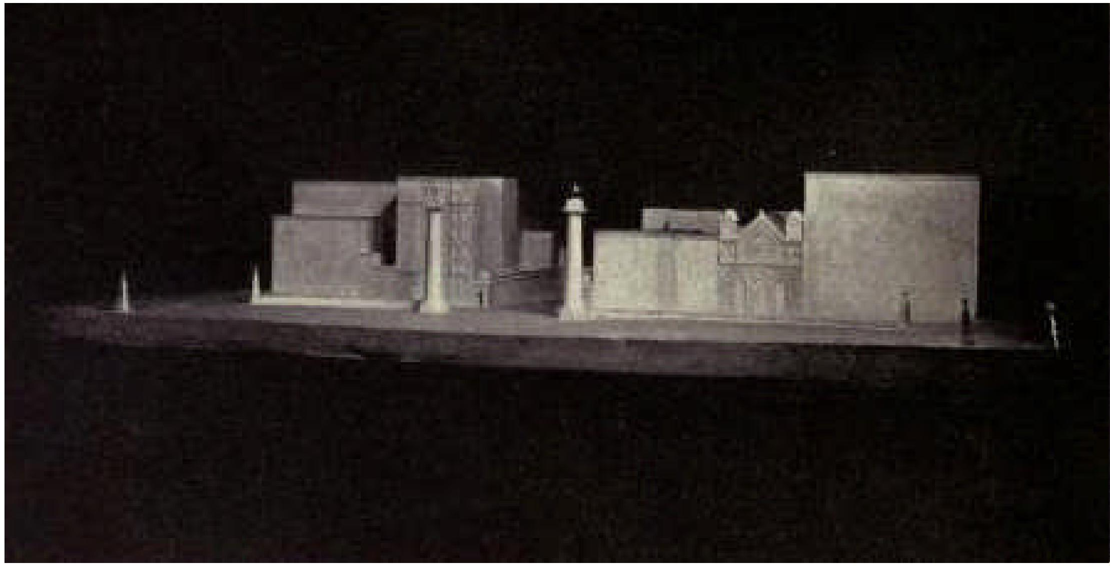
RE: excerpt from *The Eighth Wonder*

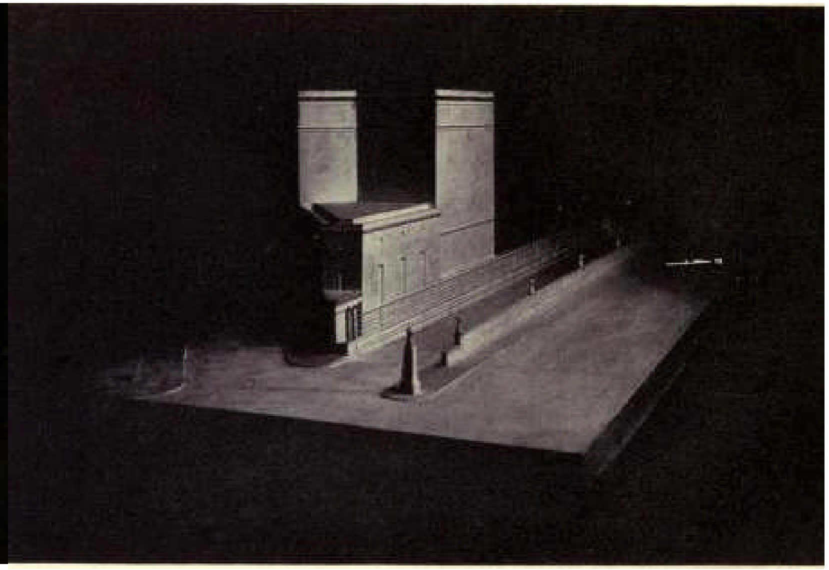


"…Since a two-line tunnel would have sufficient capacity to accommodate traffic up to 1937, and a three-line tunnel would create such traffic congestion in the vicinity of its entrances and exits as to preclude its use to capacity; also since the difference in cost between a two-line and a three-line tunnel, with interest, would pay for a new two-line tunnel when the first was outgrown, the obvious proceeding was to construct a two-line tunnel at some other location as determined by future traffic conditions. The Holland Tunnel is, therefore, a twin-tube tunnel, providing in each tube for two lines of traffic in each direction…"

RE: excerpt from *The Eighth Wonder*

<u>Left</u>: caption: "Sectional View of Holland Tunnel – under the Hudson River - looking toward New York City"



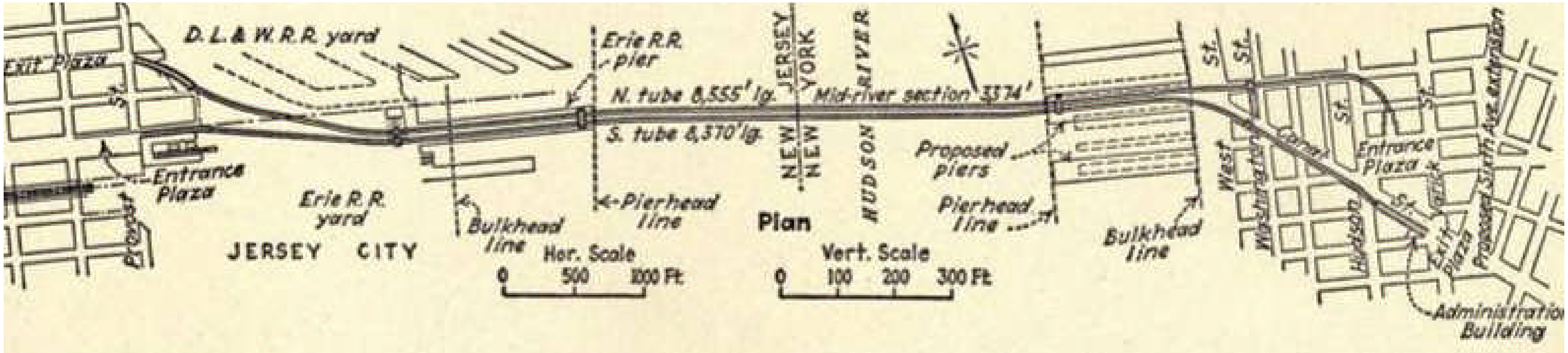


"…In planning the entrances and exits of the tunnel, a careful study was made of vehicular traffic, with particular reference to its movement at street intersections and through the tunnel. It was recognized that wherever traffic intersects, its continuity is broken. Instead of moving in a steady stream, it breaks into a series of waves as it is held up and released at intersections. This interruption in the stream of traffic at street intersections so limits the capacity of a street that its real capacity as determined by its width is never reached…"

RE: excerpt from *The Eighth Wonder*

Left: caption: "Model of Entrance to Tunnel, New York City. Looking north-northwest across entrance plaza which comprises north half of block between Broome and Watts Streets"

Right: caption: "Model of Exit from Tunnel, New York City. Looking north-west along canal Street"



"…A tunnel differs from a street in that the only interruptions by cross traffic are at the entrances and exits. Consequently these points are of vital importance, affecting as they do the ultimate capacity of the tunnel. Unless the entrances and exits insure continuity of traffic during the period of maximum demand, the capacity of the tunnel roadway can never be reached. Accordingly, the entrances and exits of the Holland Tunnel are widely separated. In New York City, one is to the north and the other to the south of Canal Street through traffic; in addition they are located so as to be served by two main north and south avenues. Tunnel traffic is thus given the best possible facility for free movement while at the same time the greatest separation is secured at a reasonable cost. In accord with this same principle the entrance and exit at the Jersey City end are located in separate streets adjacent to the railroad yards east of the north and south traffic streets connecting Jersey City with Hoboken…"

RE: excerpt from *The Eighth Wonder*

Above: caption: "Plan of the Holland Tunnel"

<u>Top Left</u>: caption: "Canal Street near future Holland Tunnel, 1920"
<u>Top Right</u>: "NYC Holland Tunnel Entrance, 1933"
<u>Left</u>: caption: "New York Tunnel Entrance"

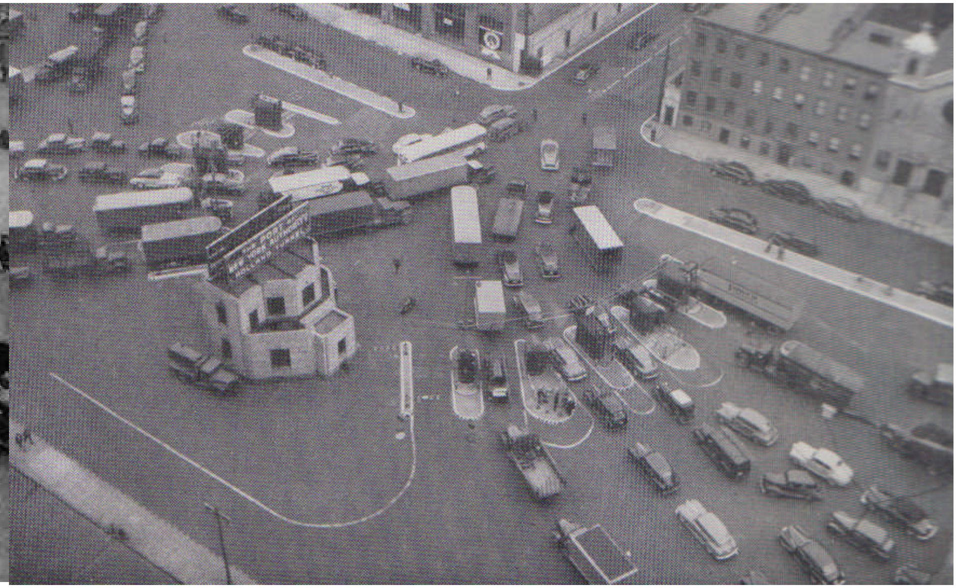
<u>Top Left</u>: caption: "New Jersey entrance of the Lincoln Tunnel, 1927"

<u>Top Right</u>: caption: "New Jersey Tunnel Entrance"

<u>Left</u>: caption: "New Jersey Tunnel Exit"

<u>Above</u>: caption: “Holland Tunnel entrance from New Jersey at night”

<u>Left</u>: caption: “New Jersey approach to the Holland Tunnel”

"…This separation of the tunnel entrance and exit traffic is considered to be a factor of the greatest importance in relieving congestion in the vicinity of the tunnel. This was particularly necessary in New York City, with its large and rapidly increasing volume of traffic. It was also called for in Jersey City, where there were no wide thoroughfares in the vicinity of the tunnel. In addition, property was taken to provide broad plazas at entrances and exits. The entrance plazas serve to accommodate the waves of traffic as they approach the tunnel and converge in the portal roadway into continuous lines of vehicles through the tunnel. Similarly wide exit plazas insure the free an uninterrupted movement of traffic away from the tunnel. Through the separation of entrance from exit, and the use of adequate plazas, the tunnel traffic can be distributed over a large number of streets…"

RE: excerpt from *The Eighth Wonder*

<u>Left</u>: caption: "Manhattan entrance to the Holland Tunnel, opening day November 13, 1927"

<u>Right</u>: caption: "Holland Tunnel entrance (Manhattan) ca. 1931"

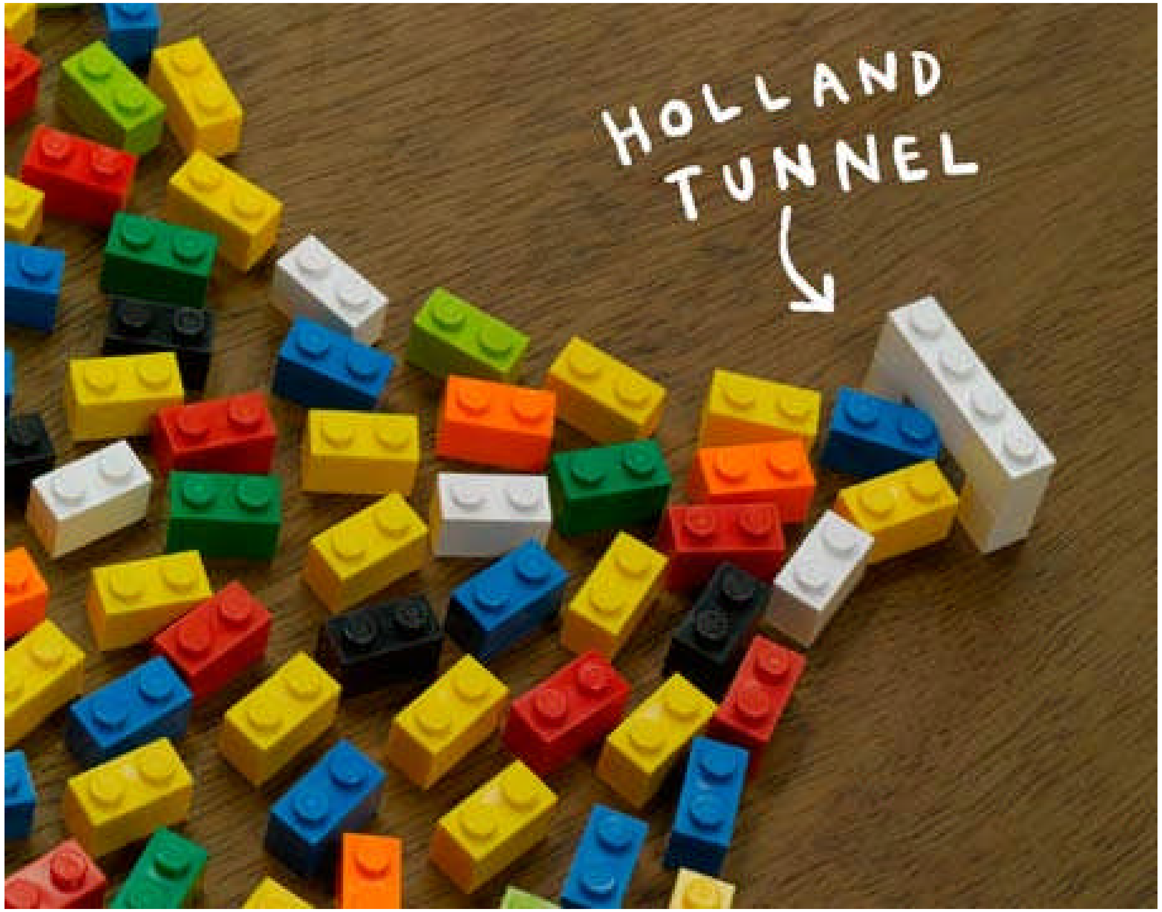
<u>Top Left</u>: caption:: "Aerial photograph of tunnel site in New York, looking West. 5/4/23"

<u>Top Right</u>: caption: "Far view of New Jersey approach. 7/28/23"

<u>Left</u>: caption: "Nos. 248-250 Erie Street being removed from exit plaza, Jersey City, NJ, 5/24/26"

<u>Top</u>: caption: "Holland Tunnel entrances in New York City, 1929"

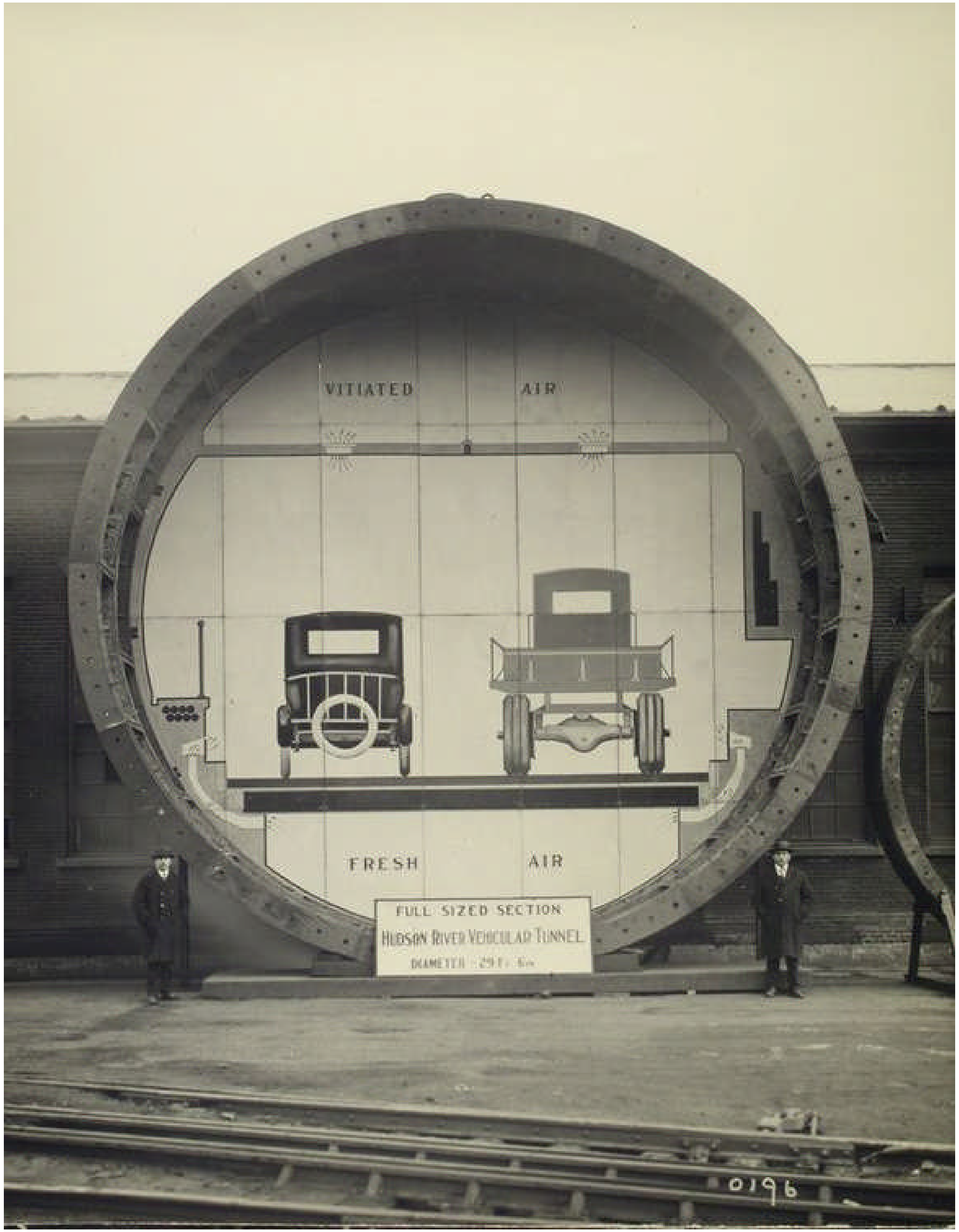
<u>Bottom</u>: caption: "Aerial view of Holland Tunnel traffic during the weekday, 1935"


HOLLAND
TUNNEL

The Right Fit

"…In considering the requirements for the width of the roadways and the clear headroom needed, measurements were taken of vehicles crossing the Hudson on ferries between New York and New Jersey. It was found that their height varied from 6 feet 6 inches for passenger cars to a maximum of 13 feet for large loaded trucks, but that the number exceeding 12 feet in height was only 1%. The width of motor vehicles varied from 6 feet for passenger cars and light trucks to a maximum of 10 feet 6 inches for army transport trucks. In the case of three-horse teams, the outside dimension of the three horses abreast was 9 feet, but the number of vehicles exceeding 8 feet in width was only 3½%…"

RE: excerpt from *The Eighth Wonder*



"…In determining the amount of clear headroom required, it was necessary to consider the matter of providing sufficient area in the tunnel roadway. Any increase in clear headroom, without increasing the size of the tunnel, could be made only at the expense of the available ventilating duct area. Any reduction in this area would increase the power required for ventilation and add to the cost of operating the tunnel. Given a maximum height of 12 feet 2 inches and a maximum width of 8 feet, a clear headroom of 13 feet 6 inches seemed adequate to allow even for jacking up vehicles in case of breakdown, and this was decided upon…"

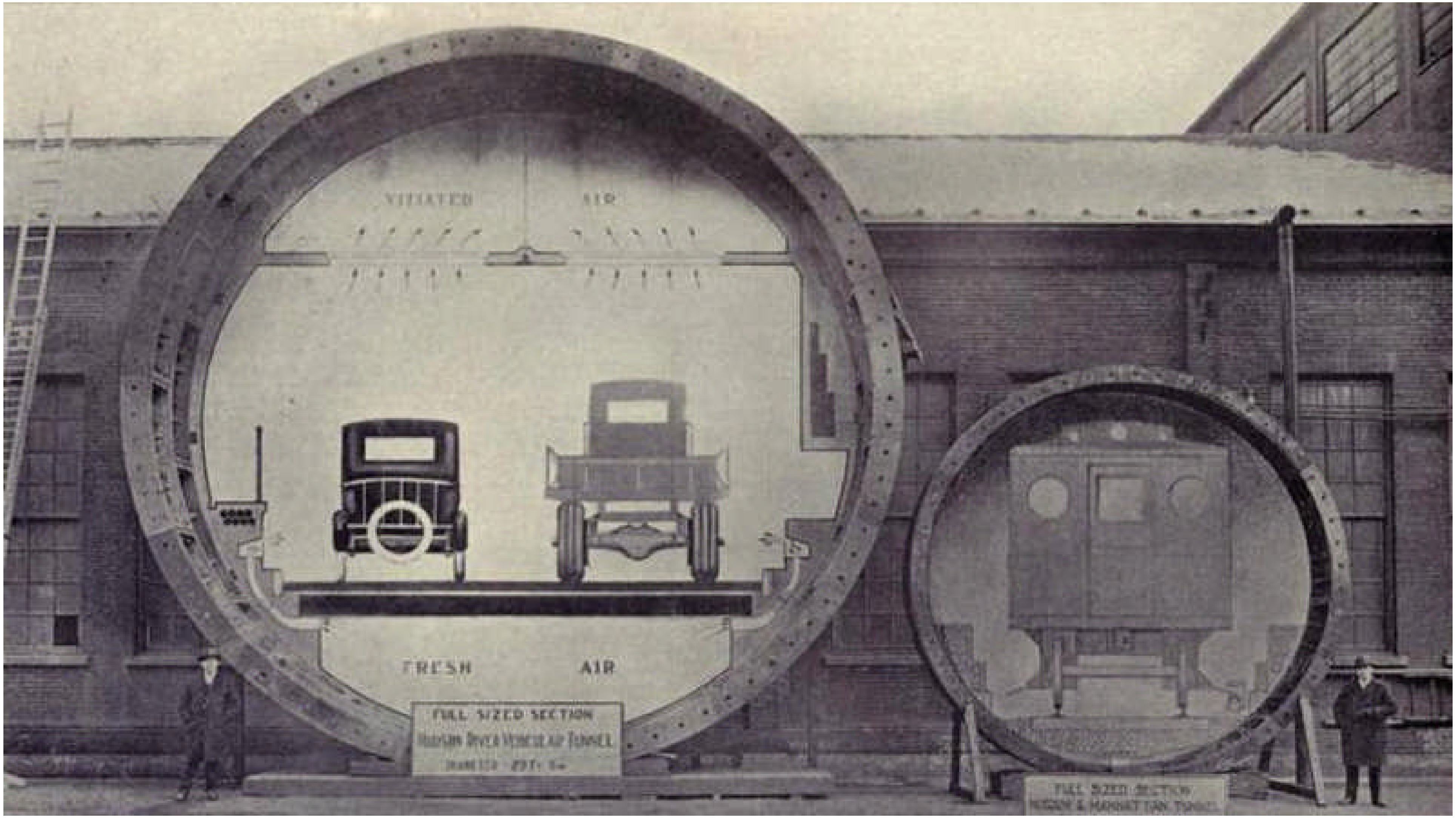
RE: excerpt from *The Eighth Wonder*

<u>Left</u>: caption: "Full sized section Hudson River vehicular tunnel 29 foot 6 inches diameter"


KEEP 75 FT. APART.
SPEED LIMITS
MAX. 35 - MIN. 20

"…Normal operating conditions in a tunnel accommodating two lines of vehicles in the same direction on one roadway obtain when there is a slow line of heavy trucks and passenger cars 6 feet wide. It is, however, necessary to provide for such a contingency as when a vehicle of maximum width has to pass another of the same width that has stalled. The roadway has to be sufficiently wide to permit the passage abreast of two vehicles of maximum width…"

RE: excerpt from *The Eighth Wonder*



<u>Above</u>: caption: "Holland Tunnel and Hudson and Manhattan RR Tunnel – Full-sized section of Holland Tunnel (diameter 29'-6") and full-sized section of Hudson and Manhattan R.R. Tunnel (diameter 16'7"). Rings weigh 16,630 pounds and 5.670 pounds per linear foot, respectively"[77]

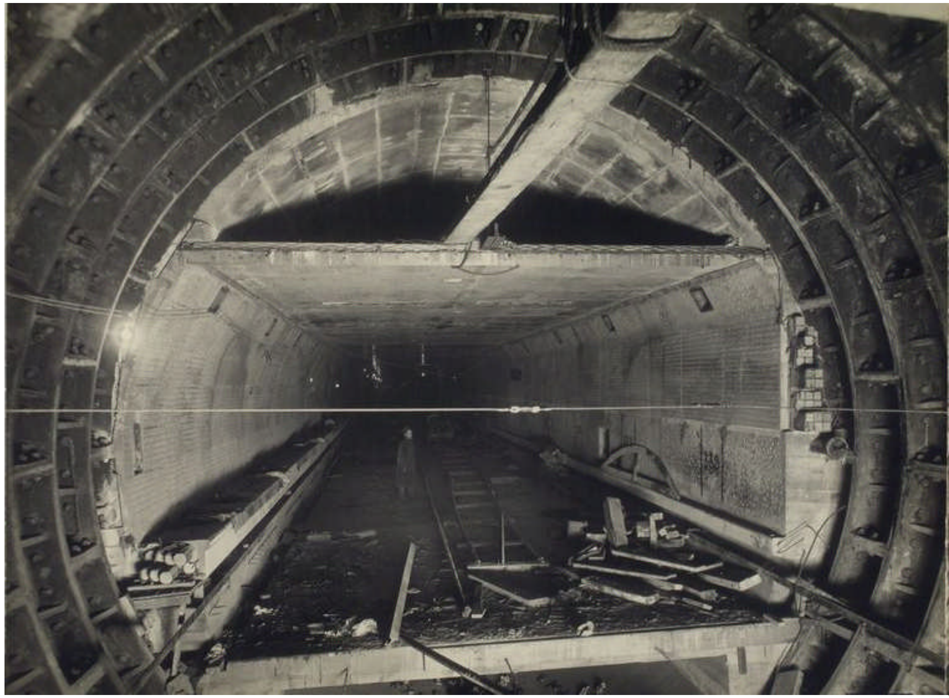
"…It was believed that in the slow line, operating at a speed varying from 3 to 6 miles per hour, a clearance of not less than 6 feet between the outside of the tire and the curb should be provided. In the fast line, due to the greater speed, this clearance should not be less than 1 foot. It was also considered for safe and convenient operation a clearance between moving vehicles of 2 feet 9 inches should be allowed. These considerations led to the adoption of a width of roadway of 20 feet, with, in addition, a sidewalk is set back from the curb line a distance of 6 inches and is located at an elevation of 26 inches above the roadway…"

RE: excerpt from *The Eighth Wonder*


STAY

"…This roadway is paved with granite blocks laid in the usual sand cement cushion layer, about one inch thick, with the joints filled with hot asphalt mixed with heated sand. By means of squeegees, a thin coating, sprinkled with sand, is left upon the surface, resulting in a smooth, resilient, and long wearing surface that will help to deaden the sounds due to traffic, and be more quickly repaired than concrete…"

RE: excerpt from *The Eighth Wonder*

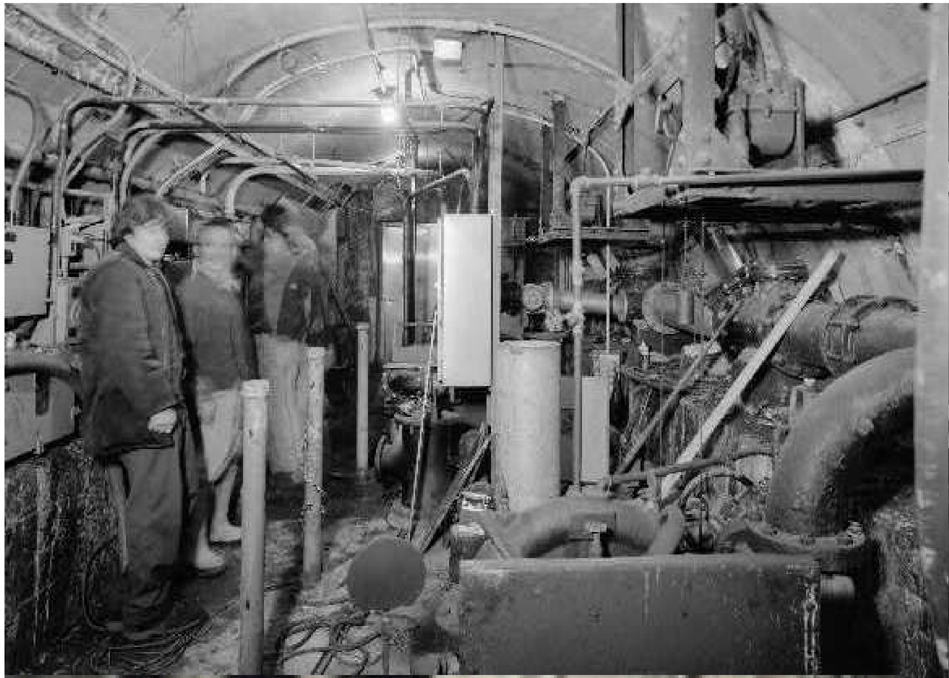
 

"…Each side of the roadway is lined with a granite curb, the roadway having a transverse slope from one side to the other, with a depressed concrete gutter behind the curbstone on the low side inlet openings at frequent intervals. The drain connects with a sump at the low point of the tunnel, from which a discharge pipe is carried under the roadway of each tunnel to the New York river shaft. Intercepting sumps with pumping equipment are provided in all the river and land shafts…"

RE: excerpt from *The Eighth Wonder*

<u>Left</u>: caption: "Concrete construction. South Tunnel West, New Jersey, 5/6/25"

<u>Right</u>: caption: "First truck to enter the Holland Tunnel, North tunnel, East of Land Shaft, N.Y. 7/20/25"



<u>Top Left</u>: caption: "North Tunnel, Middle Pump Room, located at center (lowest point) of Tunnel"

<u>Top Right</u>: caption: "North Tunnel, Pump Room located under New York side Hudson River Ventilation Building"

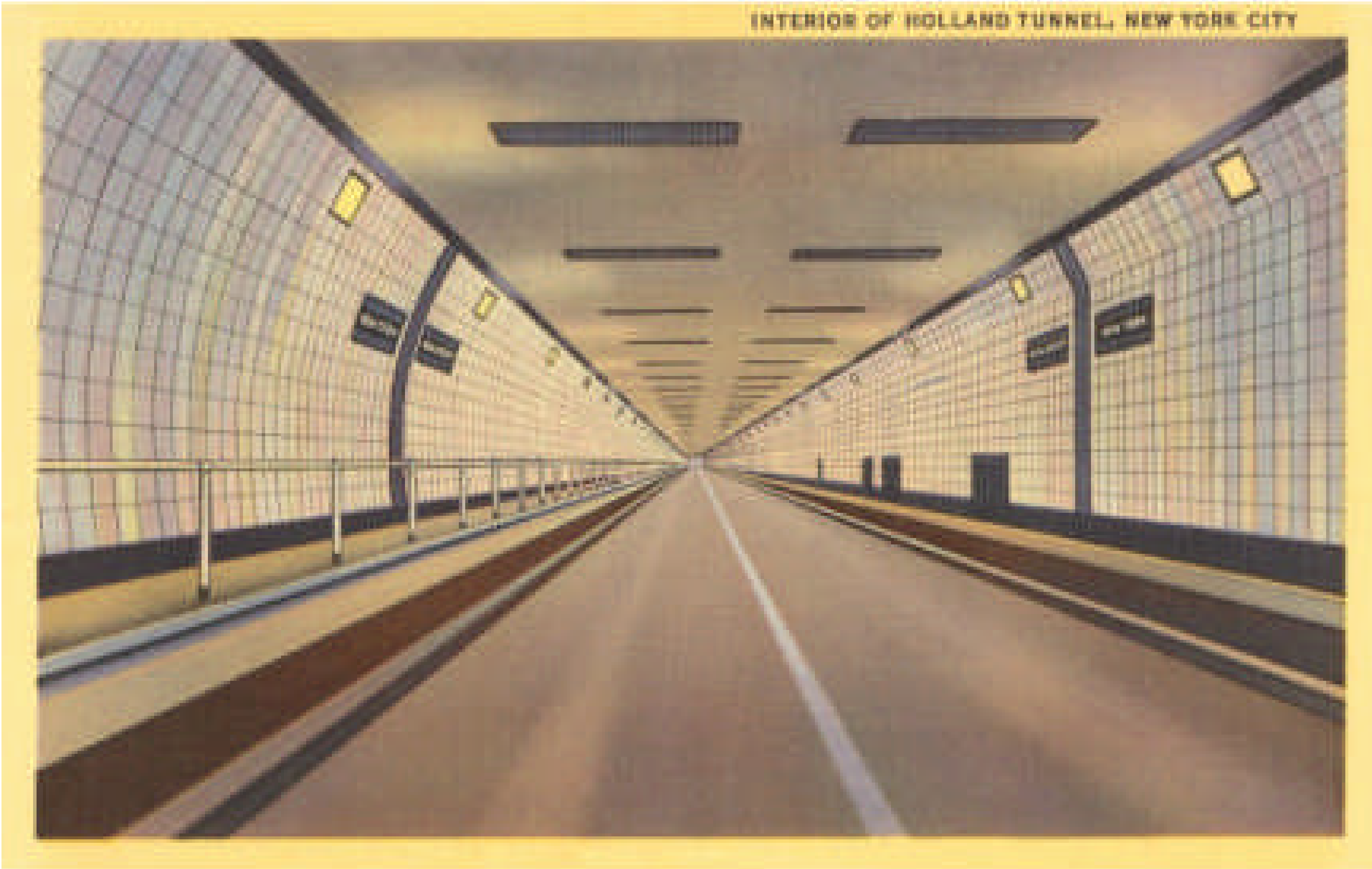
<u>Left</u>: caption: "Flooded South Tunnel. 4/3/24."

"…The tunnel is lighted by electric lamps located in the side walls of the tunnel immediately below the ceiling slabs. A continuous water main is provided throughout the entire length of each tube, with hose connections for fire protection and flushing at frequent intervals. The walls are lined with white tile, care being taken to eliminate all tile containing blue, green, or red tints, upon advice of a 'color psychologist,' on account of its 'depressing effects.' The color of the borders is a light orange. The ceiling is painted white…"

RE: excerpt from *The Eighth Wonder*

<u>Top</u>: caption: "North Tunnel, west of Spring Street shaft. Sample tiling, hand railing and lighting system. 2/10/25"

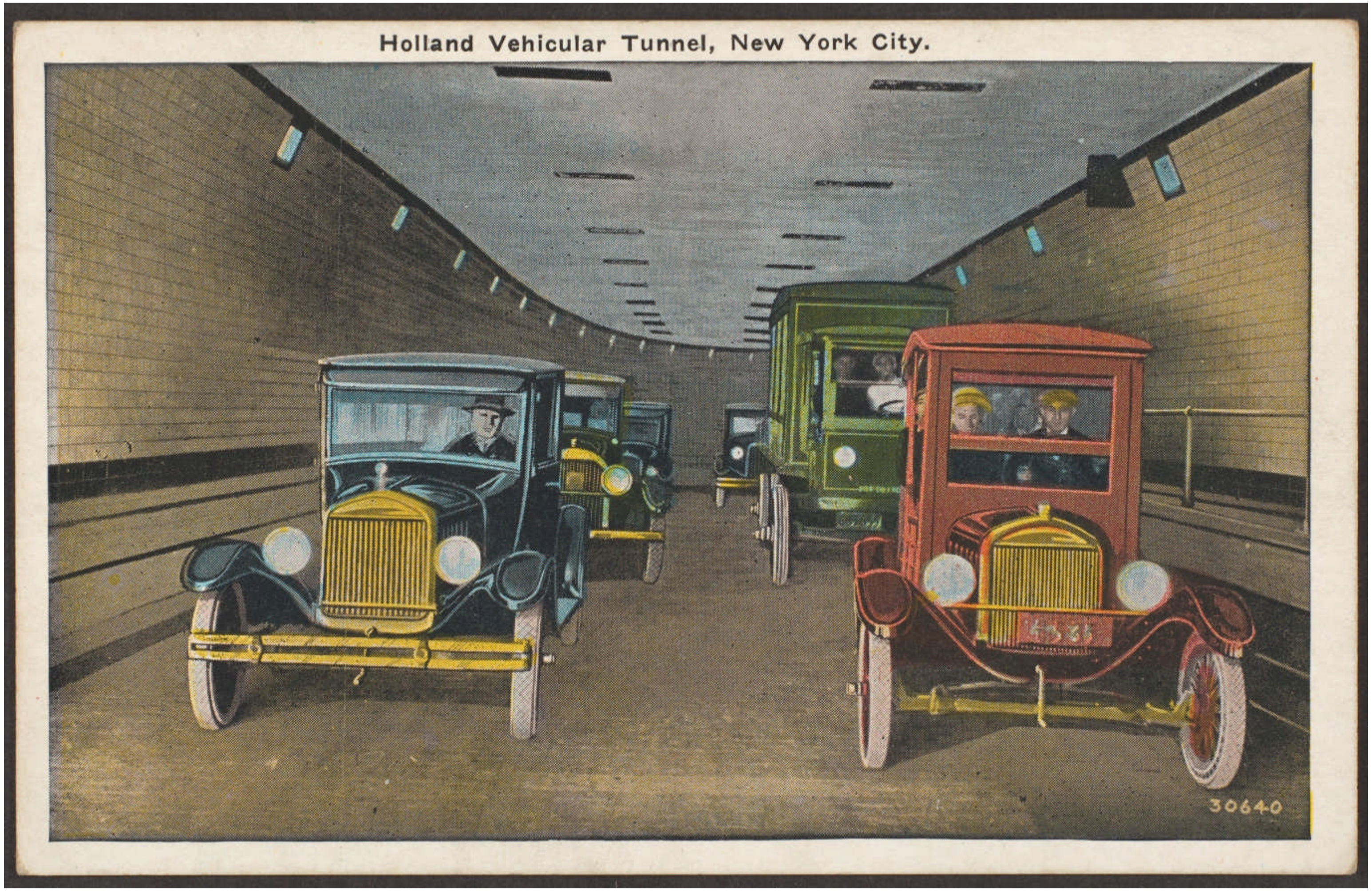
<u>Bottom</u>: caption: "Holland Tunnel State Line Markers, 7/1/26"


INTERIOR OF HOLLAND TUNNEL, NEW YORK CITY

"The tunnel, with its twin tubes, 29 feet 6 inches in diameter, is the largest sub-aqueous tunnel in America, exceeding by 6 feet 6 inches the Pennsylvania Railroad tubes. On the New Jersey side, the diameter of one of the tubes is increased to 30 feet 4 inches to meet ven-tilation requirements. This exceeds by 4 inches the diameter of Rotherhithe Tun-nel under the river Thames, London, England. Which has been the largest sub-aqueous tunnel in the world…"

RE: excerpt from *The Eighth Wonder*

<u>Left</u>: caption: "North tunnel - State line markers, New York - New Jersey. 5-1-26"


Holland Vehicular Tunnel, New York City.
30640

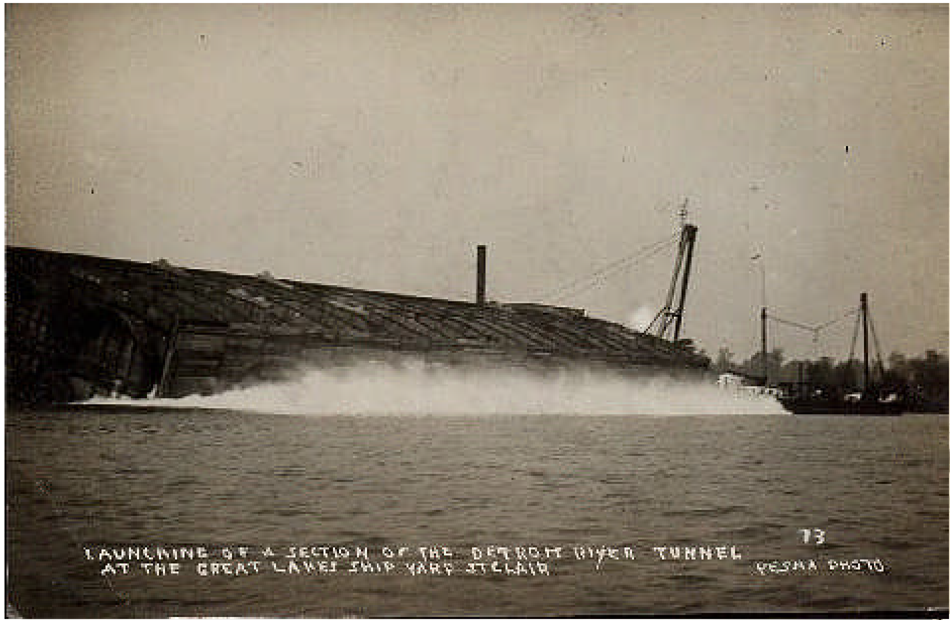
Part 3

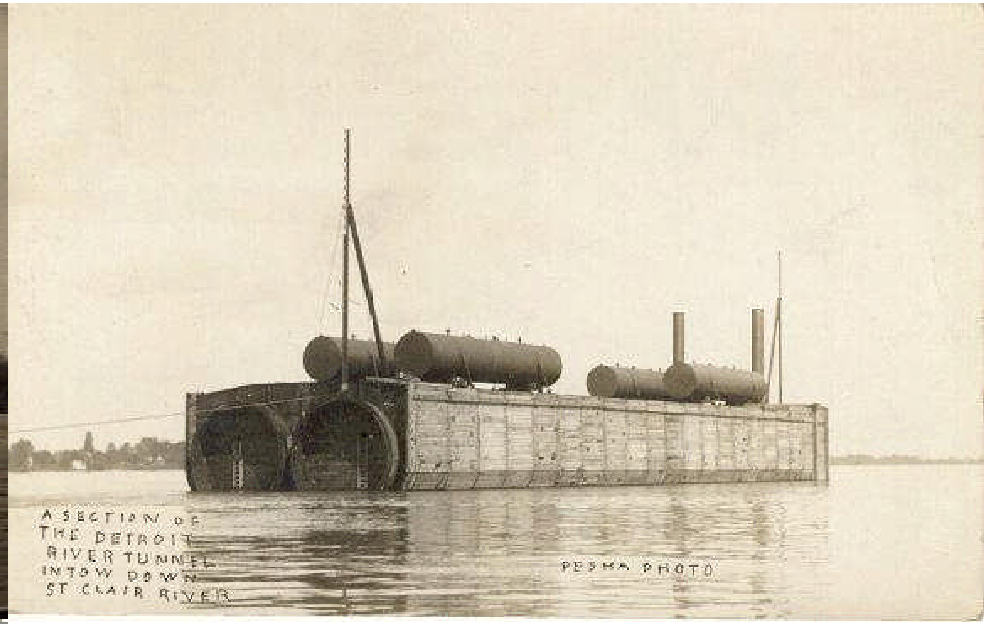
The Shield Method

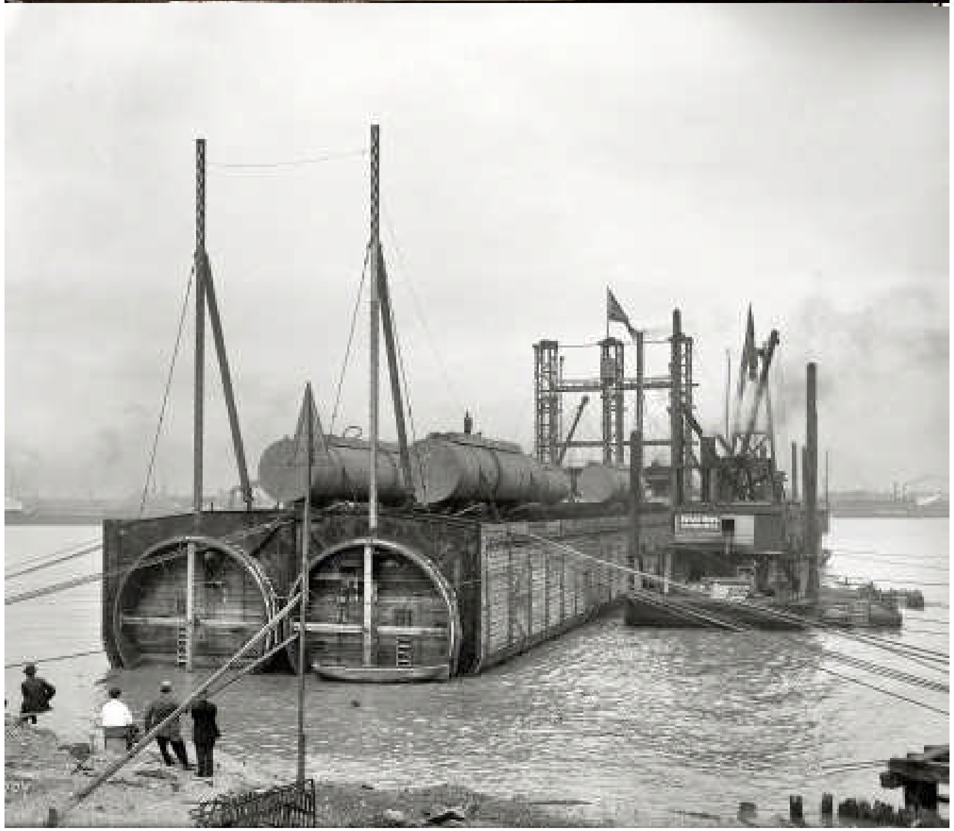
The Trench Method

"…The shield method of construction was adapted for the Holland Tunnel after careful consideration of other schemes, notably the trench method. By the trench method, the work is conducted from a plant floating in the river, and the tunnel is constructed either under a protecting roof or floated into position and sunk in sections in a dredged trench. The longest sub-aqueous tunnel built by this method is the Detroit River tunnel of the Michigan Central Railroad…"

RE: excerpt from *The Eighth Wonder*







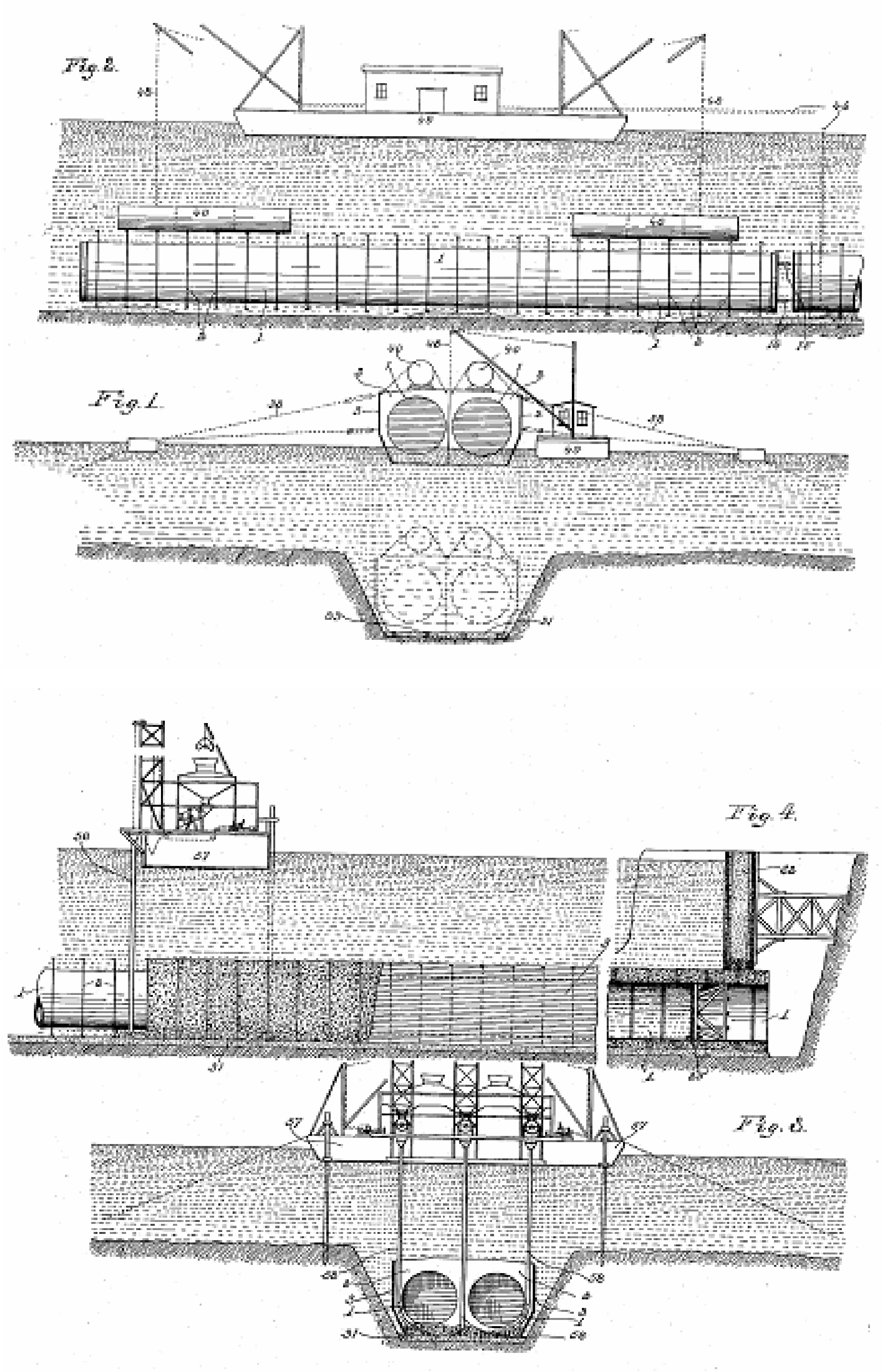
<u>Top Left</u>: caption: "Launching of a section of the Detroit River Tunnel at the Great Lakes Ship Yard St. Clair"

<u>Top Right</u>: caption: "A section of the Detroit River Tunnel in tow down St. Clair River"

<u>Left</u>: caption: "Sinking cast section of Michigan Central RR Company tunnel"

“Be it known that I, OLAF HOFF, a citizen of the United States of America, residing at New York, in the county of New York and State of New York, have invented certain new and useful Improvements in Sub-aqueous Tunnels…This invention relates to the construction of that class of sub-aqueous tunnels, which are formed by a series of pre-constructed tunnel tube sections built on shore, launched and floated to the tunnel site and then sunk to position one after another, in a trench prepared to receive them. My invention embodies certain improvements in the structural features of the tunnel and in the method of carrying out the construction which is especially devised for the building of tunnels across navigable waters where it is important to carry on the work expeditiously and by such a method as will offer the least possible temporary surface obstruction to navigation, and will also make it possible to carry the tunnel to no greater depth than suffices to avoid interference with vessels passing thereover. My construction provides a tunnel built wholly of steel and concrete and resting upon a foundation also preferably built of steel and concrete and forming part of the completed tunnel itself. Each steel tunnel tube section may be several hundred feet in length, and each tube is provided with temporary bulkheads to enable it when launched, to be floated to the tunnel site. In sinking each section to its prepared water bed, water is gradually let into the tube and the sinking is controlled by air cylinders attached to the top of the section and adapted to support the weight of the tube, or nearly so, in sinking. After the section is sunk and joined to the previously laid section, it is embedded in concrete and one of the novel features of my invention consists in so constructing the tunnel tube section that it serves as a form for the concrete, and in providing a continuous foundation of concrete upon the water bed, all as more fully described hereinafter and shown in the accompanying drawings showing my invention as applied to a tunnel constructed of tunnel tube sections of the double or twin tube type…”

RE: excerpt from *U.S. Patent No. US 907356 A* (December 22, 1908)



"…Figure 1 represents an end elevation of a tunnel tube section in position for sinking: Fig. 2 is a longitudinal vertical section of Fig. 1, showing the tunnel tube section as having been sunk to the water bed and illustrating the manner of connecting it to a previously laid section: Fig. 3 is a cross-section of a tunnel tube section in position upon the water bed and illustrating the method of embedding it in concrete: Fig. 4 is a sectional side elevation of Fig. 3, and showing the shore end of the tunnel section…"

RE: excerpt from *U.S. Patent No. US 907356 A* (December 22, 1908)

"…It was recognized that in the excavation of a trench under the Hudson River, there would be an unavoidable interference with a great volume of river traffic. Fifteen hundred boats cross the line of the tunnel daily. Such congested river conditions would make every dredge or other machine working in the tunnel an obstruction to traffic. Collisions would be frequent, increasing the time and cost of the work, with danger both to shipping and to equipment of construction. Storms, fog, and ice would cause a discontinuance of surface work for at least two months of each year. At the New York end, a large mass of ledge work, involving blasting and removal at great depth, would be a serious obstacle to open trench excavation under water…"

RE: excerpt from *The Eighth Wonder*

<u>Above</u>: caption: "Bird's-eye view of lower Manhattan and river traffic" (ca. 1914)

"…Since there was a real hazard involved in carrying on operations from a plant anchored in mid-stream, the shield method was clearly called for. In addition, silt conditions in the Hudson River were regarded as extremely favorable to this method. In a trench tunnel, soft material greatly increases the volume of excavation, while in the case of a shield tunnel this material is most easily excavated. If the silt is not shoved aside by the shields, it is easily disposed of through the tunnel. The shield may be closed with the exception of certain openings through which the material is squeezed into the tunnel as the shield advances…"

RE: excerpt from *The Eighth Wonder*

NY Land Shafts

"…The first contract provided for the sinking of two land shafts, one at Washington and Canal Streets and the other at Washington and Spring Streets, New York City. They were sunk by the compressed-air method. The double steel walls of the caissons were filled with concrete as the caissons were sunk. This added to their weight when sinking weight was needed, and at the same time completed the structure of the walls. In addition to this concrete, weight for sinking was obtained by storing the excavated material from the working chamber on the roof of the chamber as the caisson went down. This necessitated handling the material a second time, but gave the desired weight and permitted the lowering of the caisson without greatly reducing the air pressure in the working chamber, thereby preventing loss of ground…"

RE: excerpt from *The Eighth Wonder*

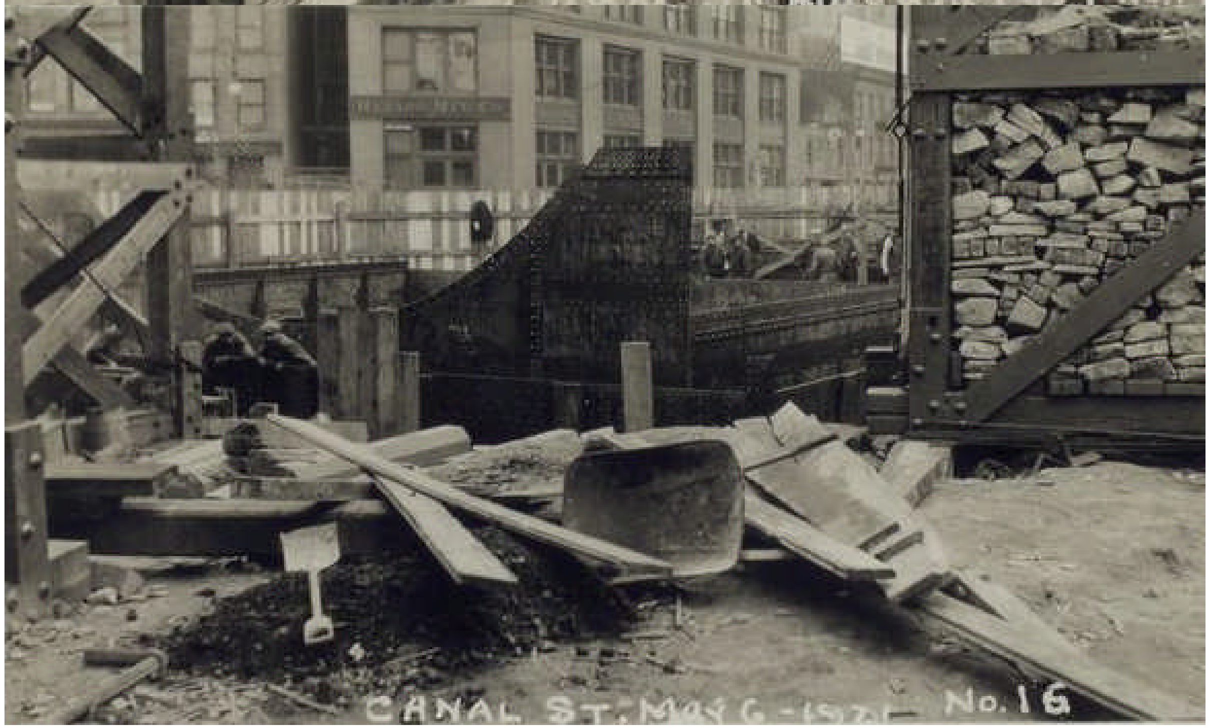
Canal St. Shaft

Excavation started Mar. 28, 1921.
First caisson steel arrived April 25, 1921
Steel erection started April 27, 1921
Concrete started July 11, 1921
Steel erection completed July 19, 1921
Steel Riveting completed July 20, 1921
Changed to blocking for sinking July 21, 1921
Air turned on July 28, 1921 - 9:30 A.M.
Excavation completed August 9, 1921
Waterproofing and brick placed August 10-11, 1921
Invert placed August 11-14, 1921.
Caisson watered and air removed August 14, 1921
Caisson unwatered August 24, 1921
Air pressure 4 lbs to 29 lbs.
Average quantity of free air ran from 500 cu. ft. on July 28 to about 30ft. below M.H.W. when quantity increased to 1200 cu. ft. and then to 1800 cu. ft. at 45 ft. depth Then a decline to 700 cu. ft. at about 53 ft. depth below M.H.W. Increase due to approach and passing through coarse sand.

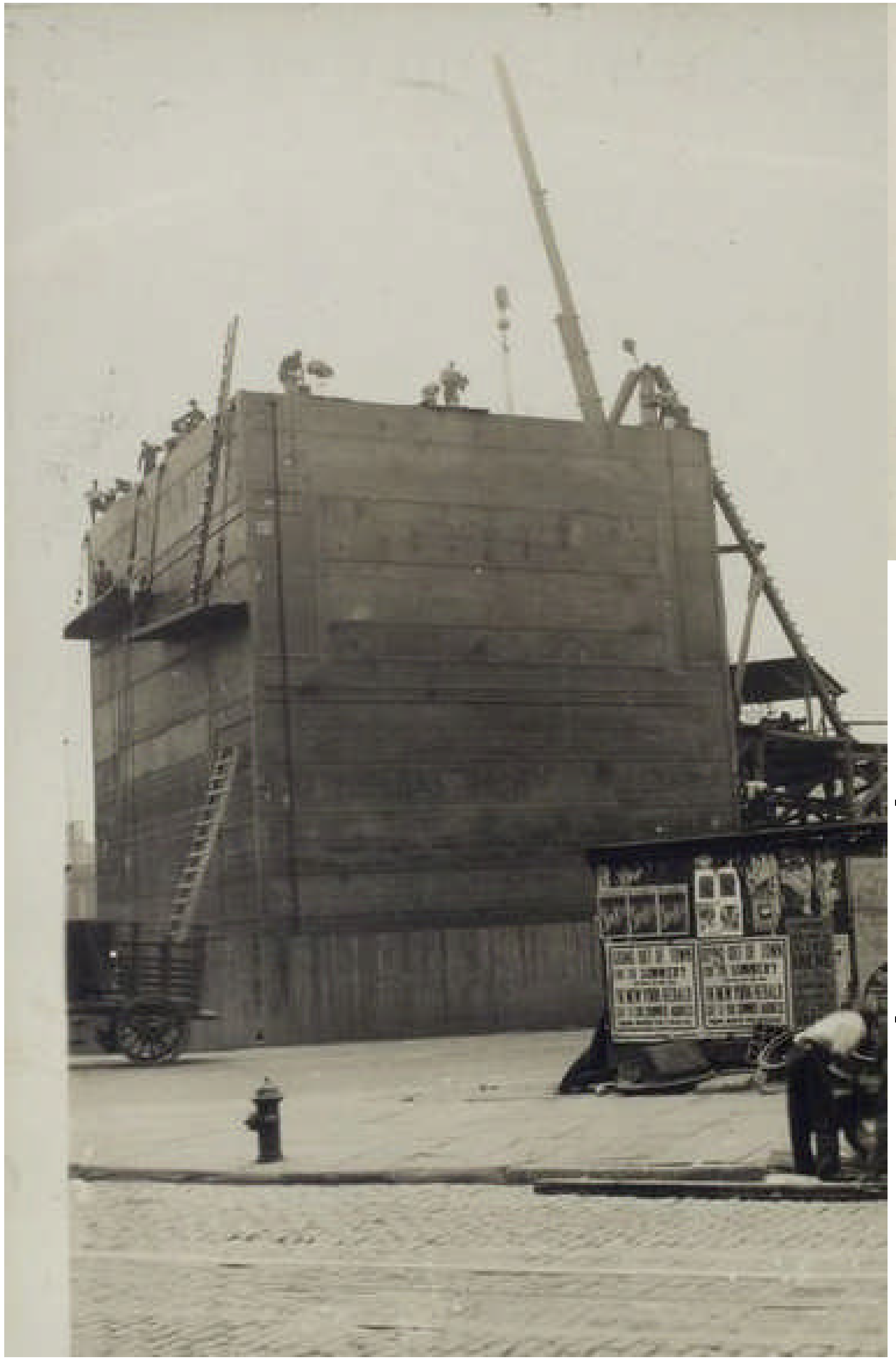
<u>Above</u>: caption: "Canal Street Shaft (Work Schedule). Material practically all red-sand fine and course and a streak of blue clay at 10 ft. below M.H.W."

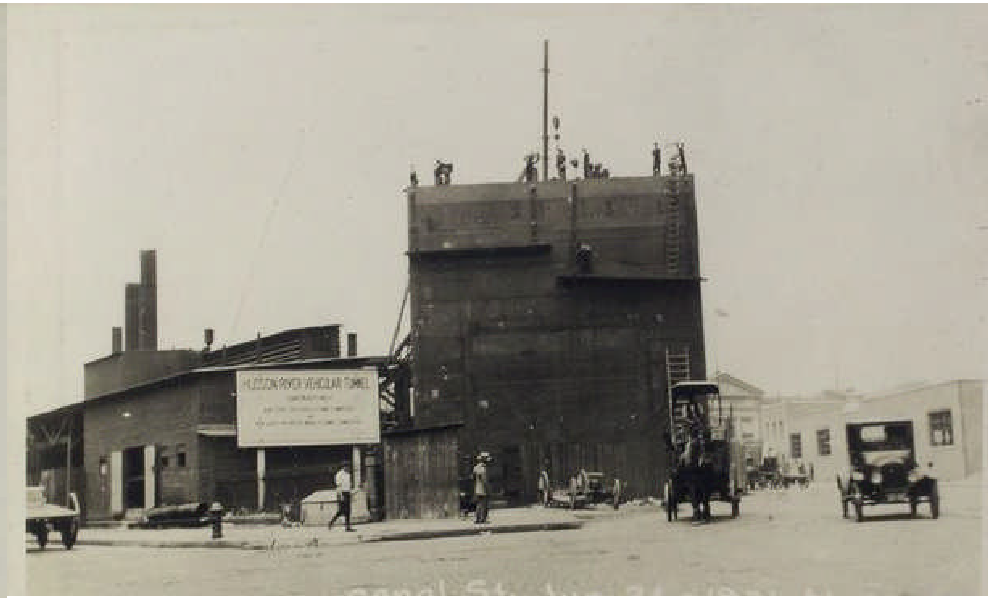
<u>Above</u>: caption: "General view of site. Canal Street shaft, April 13, 1921"

<u>Left</u>: caption: "Cutting edge - Cut through old sewer. Canal Street, May 6, 1921"



<u>Top</u>: caption: "Working chamber, Cutting edge, Blocking. Canal Street, May 6, 1921"
<u>Bottom</u>: caption: "West side, inner and outer skin plates. Canal Street, May 6, 1921"



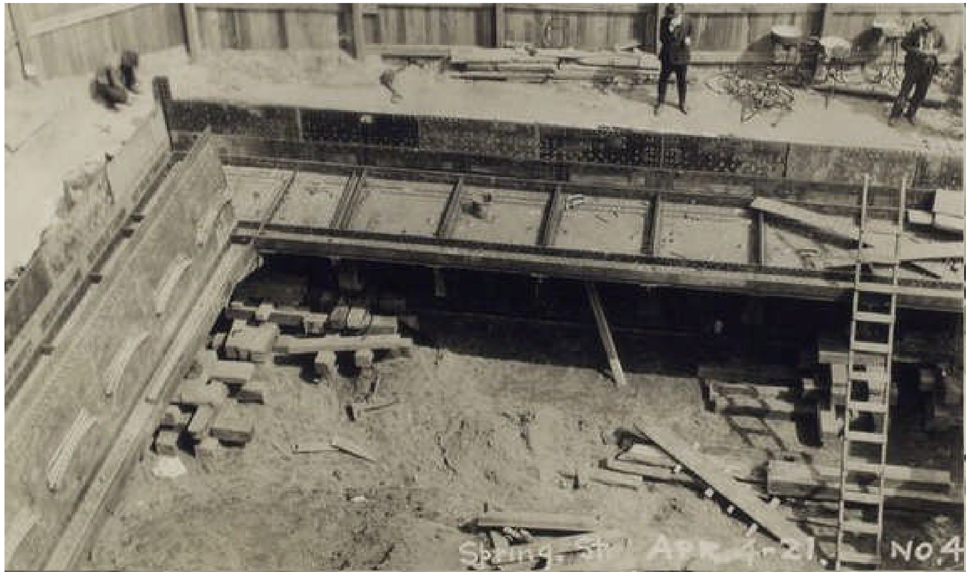


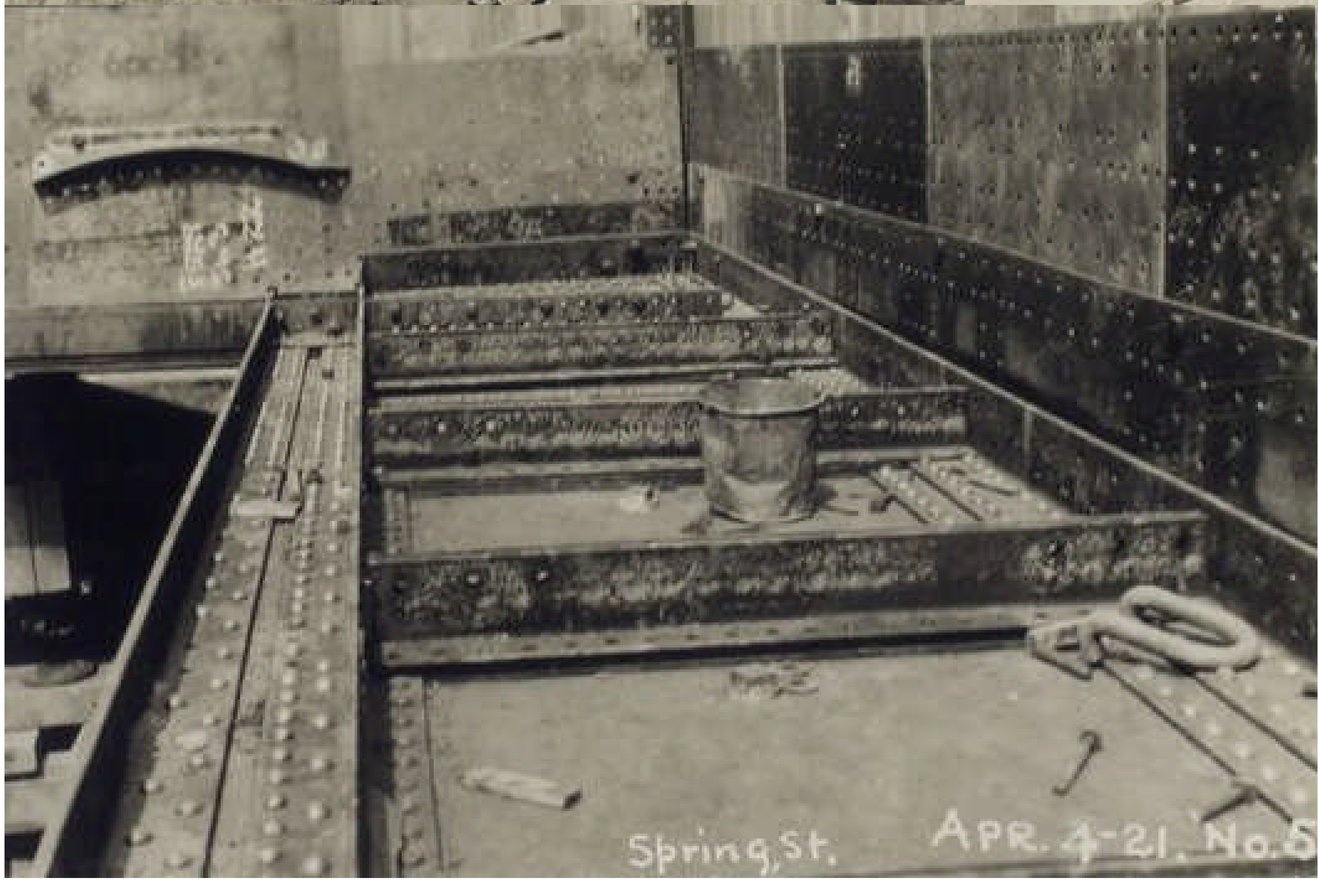
<u>Above</u>: caption: "North side, riveting. Canal Street, June 24, 1921"
<u>Left</u>: caption: "East side, riveting. Canal Street, June 24, 1921"

<u>Top</u>: caption: "Concreting, mixing plant. Canal Street, July 14, 1921"

<u>Bottom</u>: caption: "Painting. Canal Street Shaft, July 14, 1921"

<u>Above</u>: caption: "General view of Plant. Spring Street, April 4-21"
<u>Left</u>: caption: "Cutting edge. Spring Street, April 4-21"



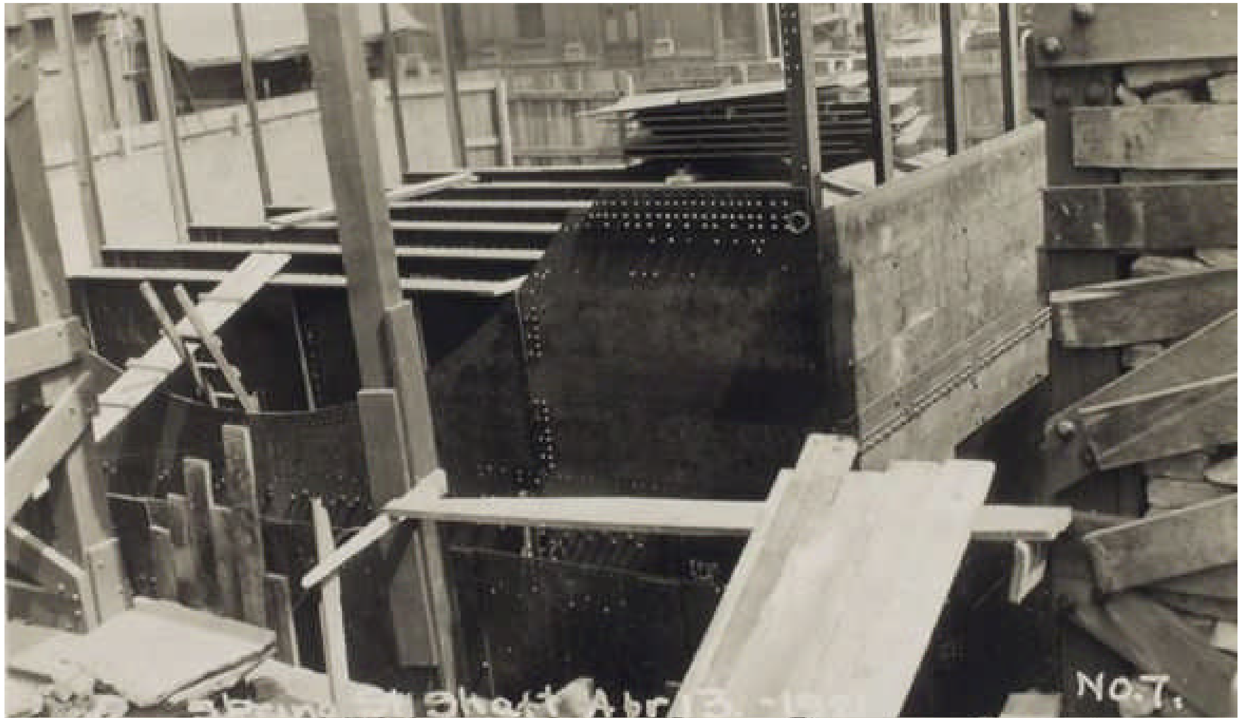


<u>Top Left</u>: caption: "Plate girder, bottom of inner skin plates, carrying brackets from cutting edge. Spring Street, April 4-21"
<u>Top Right</u>: caption: "Inner skin plates West wall - Tube opening. Spring Street, April 4-21."
<u>Left</u>: caption: "Detail of plate girder. Spring Street, April 4-21"

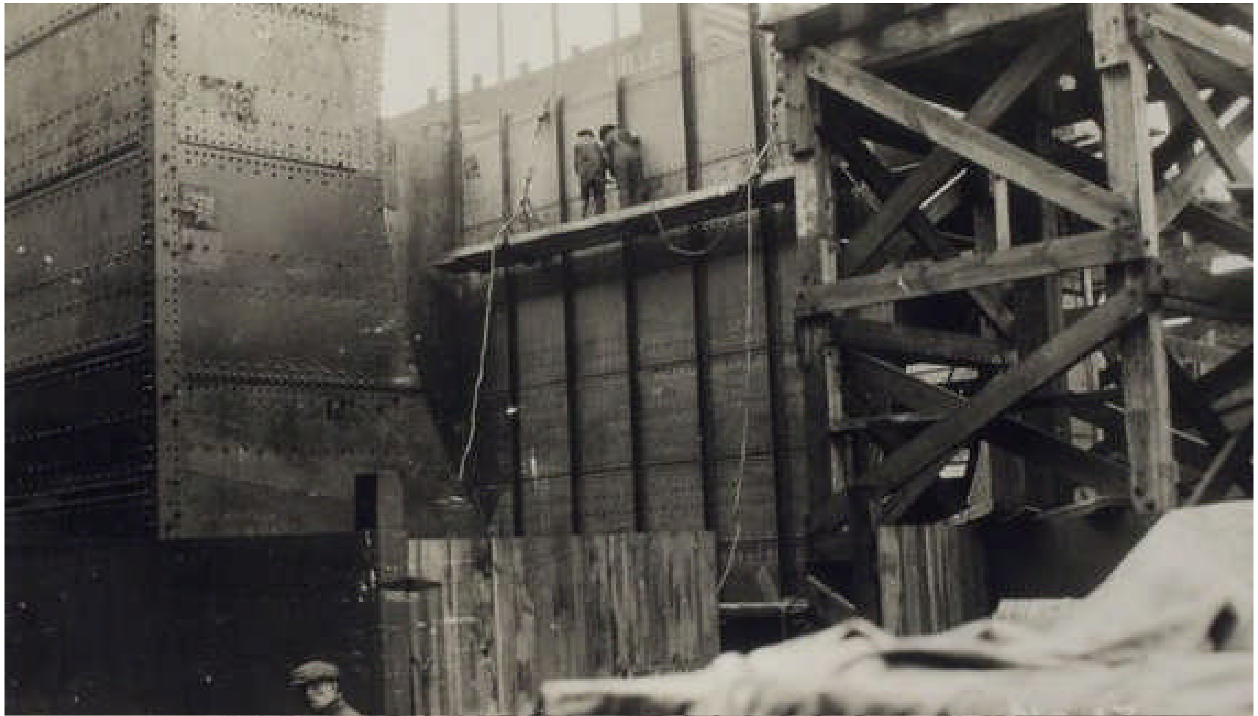
Above: caption: "First truss - North-West corner. Spring Street, April 13, 1921"

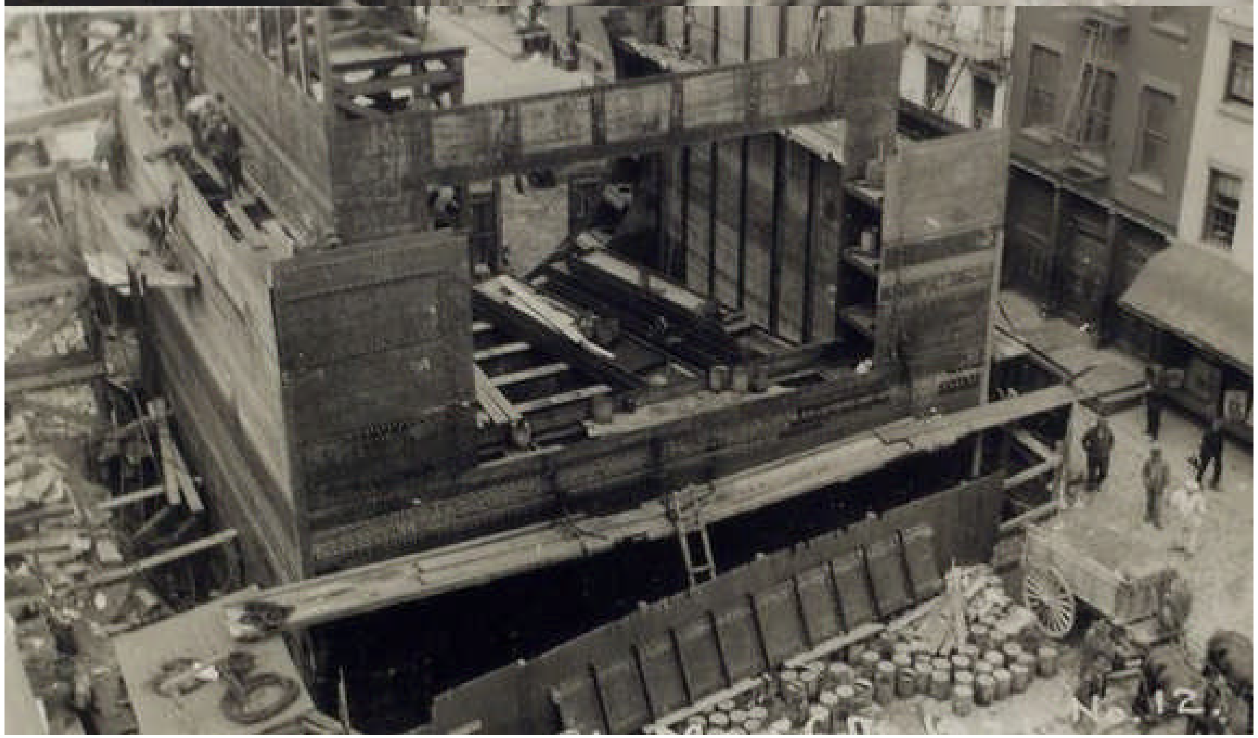
Left: caption: "Looking between skin plates. First truss at corner. Spring Street, April 13, 1921, West wall"

<u>Top</u>: caption: "Working chamber, roof girders bolted. Spring Street, April 13, 1921"
<u>Bottom</u>: caption: "Working Chamber, blocking up for bolting, April 13, 1921"



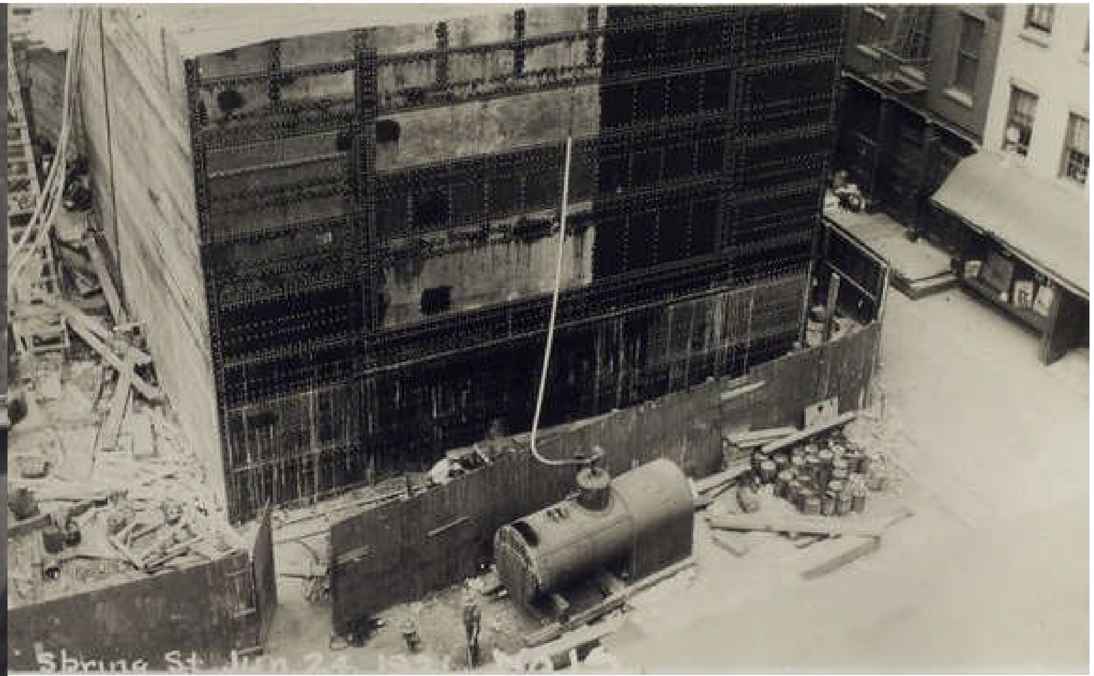
<u>Top</u>: caption: "Roof girders of working chamber in place. Spring Street shaft, April 13, 1921"
<u>Bottom</u>: caption: "Roof girders and sided angles, roof plates on blocking. Spring Street, April 13, 1921"





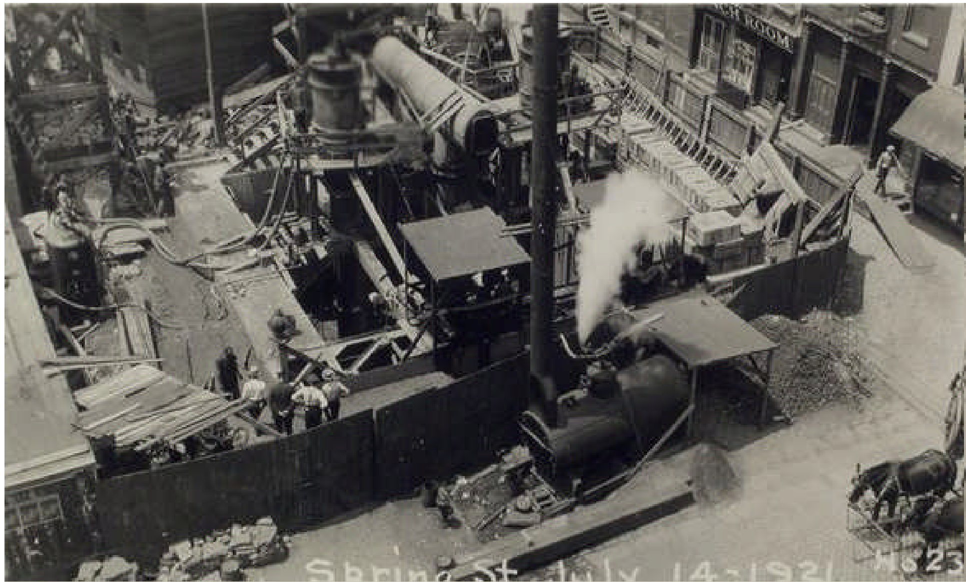
<u>Top</u>: caption: "General view, West side, tube opening. Showing riveters at work, lines of air hose. Spring Street, May 6, 1921"

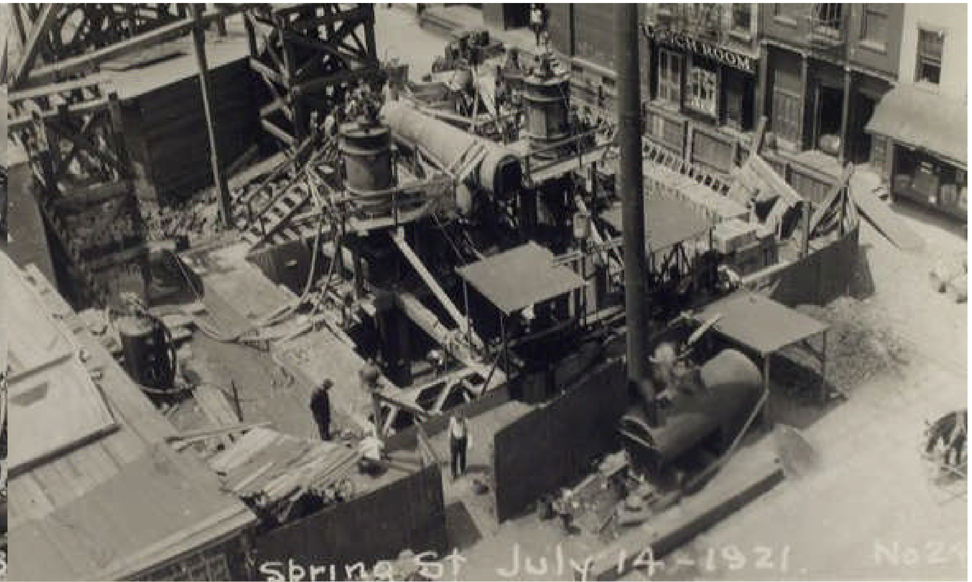
<u>Bottom</u>: caption: "General view, East side. Subway opening. Spring Street, May 6, 1921"

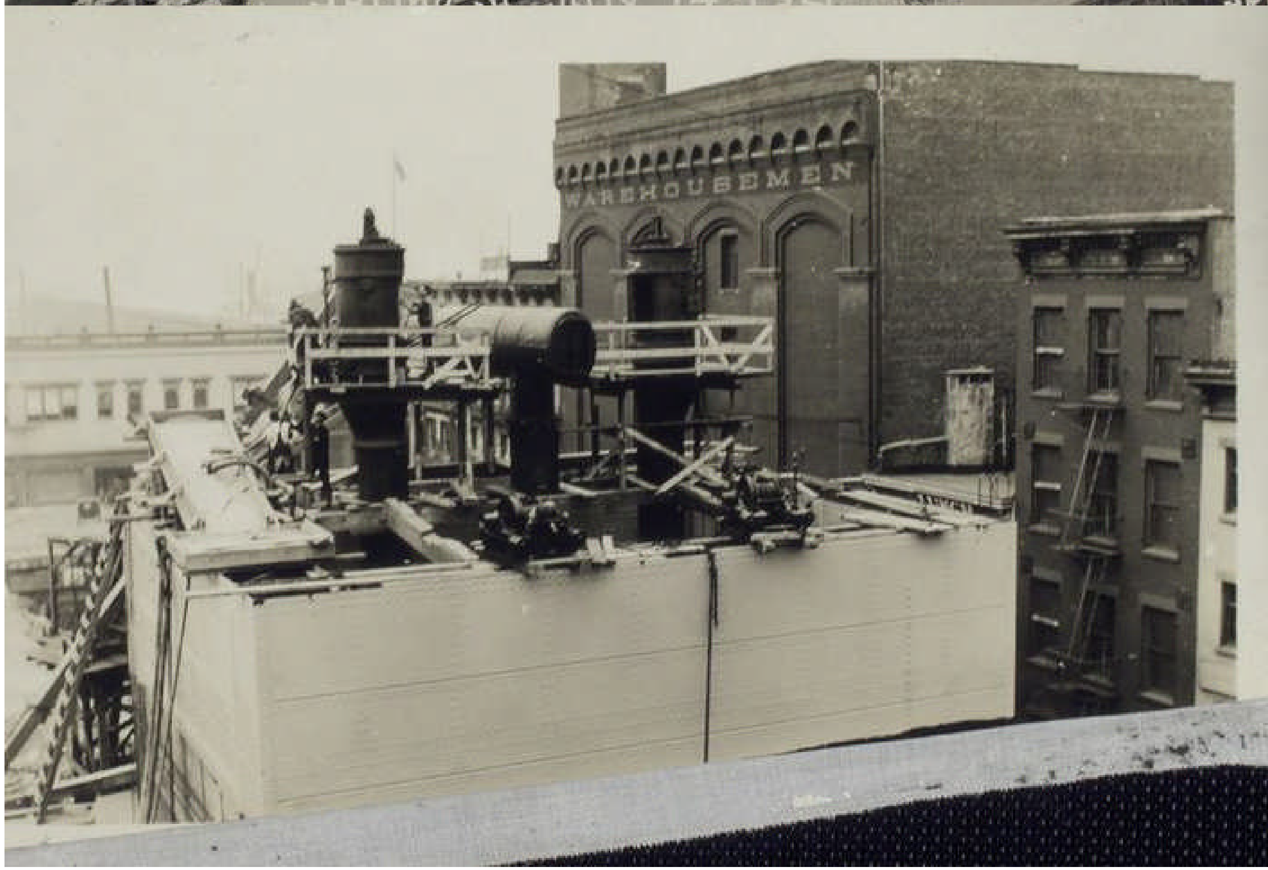


<u>Above</u>: caption: “General view. Caisson about ready to start sinking. Concrete chute at left, hoisting engines in front, air lines at side. Spring Street, June 24, 1921”

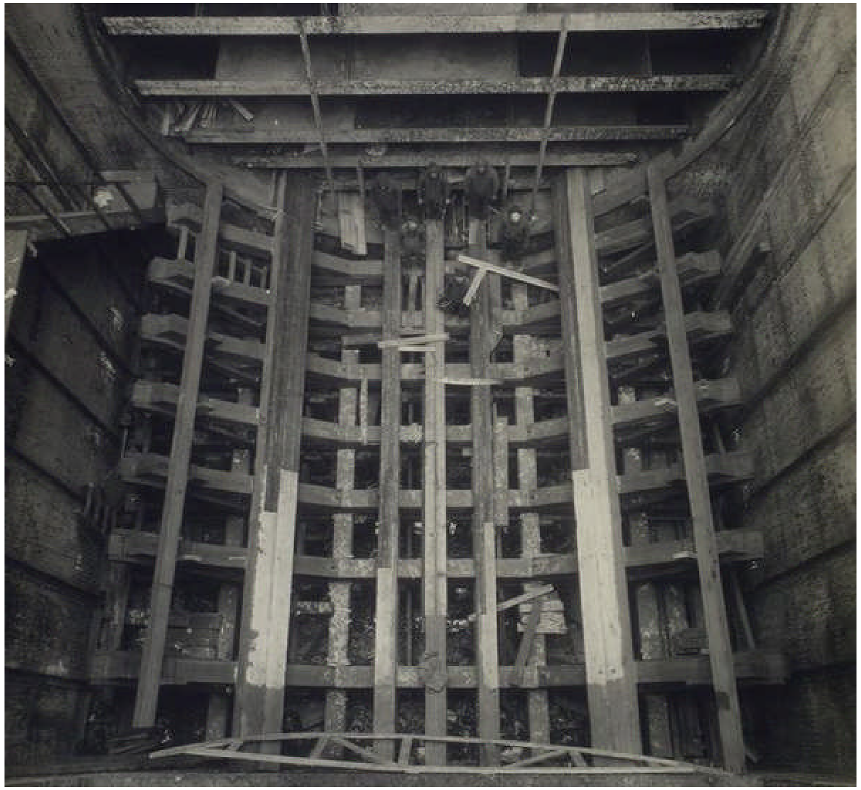
<u>Left</u>: caption: “Looking down between Muck Lock and Man Lock showing bulkhead girders. Spring Street, June 24, 1921”







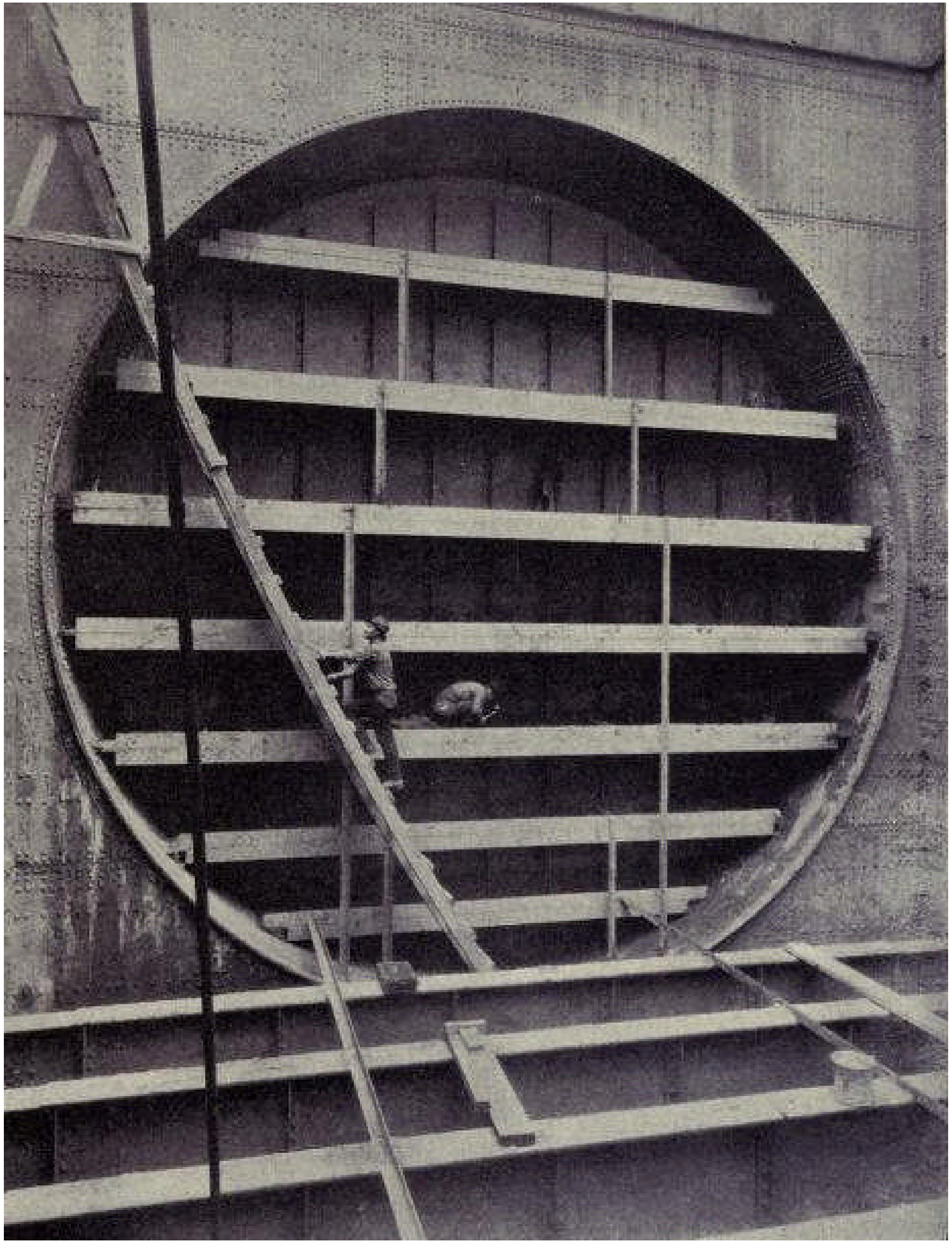
<u>Top Left</u>: caption: "Caisson top about 16 inches above surface. Cast iron weights N.E. corner. Slight fissures showing at left side. Spring Street, July 14, 1921."
<u>Top Right</u>: caption: "Shift entering lock. Spring Street, July 14, 1921"
<u>Left</u>: caption: "View of Plant. Spring Street, warehouse to the right"



"…Upon the removal of the compressed air, the bottom seals of the caissons proved to be water-tight. The shafts were now ready for the building of the shields preparatory to the beginning of shield tunneling…"

RE: excerpt from *The Eighth Wonder*

Left: caption: "Spring Street shield cradle, Spring Street shaft, New York, 11/18/23"



"…Temporary bulkheads were provided in the west side walls to connect with the approach section which was to be constructed by excavation from the surface…"

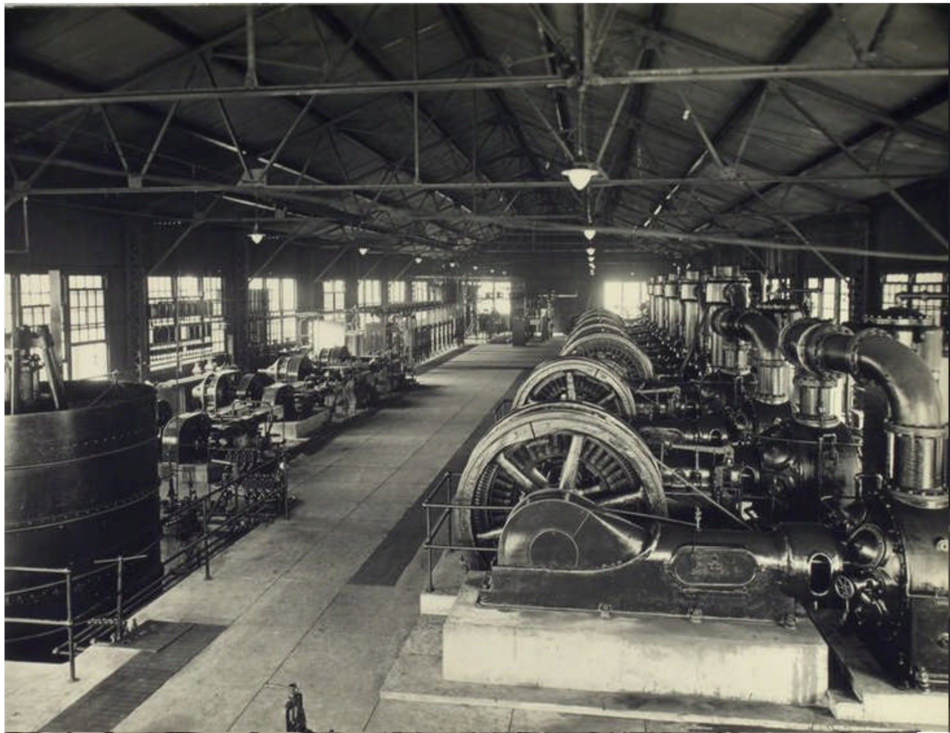
RE: excerpt from *The Eighth Wonder*

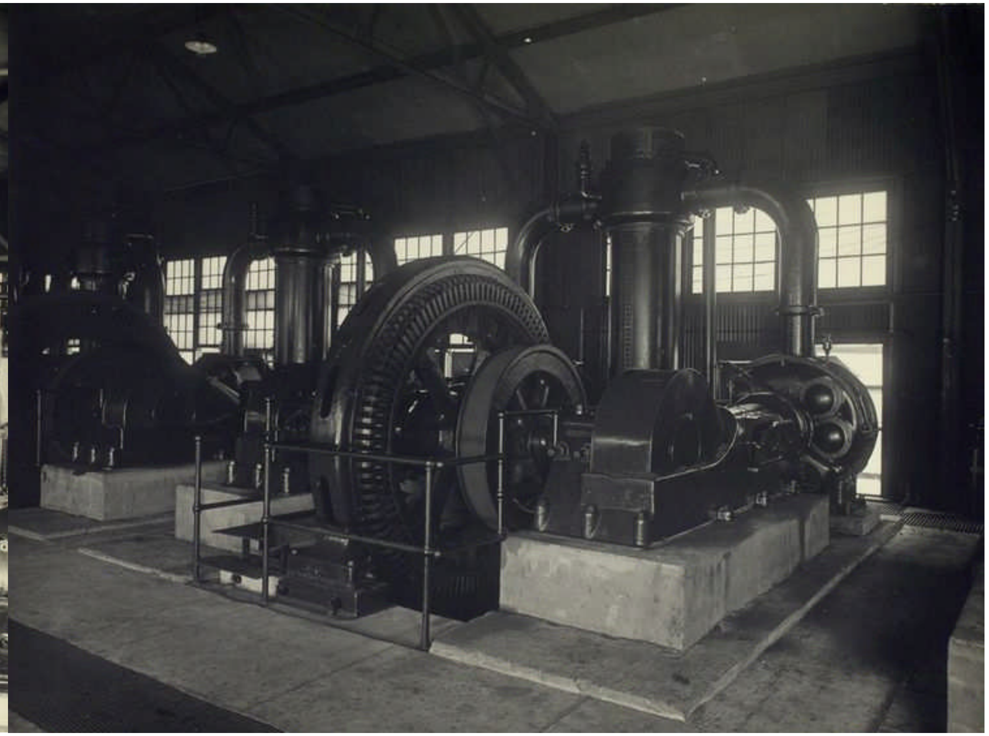
<u>Left</u>: caption: "Land Shaft Caisson ay Spring Street, New York City. Showing steel bulkhead in west side wall through which shield advanced after erection"

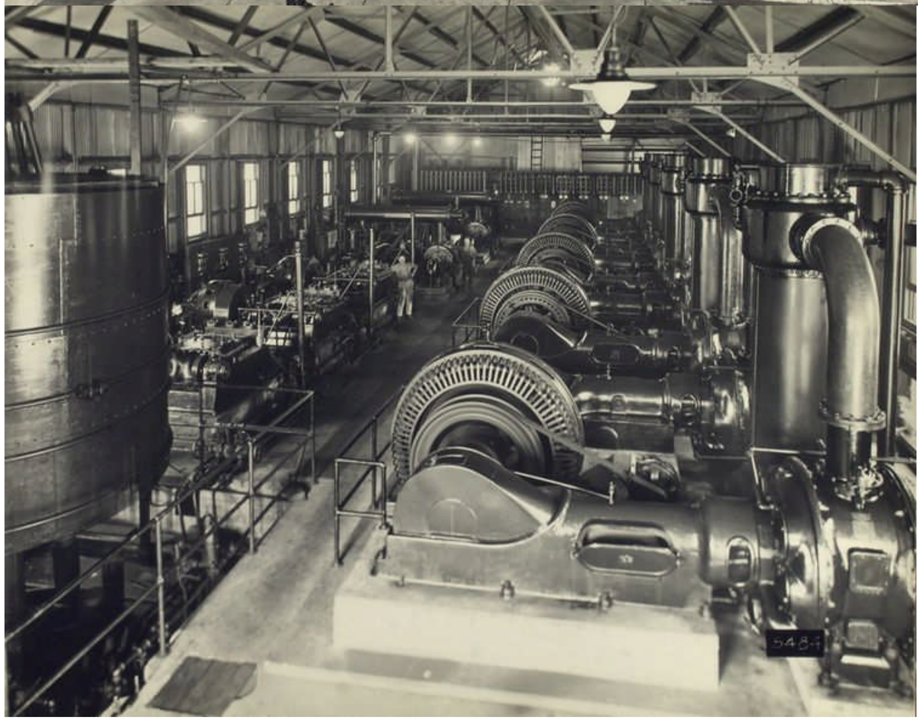
Mobilization

"…This work followed by placing under contract the entire under-river portion of the tunnel. Power plants had to be constructed to produce low-pressure air for caissons and tunnel, high-pressure air for the operation of grouting machines, air drills, and hoisting engines used below the surface, and hydraulic pressure for operating the jacks used in driving the shield and for operating the erector arm for building the tunnel lining. Overhead gantries and dumping platforms for the receipt and disposal of materials and buildings for housing the workmen had to be provided. Pipes, through which compressed air would be supplied to the tunnel headings, had to be laid to the shafts. On the New Jersey side this involved laying low-pressure lines as large as 16 inches in diameter, high-pressure lines, hydraulic lines, water lines, electric cables, and telephone cables. Every facility had to be provided, even an independent telephone system connecting all parts of the work with the public telephone system…"

RE: excerpt from *The Eighth Wonder*







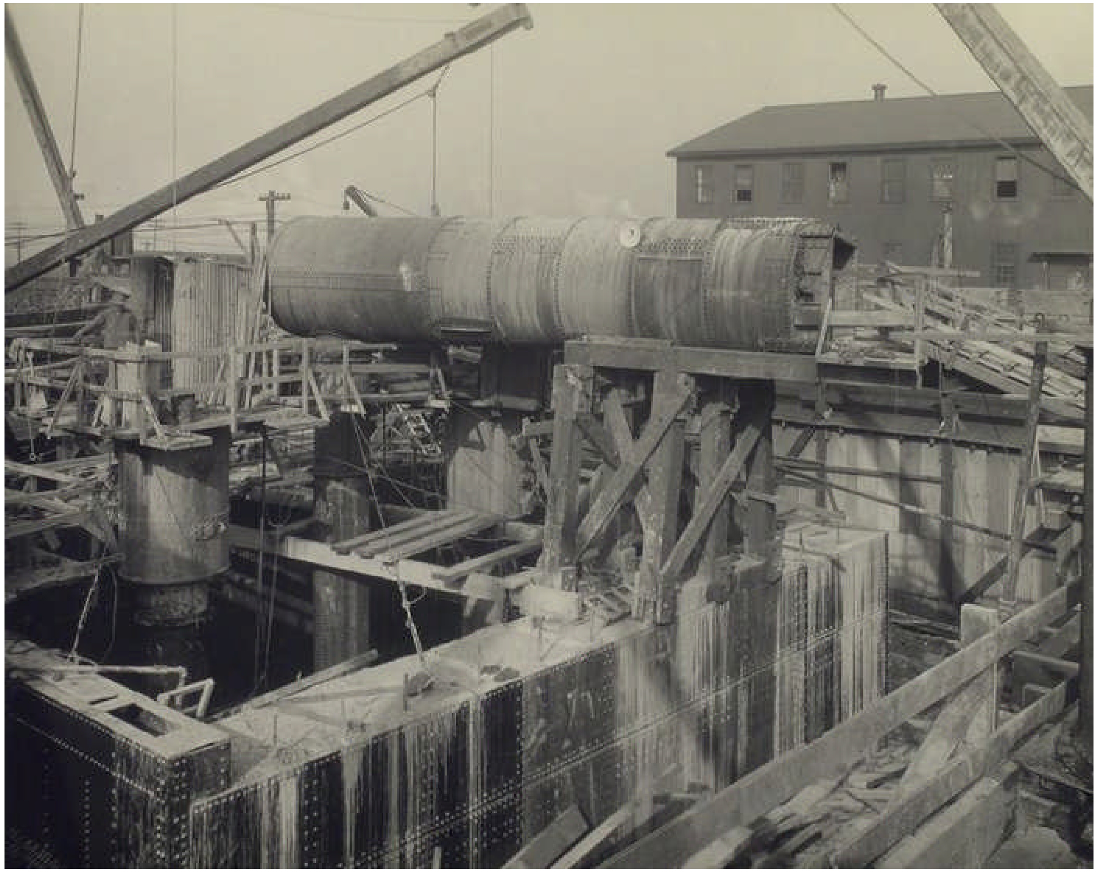
<u>Top Left</u>: caption: "Power House (General interior) Henderson & 12th Strs, Jersey City. 8/ 4/ 23."
<u>Top Right</u>: caption: "Low air compressor No. 5, Power House, 12th & Henderson Sts., J.C. 6/1/23."
<u>Left</u>: caption: "Power House (General interior view), Canal & West Street, New York. 7/23/23."

<u>Above</u>: caption: N.Y. Telephone Co. cables at Canal & Hudson Streets, New York. 12/2/24.

"…Canal Street Park was made available as a site for the air-compressing plant and engineers' field office. Pier 35 and adjacent slips were used for the storage of materials and for the disposal of excavated matter from the tunnel heading. Overhead gantries connecting the shafts with the pier permitted traffic to the water front in connection with the tunnel to pass above the city streets…"

RE: excerpt from *The Eighth Wonder*

Air-Locks



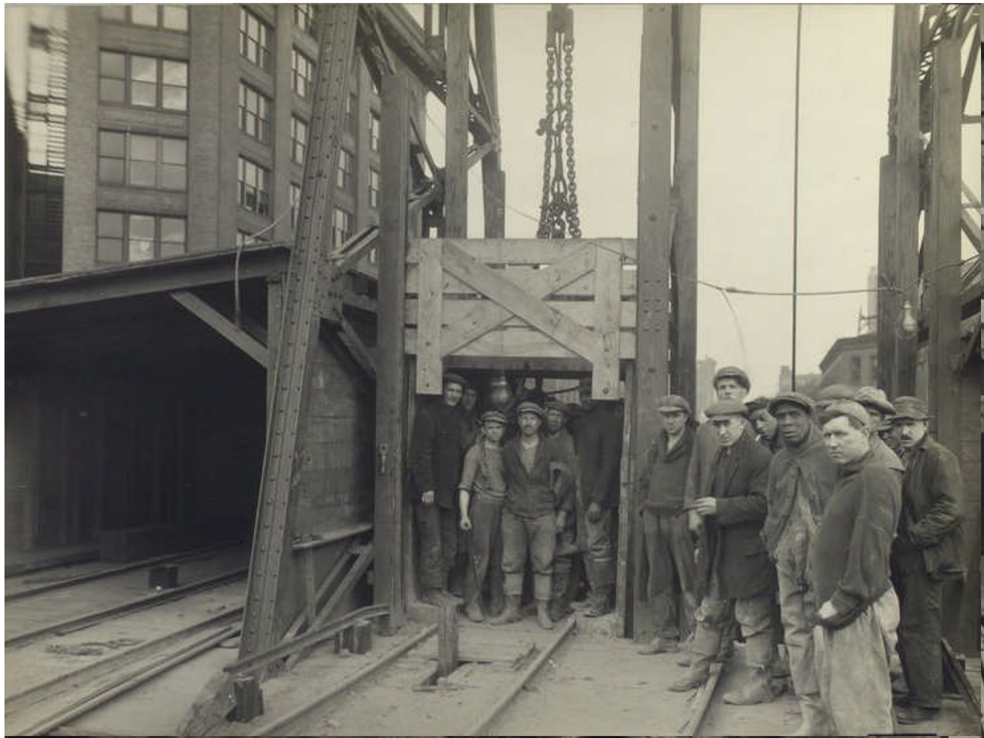
"…Every precaution was taken to provide for the safety of the workmen in the compressed-air chambers. A high emergency gangway in the upper part of the tunnel led from the shield to the locks, for escape in case of a blowout. Safety screens were installed in the compressed-air chambers. Fire is a real danger in compressed-air work on account of the increased amount of oxygen present. As an indication of the fire hazard, a candle, if still glowing when extinguished, will again burst into flame…

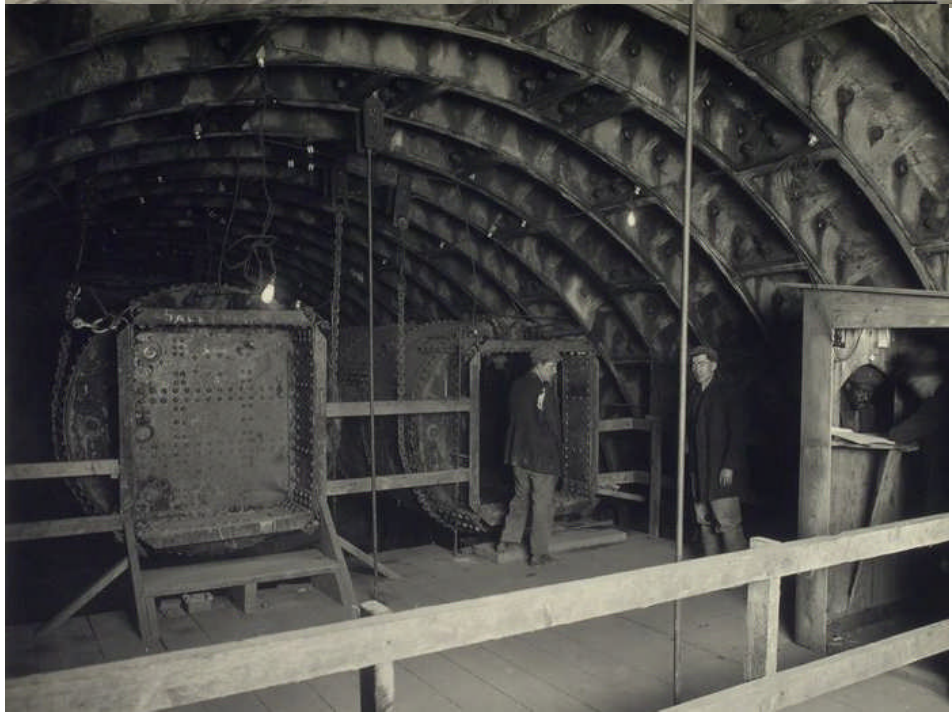
RE: excerpt from *The Eighth Wonder*

<u>Above</u>: caption: "Locks of North Land Shaft, New Jersey. 1/27/23."

“…We entered one of these (only one was used normally, the other reserved for emergencies) and saw the iron door clanged to and fastened. Then followed lessons in equalizing the pressure inside and outside the head by holding the nose and ‘snorting’ – very much as one does when trying to expel water from the nose after diving. The danger of the ‘caving in’ of one’s eardrums was stressed, and we were warned to hold up our hand the moment the pressure became too severe. This was the only way to attract the attention of the man who turned on the compressed air as the noise made even shouting inaudible. We sat wild-eyed – expecting the hideous monster to leap upon us any minute. The bark was worse than the bite. Twice we raised our hands and the pressure was turned off until the pressure in our ears was relieved. When the twenty-nine pound mark was reached the door leading into the high-pressure section was opened, and there we were in the very midst of the digging. Once accustomed to the pressure, it was not noticeable…”

RE: excerpt from *The Eighth Wonder*





<u>Top Left</u>: **caption: “Gang about to go down shaft on cage. Canal Street shaft, New York. 4/24/23.”**

<u>Top Right</u>: **caption: “Gang of ‘Sand Hogs’ Waiting In Line. Canal Street shaft and air locks, South tunnel. 4/24/23.”**

<u>Left</u>: **caption: “Man lock. South tunnel, New York. 4/24/23.”**

"…We stood watching the big burly men as they shoveled the debris into the cars that carried it out through the lower air chambers. Not particularly envious of them at such hard labor, we listened only half-heartedly to our guide until he remarked that the automobiles we had seen parked at the entrance belonged to these very 'sand-hogs'; that they made high wages and worked short hours. There are laws forbidding their working in compressed air for more than two hours at a time, for health reasons. Law likewise requires the company employing the men to furnish hot showers and hot coffee for them when they come out…"

RE: excerpt from *The Eighth Wonder*

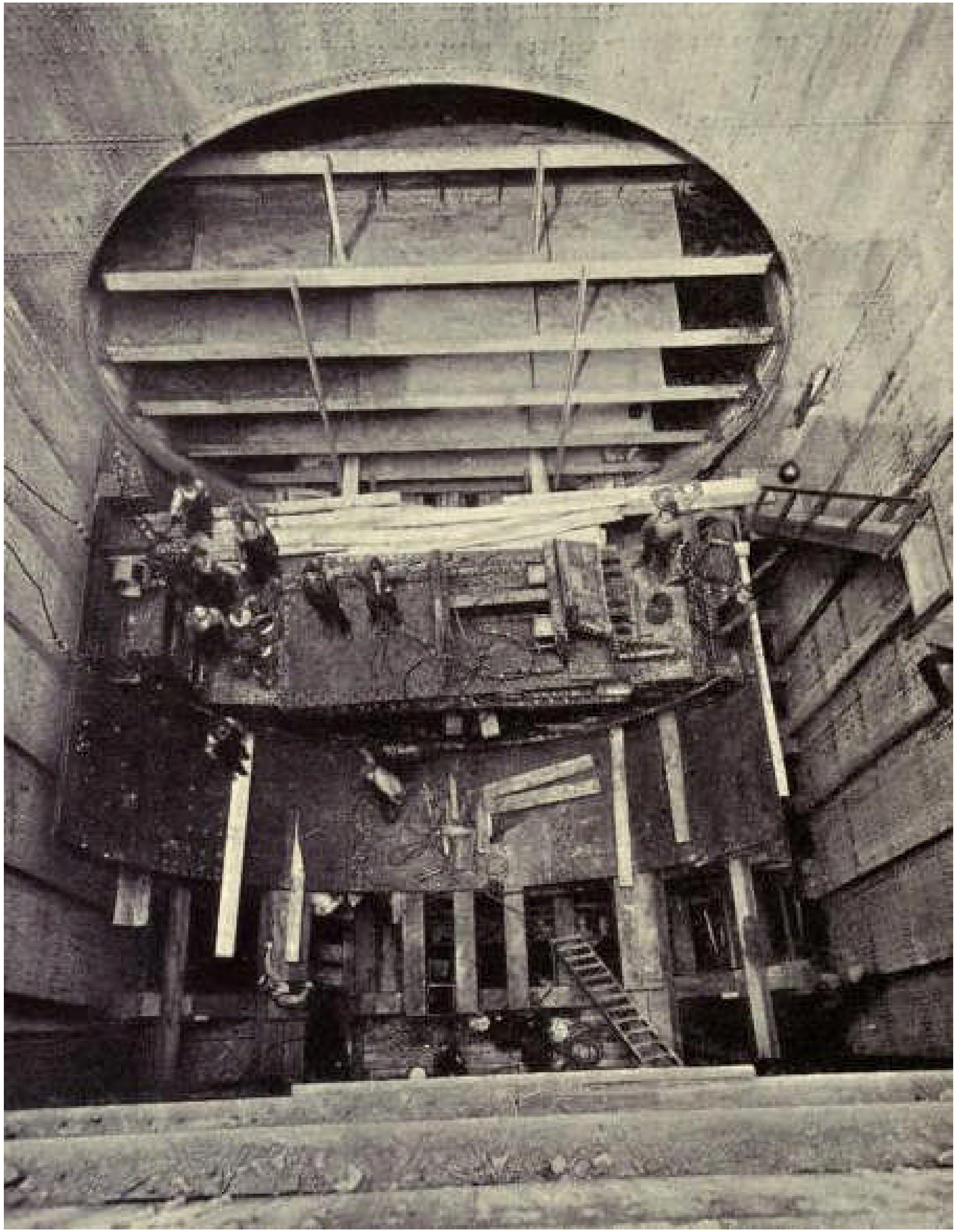
"…We picked up bits of rock for souvenirs and continued gasping when one of our hosts turned questioner. He asked if we could whistle. Assuring him that whistling did not stump the modern girl, we inquired his preference as to a tune. He consulted the other men, and after much deliberation proposed to give us a big party on the condition that we whistle 'Yankee Doodle' – all five verses. With one accord lips were puckered and cheeks distended. Our chagrin was only equaled by the laughter of our tormenters as we puffed and blew in vain. The party was given for the effort and not for the results obtained against twenty-nine pounds of pressure…"

RE: excerpt from *The Eighth Wonder*

"…In quitting the compressed air it was necessary to put on fleece-lined coats to prevent catching cold. We retraced our steps through the man-lock, where the pressure was reduced gradually back through the tube, and insisted on the law requirement of hot coffee on signing off…"

RE: excerpt from *The Eighth Wonder*

The End of the Beginning



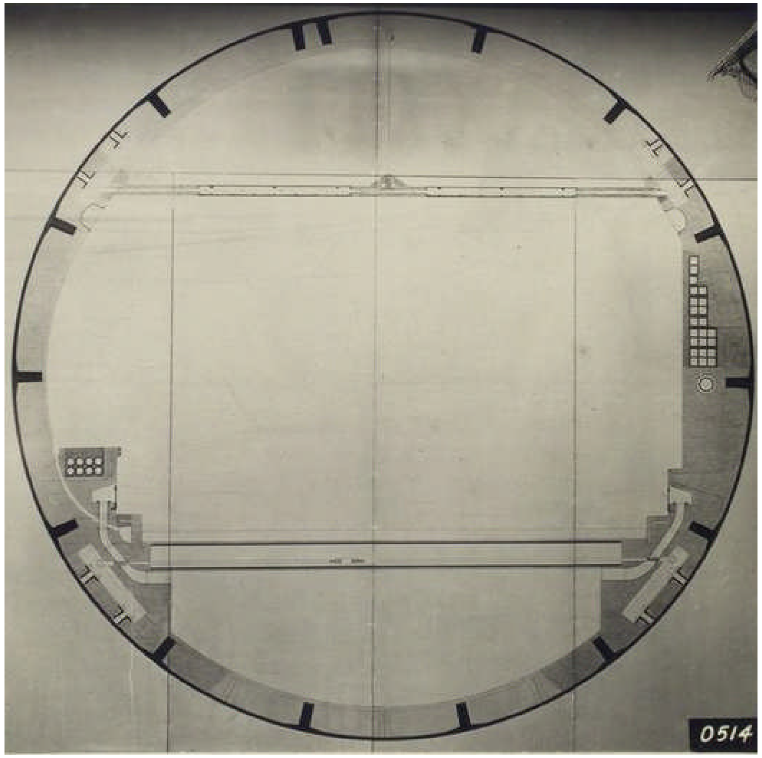
"…The first shield was erected in the Canal Street shaft. On October 26, 1922, compressed air was introduced into the shield chamber, and tunneling was begun…"

RE: excerpt from *The Eighth Wonder*

<u>Left</u>: caption: "Assembling Shield in Canal Street Shaft. View looking down into shaft, showing bulkhead in west side wall."

"…Each shield was 30 feet 2 inches in outside diameter, 16 feet 4 inches long, and the upper half was equipped with a hood projecting 2 feet 6 inches ahead of the shield proper. Five vertical and three horizontal walls divided the shield in to 13 compartments, through which the ground in front was excavated. It was equipped with thirty 10-inch jacks, having a combined thrust of 6,000 tons. A hydraulic erector was used to build the tunnel segments into a complete ring. The weight of the shield, with all equipment, was about 400 tons…"

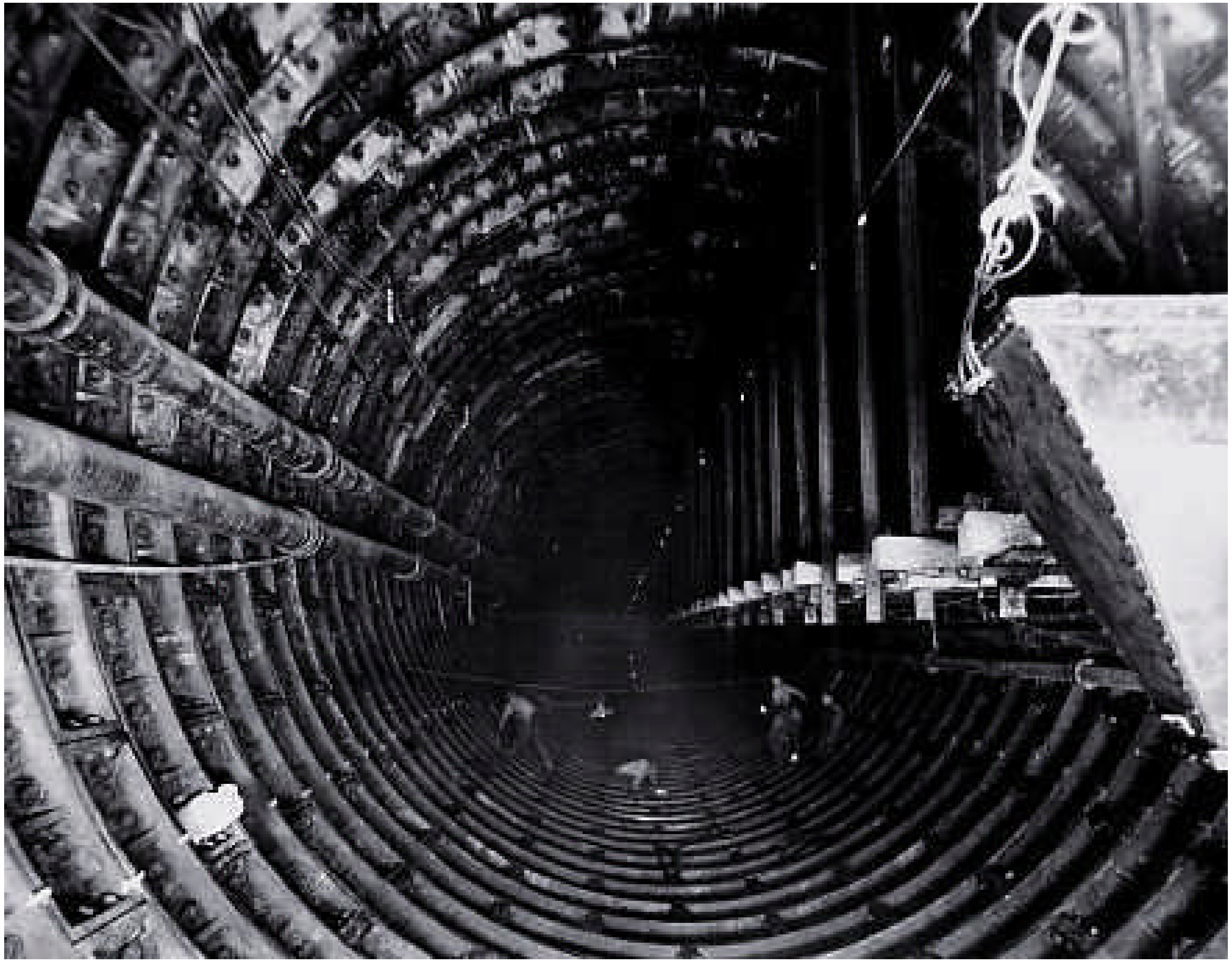
RE: excerpt from *The Eighth Wonder*

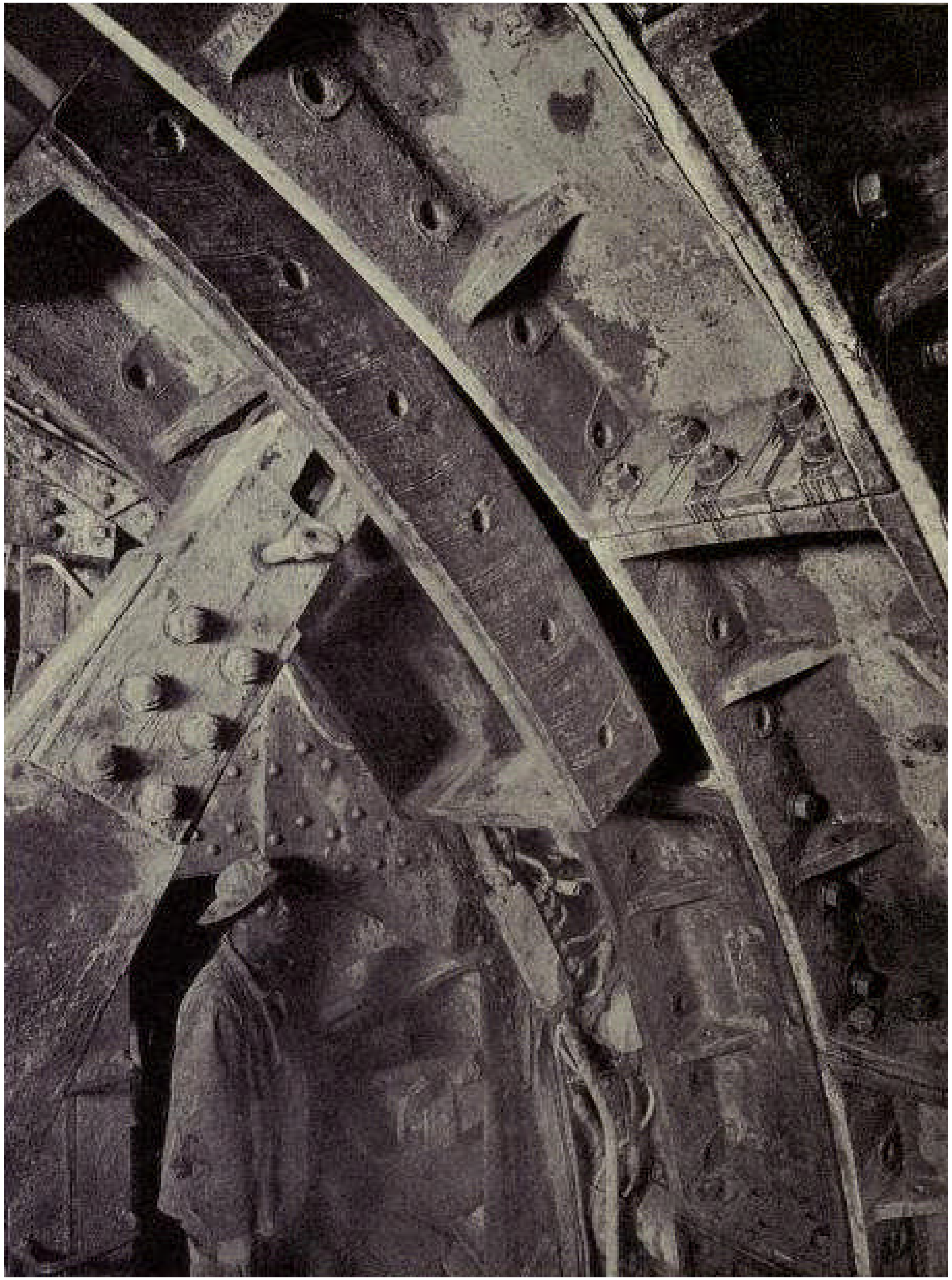


"…The tunnel lining is composed of rings 2 feet 6 inches wide, consisting of 14 segments, each approximately 6 feet long, with a key one foot long, bolted together. Inside the lining is an inner lining of concrete 19 inches thick…"

RE: excerpt from *The Eighth Wonder*

<u>Left</u>: caption: "Concrete lining of the tunnel showing different steps in placing"





"This work was done under a shield, or movable head, slightly larger than the external diameter of the tunnel. The shield was forced forward two and a half feet at a time, the width of a section, by means of thirty hydraulic jacks supported against the end of the tunnel already built. Several of the jacks were then removed and a segment was hoisted into place by a tremendous erector arm till a complete ring had been added, and then the shield was forced ahead again. Doors in the lower part of the shield allowed about thirty per cent of the displaced compressed silt to enter the tunnel on each shove…"

RE: excerpt from *The Eighth Wonder*

Left: caption: "Erector Arm. Swinging iron segment into place in tunnel lining, South Tunnel"

<u>Above Top</u>: caption: "Steel pile segments and forms for setting concrete invert. 4/30/25."

<u>Above Bottom</u>: caption: "Concrete invert, North Tunnel East, New Jersey"

<u>Left</u>: caption: "Iron men bolting plate in place, South tunnel, New York, 4/5/23"

<u>Above</u>: caption: "Proposed test - Cast Iron section. Canal Street, July 14, 1921."

<u>Above & Left</u>: **caption: "Broken plate. Cast-iron lining South tunnel. 11/22/22."**

Into the Void

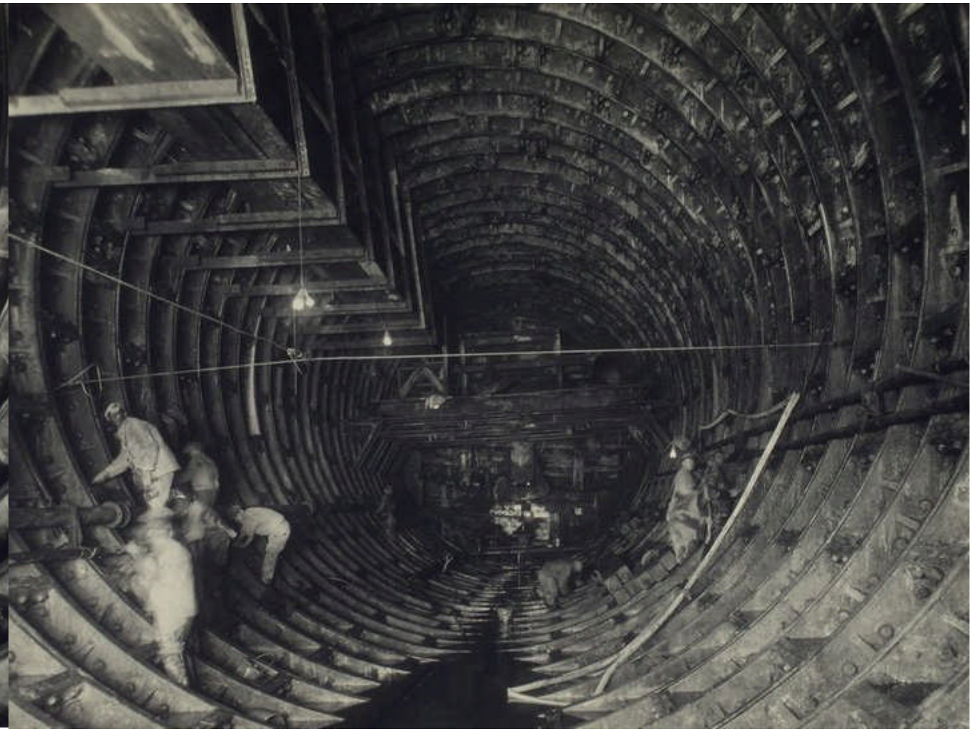
"…As the shield advanced and the lining was erected behind it, the space due to the difference in the diameter of the shield and the rings forming the lining was filled by forcing a grout of cement and sand in equal parts into the void under high air pressure. For this purpose each segment was provided with a grout hole fitted with a screw plug. The lining was made water-tight by placing hemp grommets soaked in red lead around the bolts, and by caulking lead wire into grooves between the segments…"

RE: excerpt from *The Eighth Wonder*

Left: caption: "Cast-iron tunnel segment with grout plug temporarily removed"

<u>Above</u>: caption: “Grouting in South tunnel, New York. 4/10/23.”

<u>Left</u>: caption: “Grout nose and nipple in plate with man on wrench, South tunnel, New York. 4/9/23.”



Top Left: caption: "Cleaning, caulking, pointing and making iron watertight invert, South Tunnel east, N.J. 12/5/24."
Top Right: caption: "North Tunnel West shield at Ring No. 312 and cleaning and caulking, N.J. 4/1/25."
Left: caption: "Ring No. 266, South tunnel, New York, showing clay and mud coming through grout hole. 6/13/23."

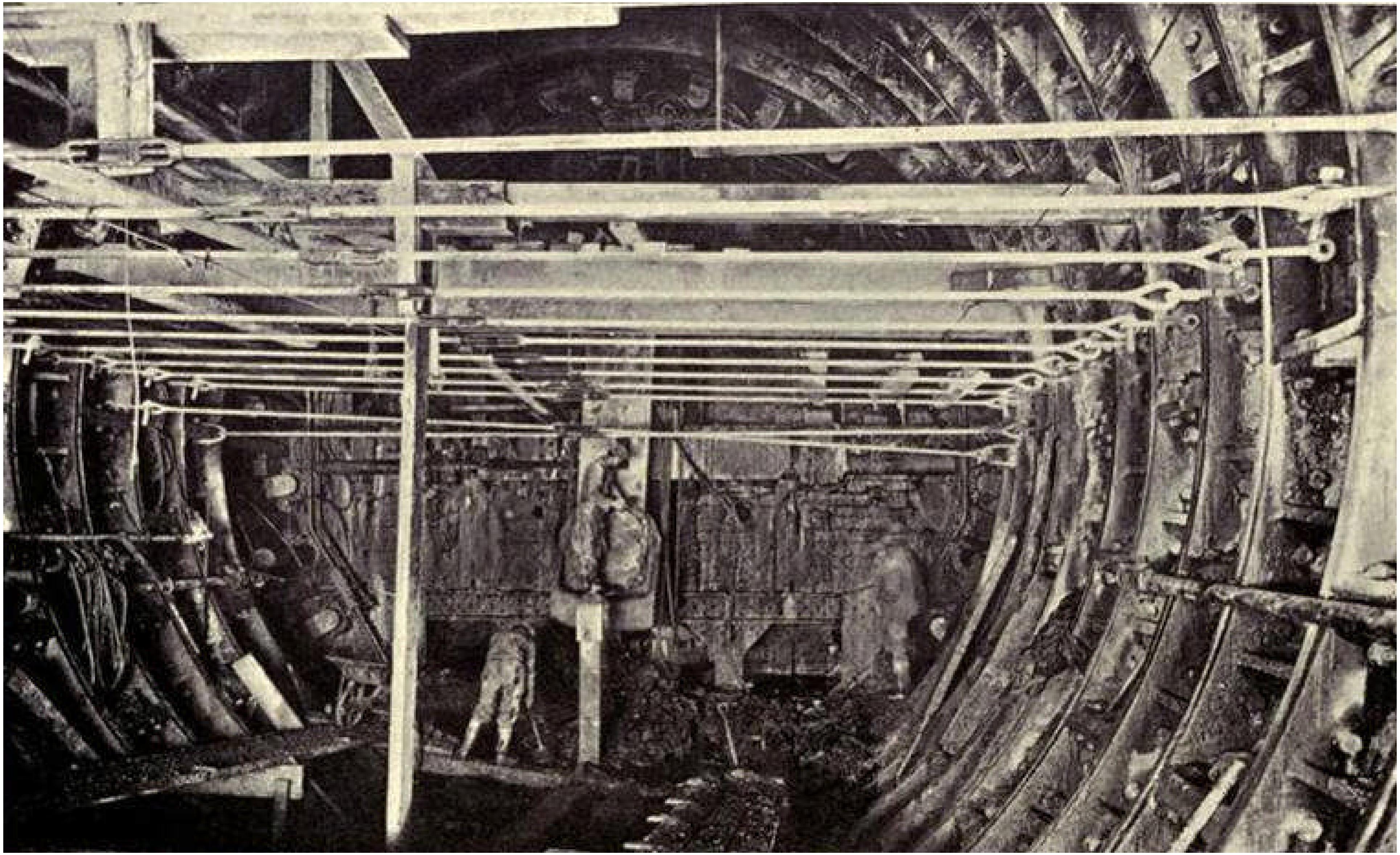
NY Shield Driving

"…Shield driving requires extreme care and exactitude to keep to line and grade. The position of the shield fixes the location of the tunnel, and no correction can be made afterward. It is absolutely essential that the slightest deviation of the shield from its theoretically correct position be known at once, so that measures may be taken to remedy the error during the next shove. The shield is guided by the operation of the jacks distributed around its circumference, omitting the use of those jacks in the direction toward which the shield is to move…"

RE: excerpt from *The Eighth Wonder*

"…The starting of the shields out of the caissons at the New York land shafts was difficult because of the large diameter of the shields and the shallow cover overhead. The material at this point was granular, consisting largely of fine sand, which if undisturbed, held air fairly well. As the shields were under the city streets, it was impossible to increase the cover overhead. To avoid blow-outs at the face with the consequent inrush of water, it was necessary to regulate the air pressure carefully and to protect the face during each successive step in excavating. As a preliminary step to shoving the shields out of the caissons, the circular steel bulkheads in the caissons were burned out in front of the shields. The work was done by removing the steel in horizontal layers, each layer carefully protected as the steel was removed to avoid exposing a great area of the face to air leakage, especially when the air pressure sufficient to dry out the bottom would be heavy enough to cause a blow-out at the top…"

RE: excerpt from *The Eighth Wonder*



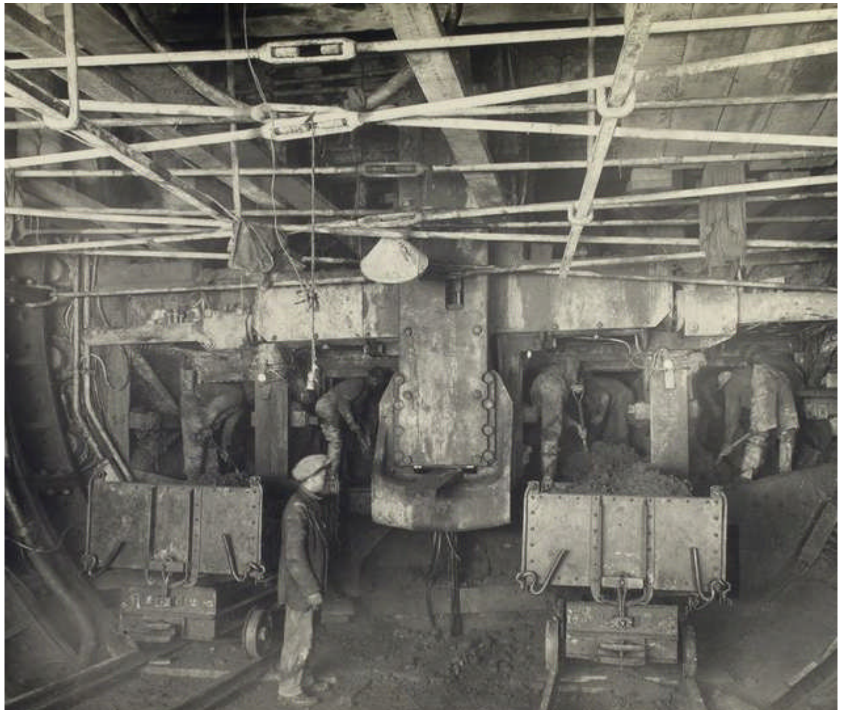
<u>Above</u>: caption: “Shield, South Tunnel, Canal Street at West Street, New York City. View of rear end of shield in place and temporary bulkhead. Tunneling operations temporarily suspended and air pressure removed in order to remove shaft deck and place cages in shaft and air locks in tunnel.”

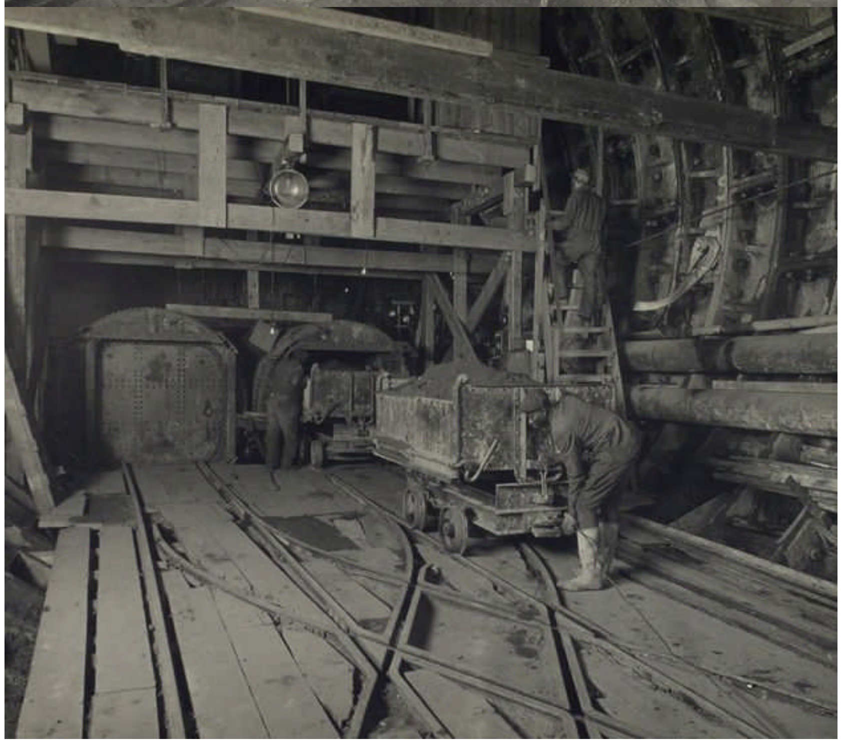
"…Removal of the steel bulkhead was started, with the steel above intact and with air pressure sufficient to dry out the bottom. After the lower third of the steel bulkhead had been removed, a wooden bulkhead was built in front of the shield, and the space between this bulkhead and the ground ahead was packed with clay. The air pressure was then reduced until it balanced the water pressure at the top of the shield, and work was begun at the top, removing the top plates and proceeding downward. As these plates were removed, breast boards packed front and back with clay were inserted to cover the exposed excavation. This work proceeded down to the point where the bottom plates had previously been removed, while at the same time the air pressure was raised step by step to balance the water pressure. The shield was then advanced against the wooden bulkhead at the bottom, compressing the clay which was removed as the shield advanced, with the jacks reacting against the cast-iron tunnel lining temporarily erected in the shaft…"

RE: excerpt from *The Eighth Wonder*

"…In order to prevent the leakage of air around the hood of the shield, an annular pocket was excavated ahead of the hood the full length of a shove, and the pocket was packed with clay. This served a double purpose: first, the hood, as the shield advanced, cut into this clay and made a thorough seal in front against air leakage; and second, by exploring the full length of the shove, assurance was had that the shield would not pick up and drag timbers in front of it, leaving open channels behind them through which air could readily escape. The necessity of taking this precaution is evident when it is considered that at this point there were but 14 feet of cover above the shield to the street surface, and only 8 feet from the top of the shield to the under side of an old brick sewer, which would readily allow the air to escape from the tunnel heading…"

RE: excerpt from *The Eighth Wonder*



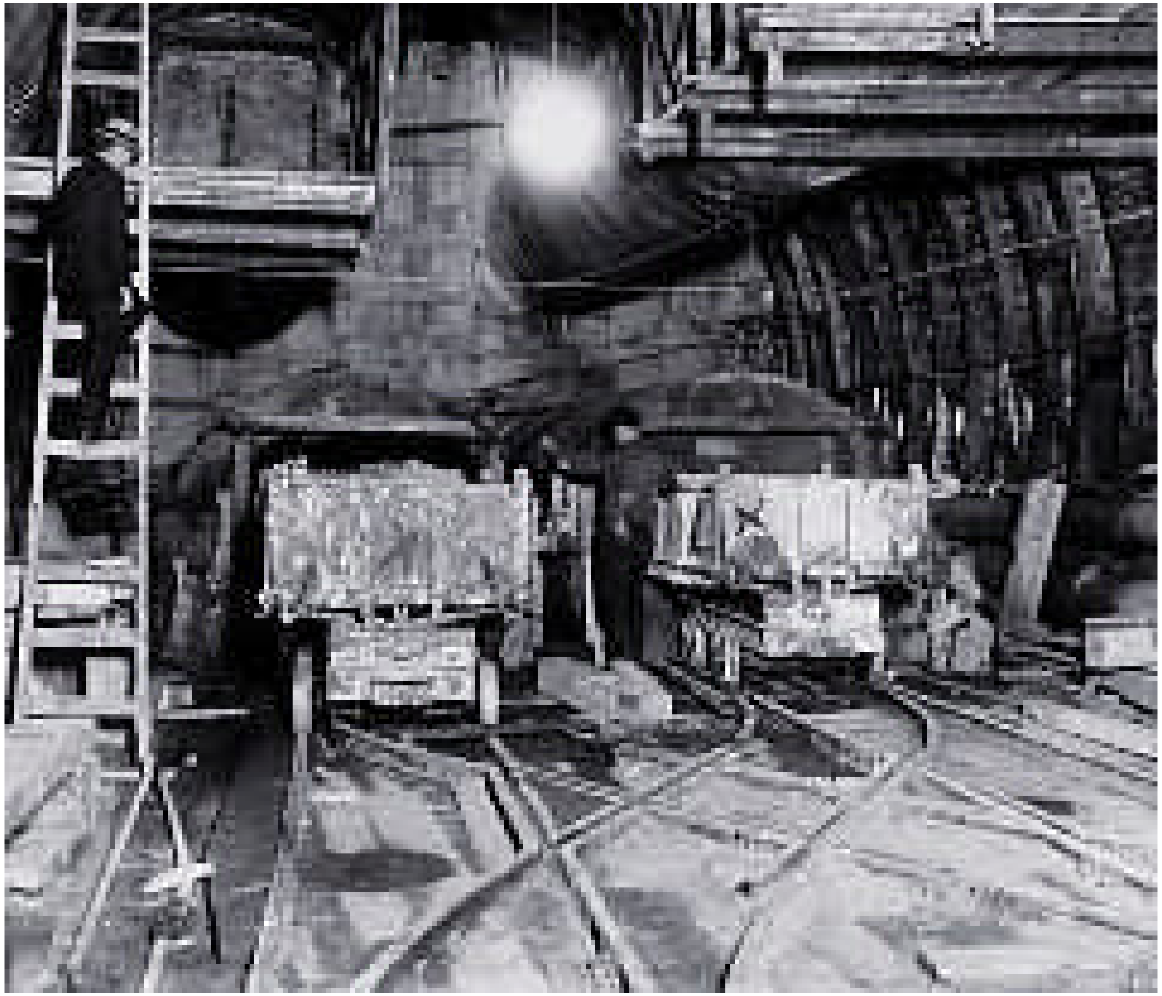


"…As the tail of the shield left the caisson, grouting was at once started to fill the annular space which the shield left outside the tunnel lining. Every effort was made to keep this space fully grouted, even to the extent of stopping the shield in the middle of a shove to keep the grout up with the shield. The method just described was later modified so that in the bottom quarter of the shield, instead of packing ahead with clay, a fixed wooden bulkhead was built in the shield, and the shield was advanced into the fine wet sand with this bulkhead in place. This compressed the earth, driving out the water, so that the material was firm and could be excavated during the shove over the top pf the bulkhead, or through small openings in the bulkhead itself. This prevented a free run a wet material into the bottom which is the ordinary method of tunneling under a river…"

RE: excerpt from *The Eighth Wonder*

<u>Top</u>: caption: "Miners in shield, shoveling out, South tunnel, New York. 4/5/23."

<u>Bottom</u>: caption: "Muck cars coming out of muck lock, South tunnel. 4/25/23."



"…The grouting previously described was continued, and not only prevented an abnormal escape of air at the tail of the shield, but also prevented settlement of the streets and adjacent buildings. The buildings at the corner of West and Spring Streets settled slightly, but at no time were they in need of shoring, nor were the occupants disturbed at any period of the tunnel work. This was the situation also with the New York Central tracks under which the Canal Street tunnel was driven. The grouting was carried on so effectively that it filled some of the old sewers in the vicinity which later had to be cleaned out…"

RE: excerpt from *The Eighth Wonder*

Too Close for Comfort

“…The Canal Street shield passed very close to a cofferdam around an excavation for a sewage treatment plant, and it was evident from the first that great care must be exercised in driving the tunnel past this location. At the nearest point the shield was within 5 feet of the steel sheeting of the cofferdam, with the bottom of the sheeting at about the springing line of tunnel. On November 30th, when the shield was about 40 feet away, it was noticed that sand and water were being forced through the sheeting into the cofferdam by the air pressure from the tunnel heading. In about two hours approximately 159 cubic yards of earth had been blown into the excavation from behind the sheeting, and it was plain that not only was the cofferdam in danger, but the continuation of tunneling operations would be hazardous because the cavities left in the ground provided open channels for the leakage of air, which might have resulted in a tunnel blow-out. It was decided that tunneling operations should be temporarily suspended, that the steel sheeting of the cofferdam should be left in place permanently, and the concrete walls of the permanent structure be placed immediately, being increased in thickness to enable them to withstand the pressure from tunneling operations…”

RE: excerpt from *The Eighth Wonder*

NY River Bulkheads

"…Preparatory to tunneling under the river bulkhead, clay and other material to prevent the escape of the compressed air from the tunnel were deposited in the slip between the piers and on the landward side of the river bulkhead construction. Not only were the voids around the piles filled, but the soft mud in the slip was displaced by the heavier clay, a firmer material and better adapted to resist air leakage…"

RE: excerpt from *The Eighth Wonder*

Left: caption: "Marginal Street in front of Lehigh Valley Pier No. 34 - view of clay bagging placed on the surface of the ground to prevent air escaping from South tunnel, New York. 4/24/23."

"…In this section great care was taken in excavating ahead of the hood to be sure that all piles within the area of the tunnel section were cut off before coming in contact with the shields. This was done to avoid pushing the piles through the ground and leaving back of them an open channel for air to escape. These piles extended down to the springing line of the tunnel excavation, and as many as thirty had to be cut off at one time in advancing the shield the length of one ring. In this manner both shields passed under the river bulkhead without accident…"

RE: excerpt from *The Eighth Wonder*

<u>Above</u>: caption: "Piles encountered in breasting down for ring No. 144, South tunnel, N.Y. 4/25/23."

Hudson River Silt

"…The tunnels then entered the Hudson River silt. The front of the shield was completely bulkheaded. Some of the lower pockets in the shield were opened to allow a part of the material to enter the tunnel as the shield was advanced. The balance of the material in excavation was displaced bodily…"
RE: excerpt from *The Eighth Wonder*

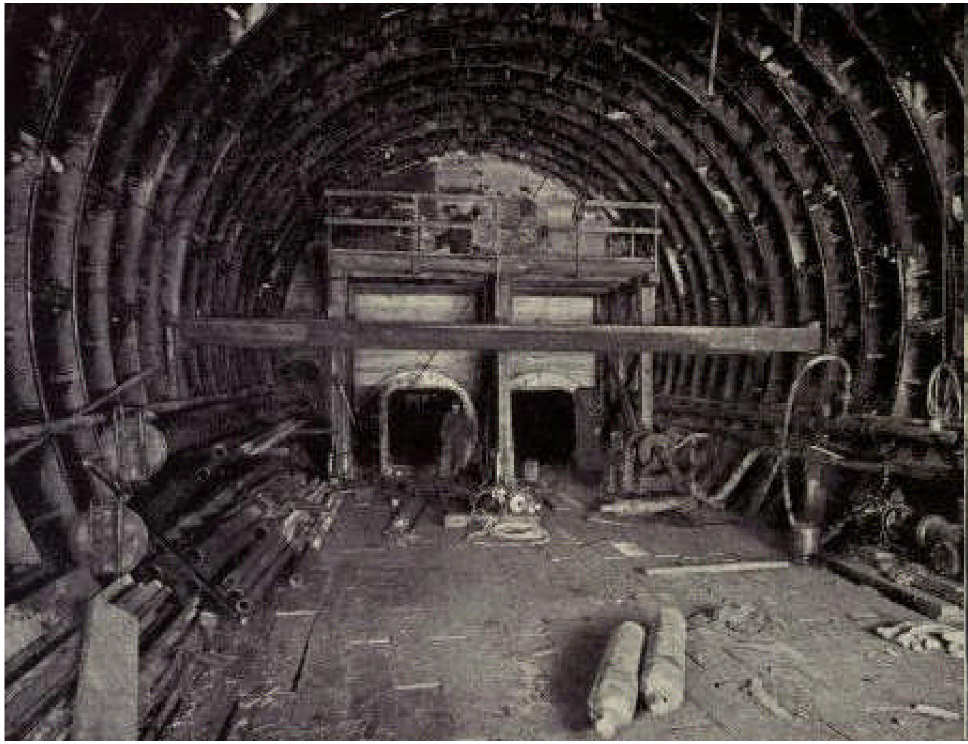
"…At once it was noticed that there was a tendency for the tunnel lining to rise behind the shield. This rising always accompanied movement of the shield; whenever the shield was stopped the rising ceased. The difficult feature at this point was that the shield was so heavy that it settled while the cast-iron tunnel lining behind the shield rose, so that the shield at all times was below grade while the tunnel lining a short distance back was above grade…"

RE: excerpt from *The Eighth Wonder*

<u>Left</u>: caption: "Tightening bolts in New Jersey North Tunnel East. 05/09/24."

"…The bulkhead contained four air chambers or locks. Two large compartments at the bottom of the bulkhead were equipped with tracks for bringing supplies to the workers and for removing excavated material. Two smaller chambers were provided in the upper section for the workmen who on entering or leaving the tunnel must be gradually brought from one pressure to another…"

RE: excerpt from *The Eighth Wonder*




"…The bulkheads in the shield were moved forward to reduce weight by lessening the amount of muck in the shield. This aided somewhat in keeping the shield from settling and then more material could be taken in through the shield. This procedure lessened the pressure on the tunnel behind and reduced its tendency to rise. As the contract required that a second tunnel bulkhead should be constructed in this vicinity, the south shield was stopped after passing through 218 feet of silt and the bulkhead was built. This bulkhead, which is typical of all the bulkheads, is a concrete wall 10 feet thick, equipped with the usual muck, man and emergency locks, and adds temporarily considerable weight to the tunnel…"

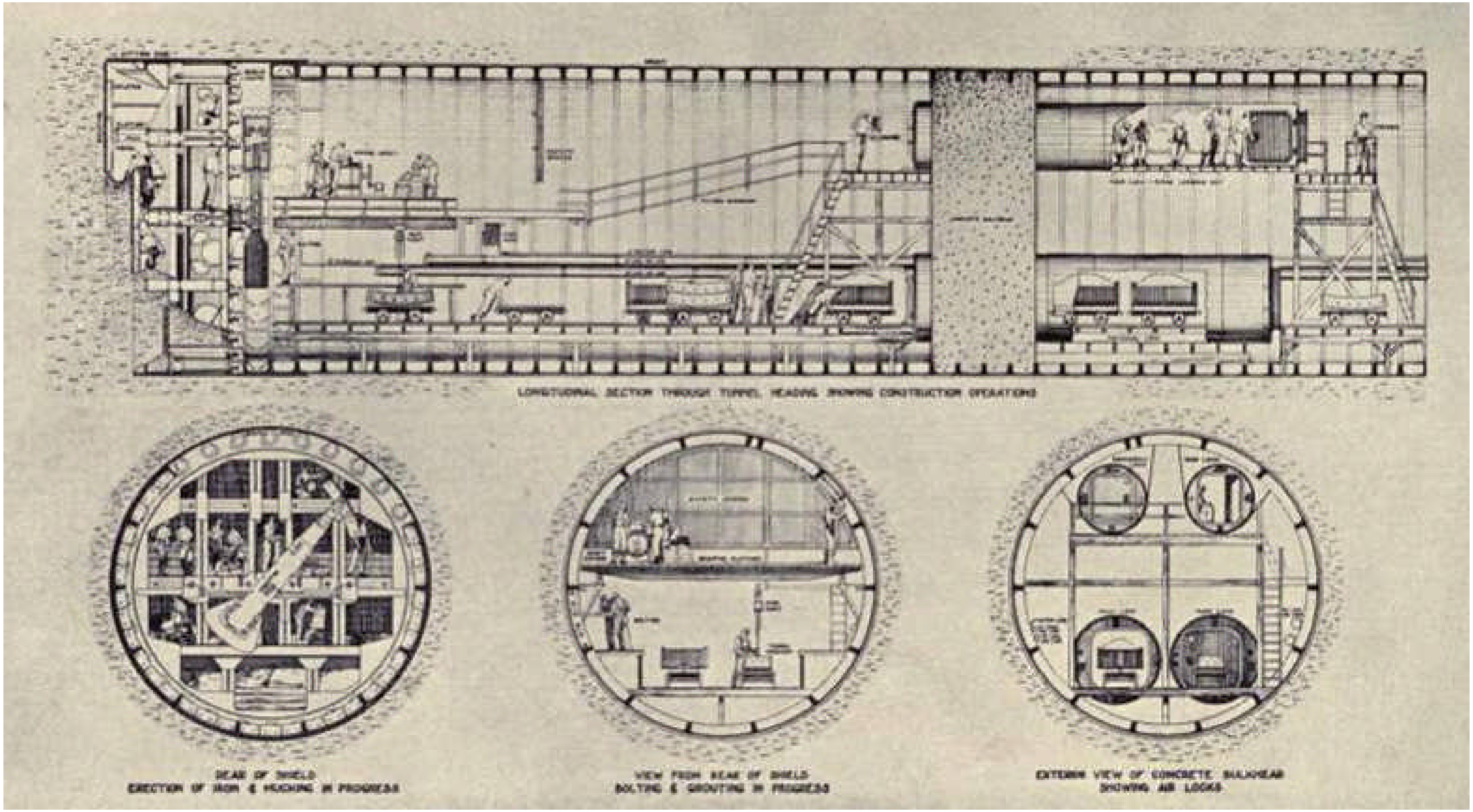
RE: excerpt from *The Eighth Wonder*

<u>Left</u>: caption: "Concrete Bulkhead and Locks. South Tunnel, Canal Street, NYC"

<u>Right</u>: caption: "Bulkhead from inside. South tunnel. New York, 4/7/23."

"…With this additional weight, the rising of the tunnel was somewhat checked and after tunneling a distance of 121 feet farther in the silt the shield entered at the bottom of the sand layer which overlies the rock, and thereupon all rising of the completed tunnel during shield driving ceased. In the north tunnel, which was driven through the same material after the south tunnel was built, a larger amount of material was taken in through the shield at the start, and while there was some rising of this tunnel behind the shield, it was very much less than in the south tunnel. In neither tunnel was the movement sufficient to endanger the structure…"

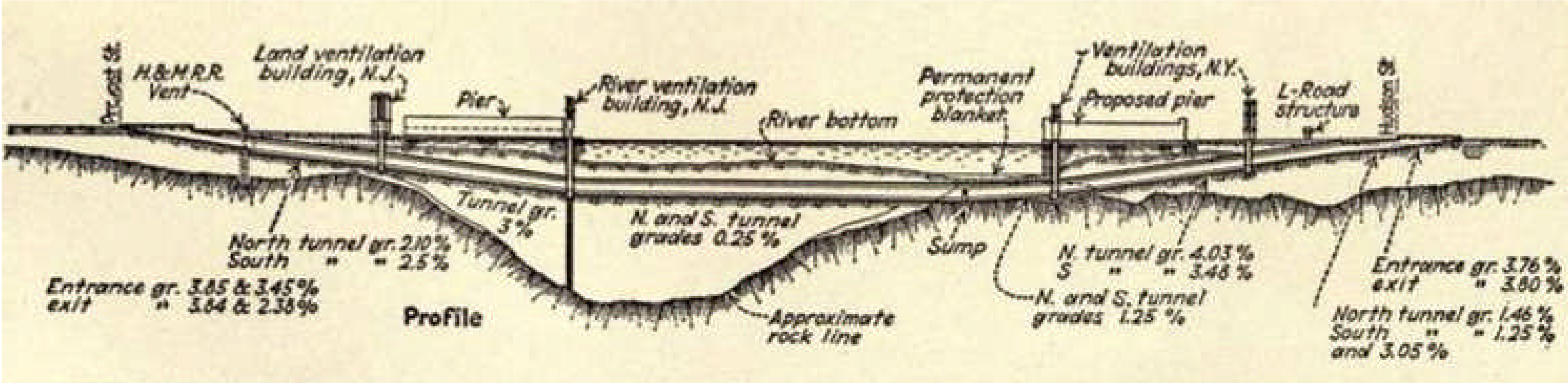
RE: excerpt from *The Eighth Wonder*



<u>Above</u>: caption: "Longitudinal Section Through Tunnel Heading, Showing Construction Operation. Below, rear of shield showing erection of iron and mucking in process; view from rear of shield with bolting and grouting in process; exterior view of concrete bulkhead showing air locks"

"…The excavation in the part-earth and part-rock section just east of the New York river shaft caisson was carried on by driving a short bottom heading in advance of the shield, in which was placed a concrete cradle with steel rails embedded in it upon which the shield slid. After placing the cradle the rock was blasted out for one or two advances of the shield and then the soft material on top was carefully excavated and supported by poling and breast boards…"

RE: excerpt from *The Eighth Wonder*



"…Ever ride through the Holland Tunnel in your car? An easy, effortless and safe trip, wasn't it? Well, don't be alarmed when you learn that certain sections of this sturdy old tube - the granddaddy of all sub-aqueous vehicular tunnels - rise and fall with the Hudson River tides. The reason is simply that part of the tunnel rests on river silt and another section, near the New York pierhead line, on a ledge of rock. Upon the rock the tunnel resists the tides but where it leaves the rock and enters silt, immobility leaves off and mobility sets in…lined the mobile section with cast steel instead of the cast iron used elsewhere. The greater tensile strength of steel absorbs the strain, making the so-called 'bending' perfectly harmless…"

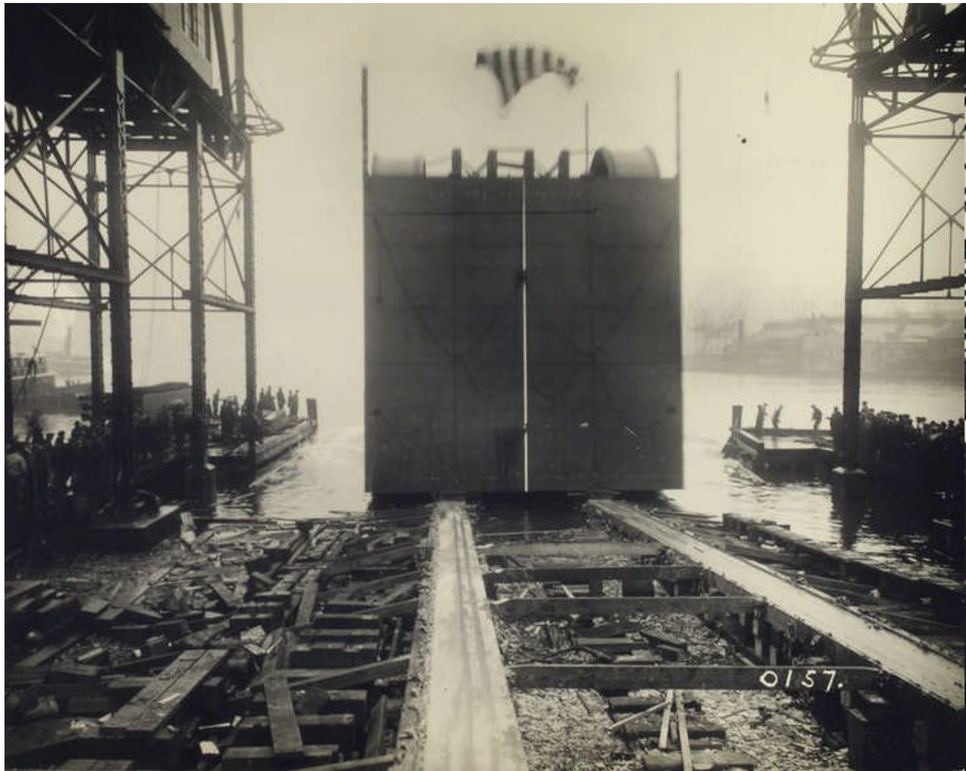
Mechanix Illustrated, **June 1941**

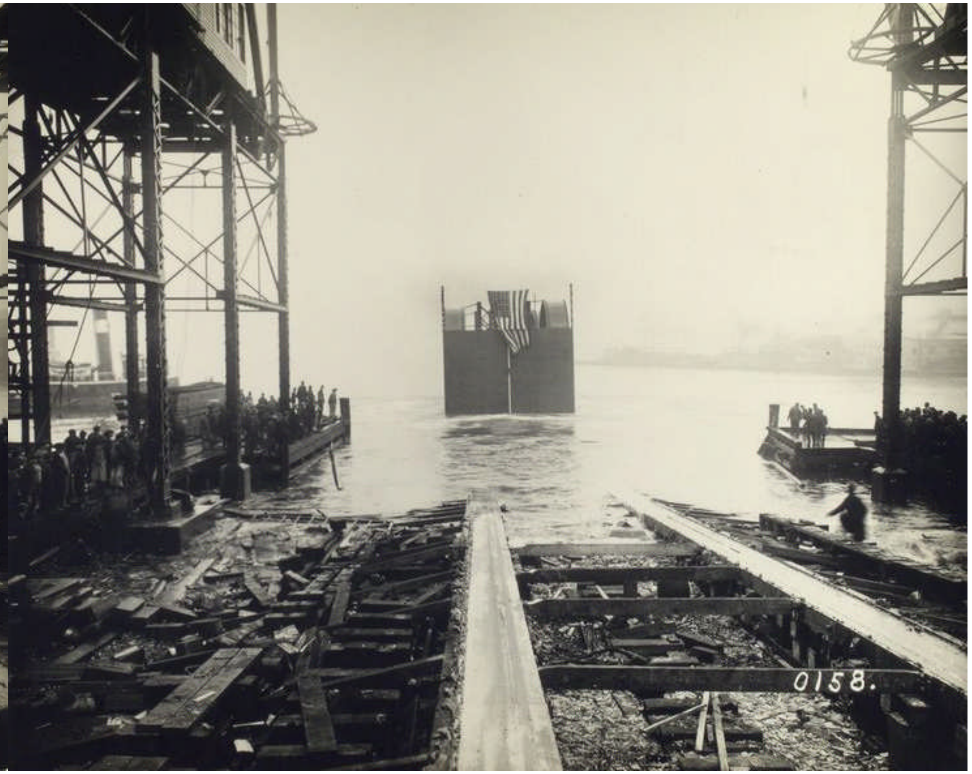
Above: caption: "Profile of the Holland Tunnel"

NY River Caisson

"…The New York river ventilating shaft caisson was sunk by the compressed air method in the river near the New York overhead line. It was built on launching ways, then launched and drydocked. After concrete had been placed in the pockets surrounding the working chamber, additional steel was erected, carrying it to a height of 55 feet…"

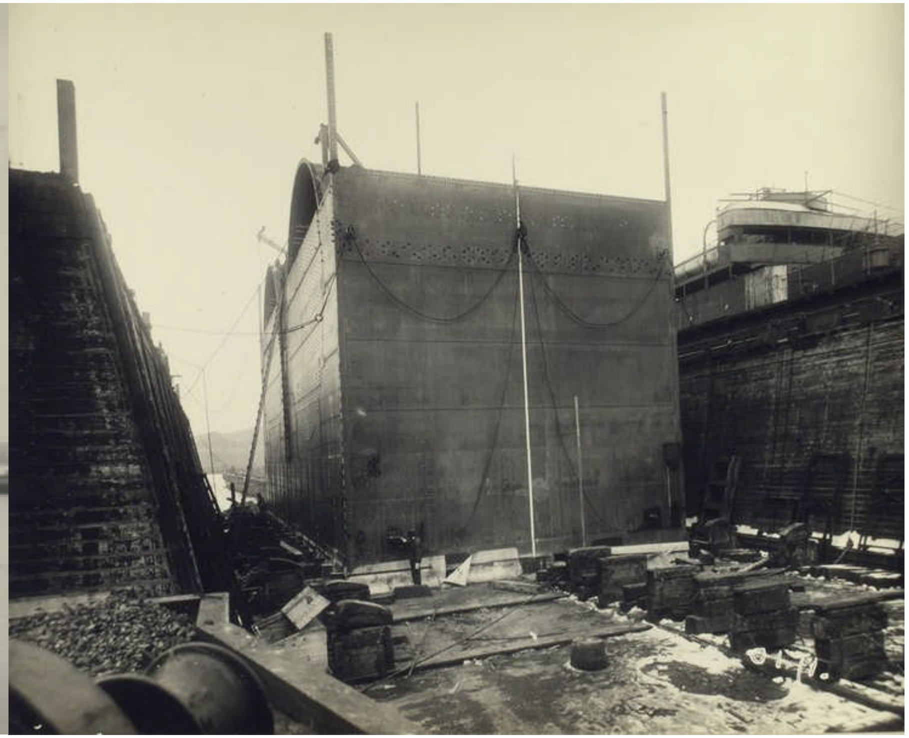
RE: excerpt from *The Eighth Wonder*





<u>Above L&R</u>: caption: “View of launching of New York River Shaft Caisson, Staten Island Shipbuilding Co.’s Plant, Mariner‘s Harbor, S.I. 12/5/22.”

<u>Left</u>: caption: “Launching party, launching of New York River Shaft Caisson, Staten Island Shipbuilding Co.’s Plant, Mariner‘s Harbor, S.I. 12/5/22.”



<u>Top Left</u>: caption: “View of launching of New York River Shaft Caisson, Staten Island Shipbuilding Co.’s Plant, Mariner’s Harbor, S.I. 12/5/22.”

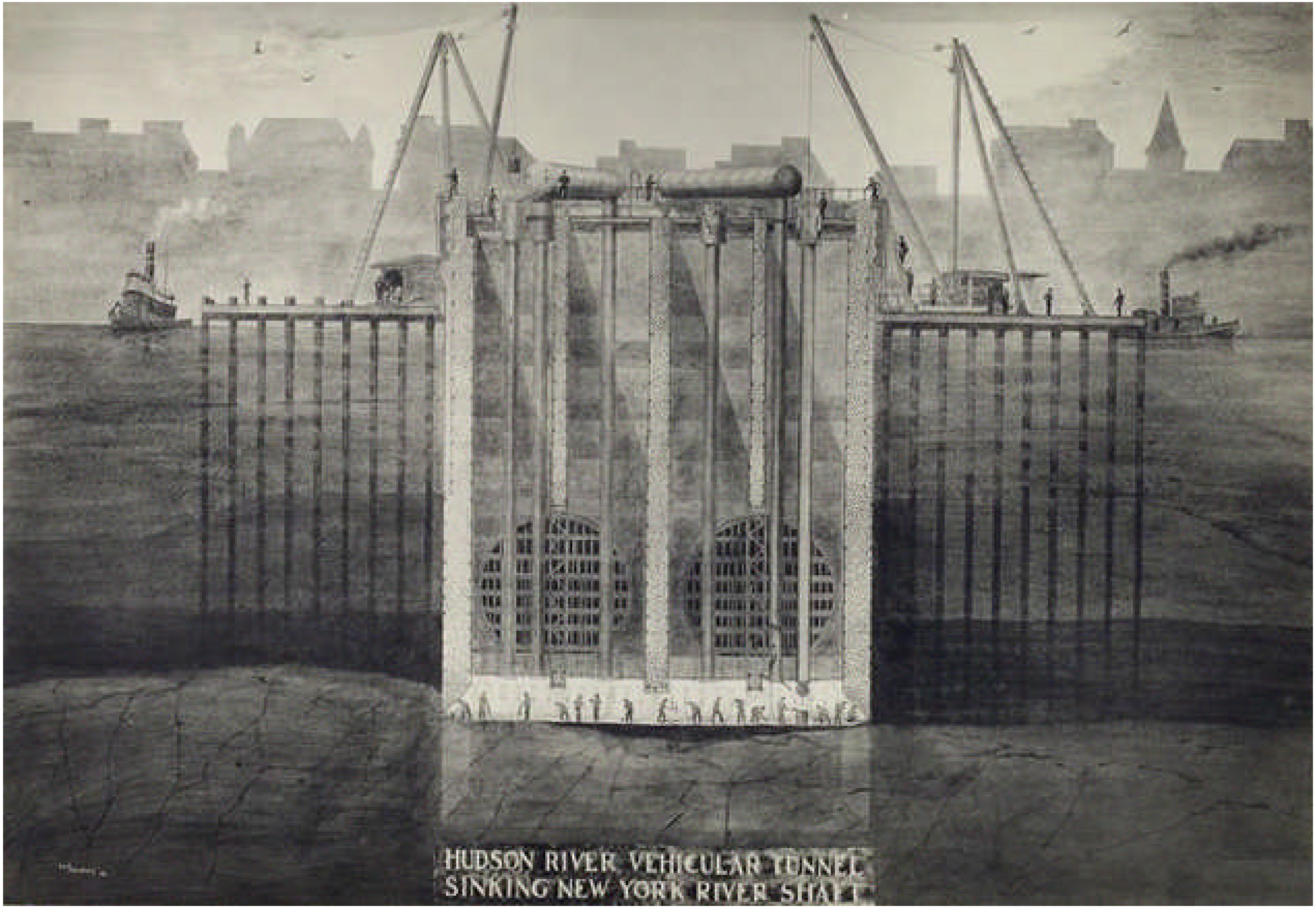
<u>Top Right</u>: caption: “General view New York River Shaft Caisson in dry dock after launching, Staten Island Shipbuilding Co.’s Plant, Mariner’s Harbor, S.I. 12/5/22.”

<u>Left</u>: caption: “General view New York River Shaft Caisson. Staten Island Shipbuilding Co.’s Plant. Mariner's Harbor, S.I. 1/2/23.”

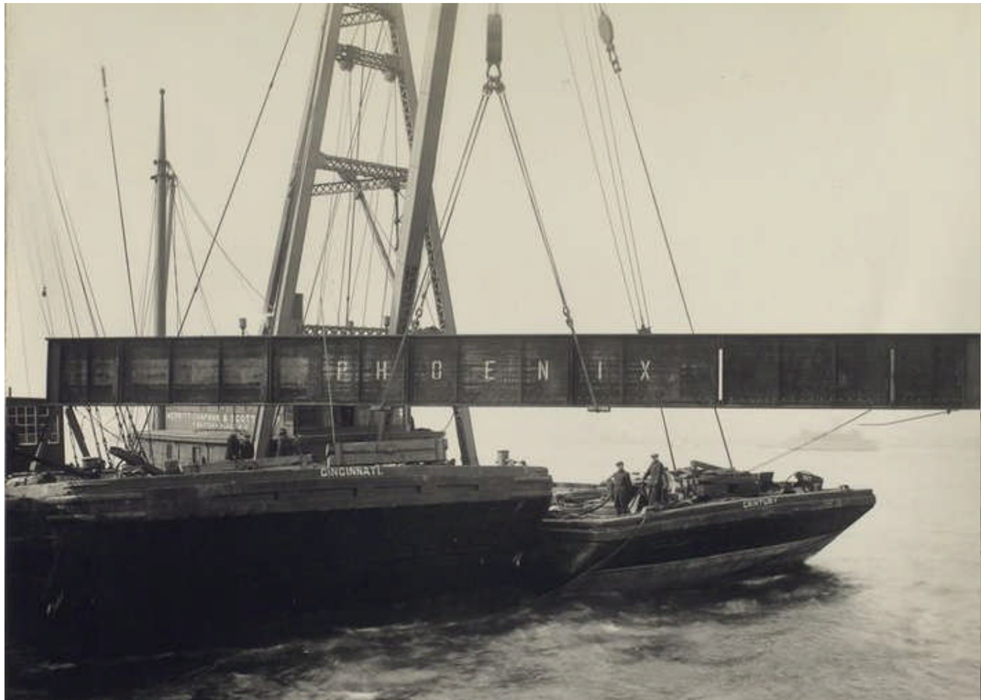
<u>Above</u>: caption: "General view New York River Shaft Caisson. Upper New York Bay North of St. George, S.I. 1/20/23."

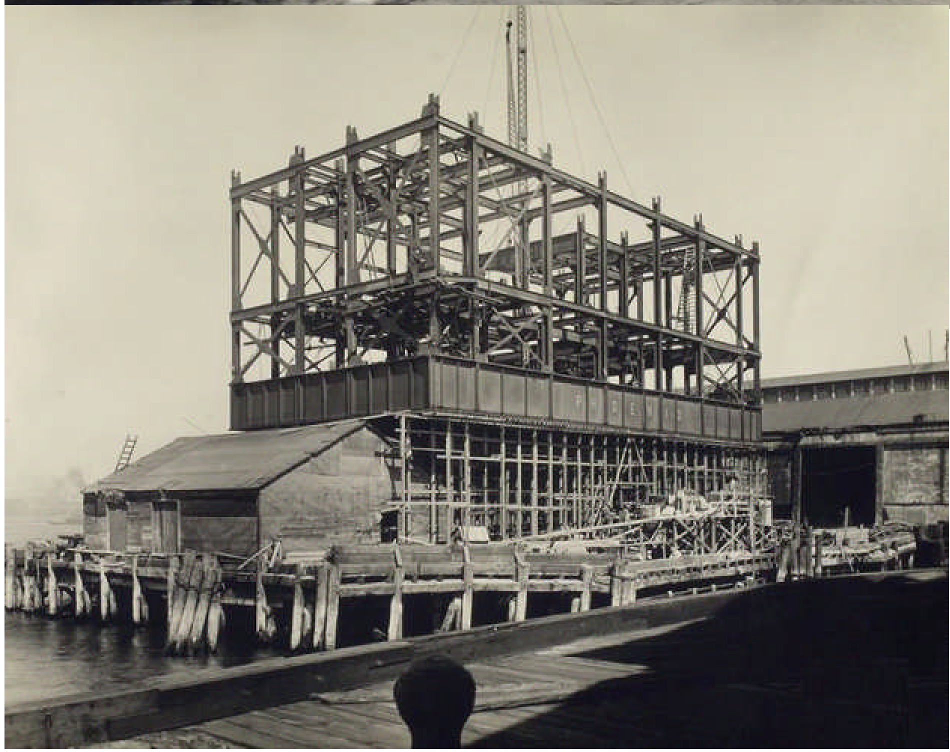
"…A platform supported on piles had been built on three sides of the site (the south side being open ready to receive the caisson), and the caisson was towed to its position on the work. The caisson at that time weighed approximately 1,650 tons. Upon arrival, additional steel was erected and concrete was placed in the walls, the caisson sinking as the additional weight was placed. Care was taken to keep the entire center of gravity as low as possible to maintain the necessary stability. When it had reached a depth of 35 feet, the cutting edge encountered the river bottom, into which it settled at each low tide, and weight was added with sufficient rapidity to overcome the tendency to float on the subsequent rising tide…"

RE: excerpt from *The Eighth Wonder*



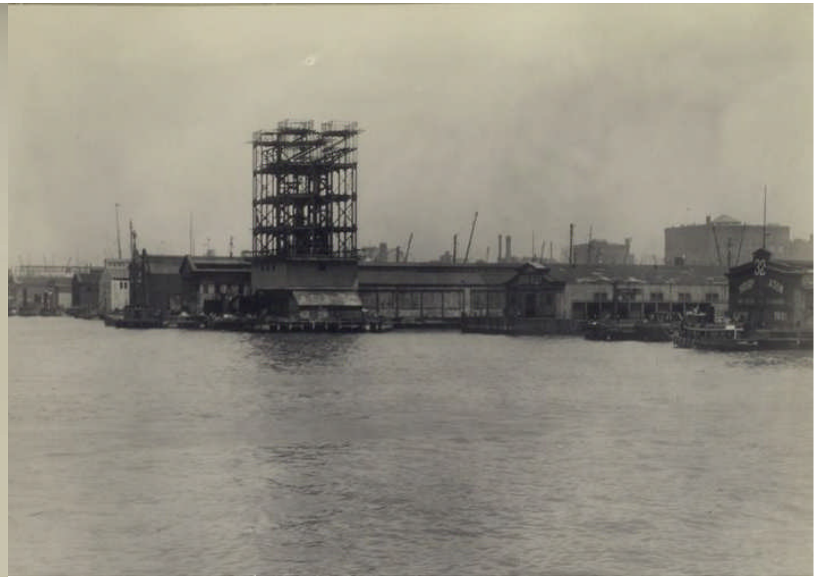
<u>Above</u>: rendering showing operations of sinking New York River Shaft Caisson



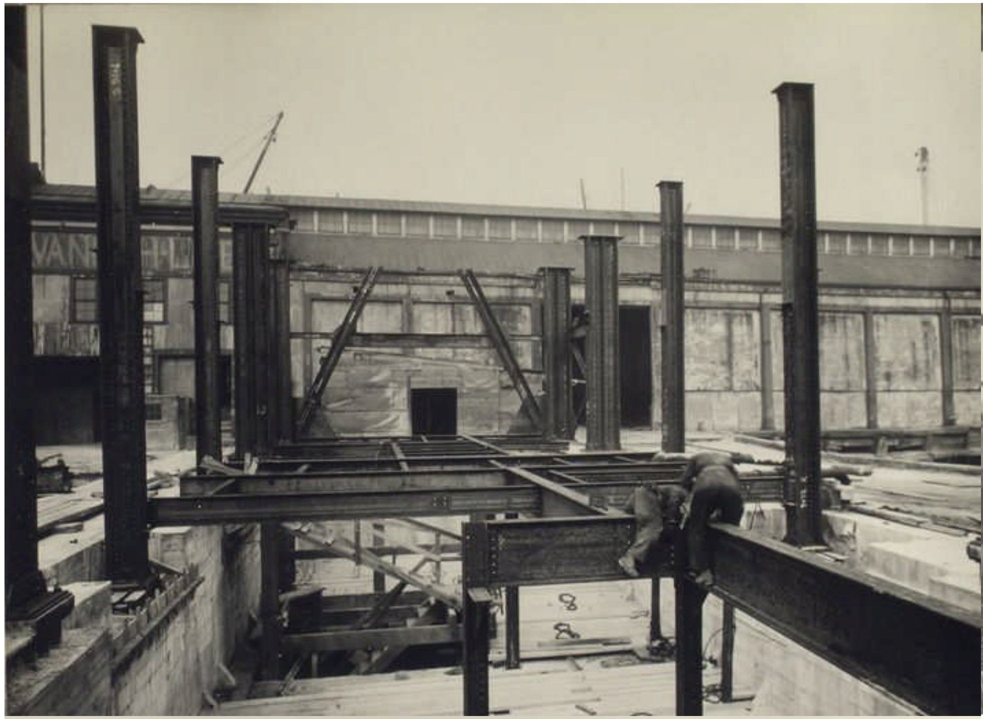


<u>Above L&R</u>: caption: "River Ventilation Building, New York. Erection of steel girders. 3/12/26."

<u>Left</u>: caption: "River Ventilation Building, New York. Erection of steel to third floor level. 4/20/26."



<u>Above</u>: caption: "Steel framing and brick work - River Ventilation Building, New York. 6/10/26."
<u>Left</u>: caption: "River Ventilation Building, N.Y. Erection of steel to fourth floor. 5/4/26."

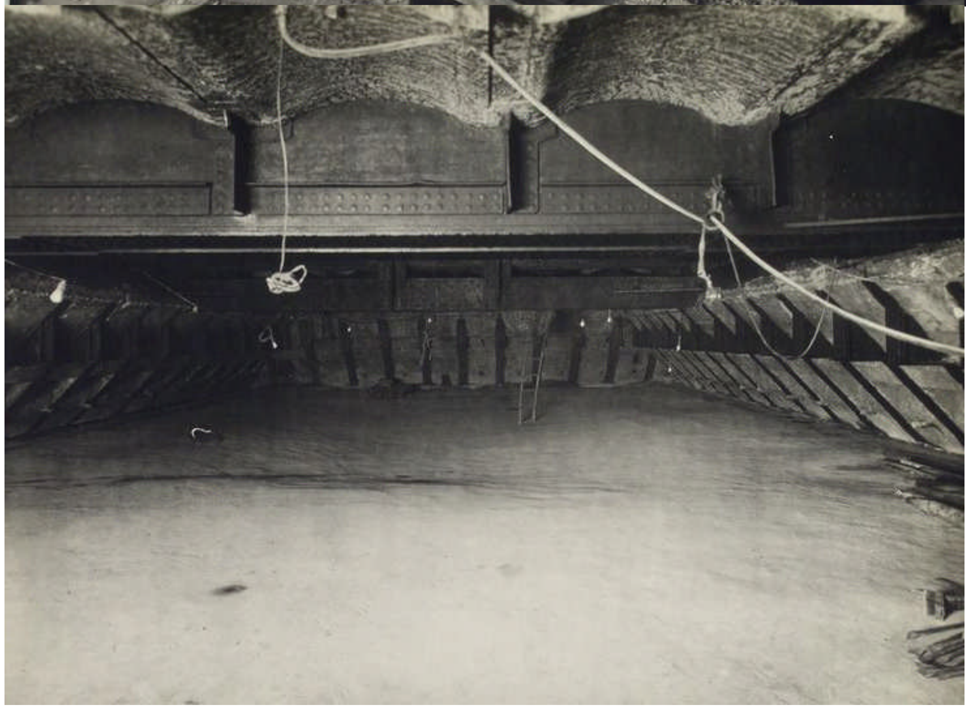


<u>Top Left</u>: caption: "River Ventilation Building. Steel columns for Pier Deck and mezzanine floors, N.Y., New York. 5/28/26."
<u>Top Right</u>: caption: "Progress of placing electrical conduits in River Ventilation Building, New York. 6/5/26."
<u>Left</u>: caption: "River Ventilation Building, Pierhead Line between Piers 34 and 35, North River, New York. 11/17/26."

"…No excavation was carried on in the working chamber until the cutting edge had penetrated about 9 feet into the mud, as the weight of the caisson displaced the material up to this point. Compressed air was then introduced into the working chamber and the usual shaft mucking operations started. At a depth of 69 feet below mean high water, rock was encountered. This was taken out in lifts about 6 feet deep and the caisson was lowered by successive drops until it reached its final position. The upper half of the outside of the caisson, or the part which is exposed to open water, was covered with waterproofing, which in turn was covered with an 18-inch layer of protection concrete. An additional protection is afforded in the upper portion by a granite facing where the shaft is expose to tidal action…"

RE: excerpt from *The Eighth Wonder*





<u>Top Left</u>: caption: "General interior, view of working chamber, New York River Shaft Caisson. 12/20/22."
<u>Top Right</u>: caption: "Working chamber, River Shaft Caisson, New York. 8/22/23."
<u>Left</u>: caption: "Protection Concrete bottom River Shaft Caisson, N.Y. 12/31/23."

"…After the caisson was sealed to the rock and waterproof, the east and west shield bulkheads in both the North and South Tunnel chambers were burned out and both shields were driven through the caisson. A timber and concrete cradle of sufficient strength to carry the shield was erected in each chamber and the shield jacked across. After the shields had progressed a sufficient distance west of the river shaft to permit tunnel bulkheads, these were built in each tunnel and placed in operation. After this, tunneling operations were carried on from the river shaft, releasing the tunnels between the land and river shafts for the placing of concrete lining…"

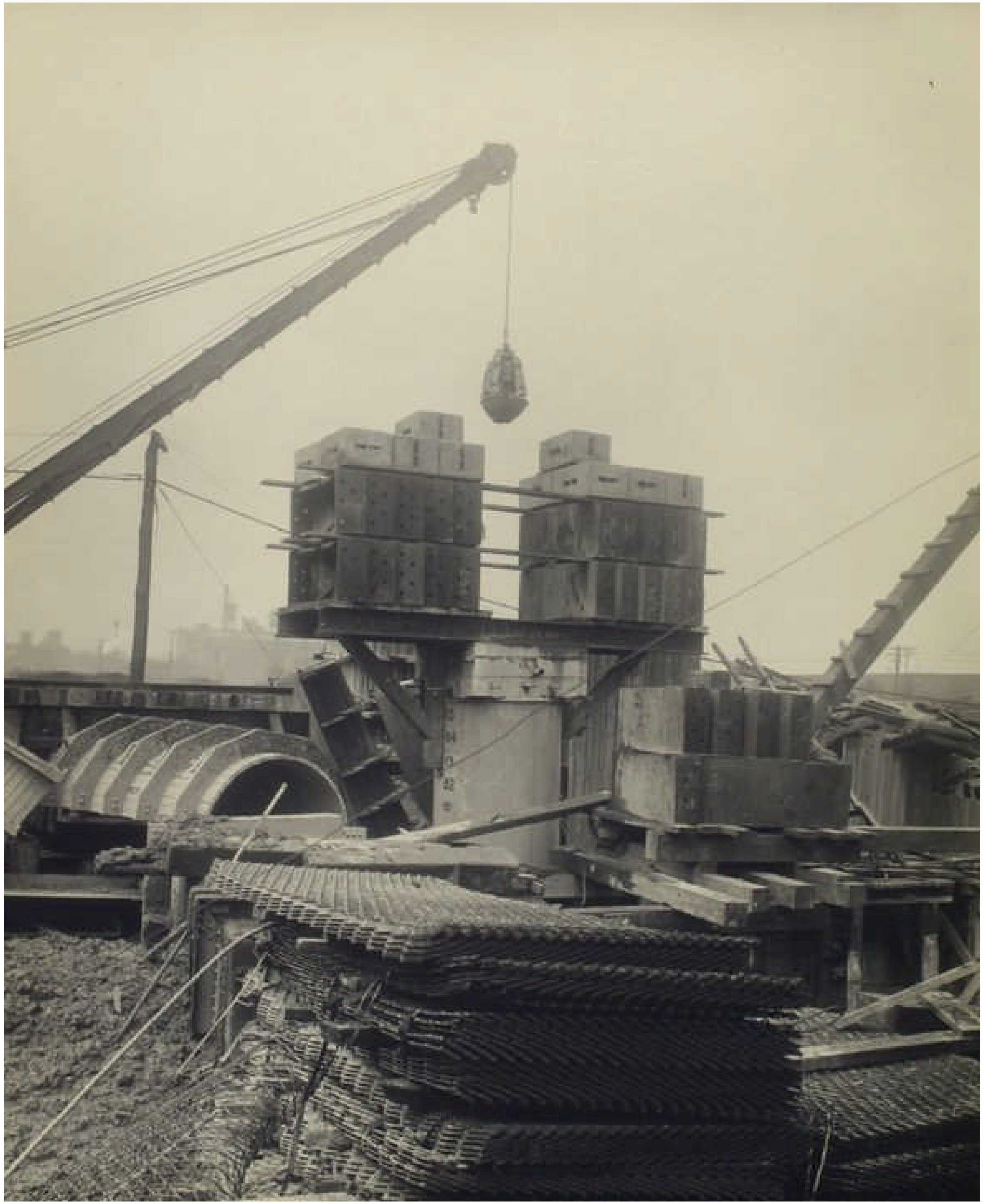
RE: excerpt from *The Eighth Wonder*

Left: caption: "Tunnel shield entering caisson, South tunnel, N.Y. 1/31/24."

Part 4

On the Jersey Side

NJ Land Shafts



"…The caissons for the north and south land shafts on the New Jersey side were assembled and started sinking in the fall of 1922. After the caissons had passed through the cinder fill of the railroad yard, a timbercrib filled with riprap was encountered which made excavation extremely difficult. The timbers had to be sawed or chopped into short lengths and some of the rock broken up…"

RE: excerpt from *The Eighth Wonder*

<u>Left</u>: caption: "Caisson A-2 for foundation's air ducts at land shafts, New Jersey. 5/6/25."

Above: caption: "NJ Holland Tunnel Exit at middle-left of photograph"

Left: caption: "At the time this map was published in 1977, it was already out of date. Note that the Lehigh Valley RR ran along the Morris Canal Basin. The Jersey Central Terminal is shown as it appeared before the construction of Liberty State Park."

NJ Shield Driving

"…The north tunnel shield east and the south tunnel shield west were built first and started out from their respective caissons. After the south tunnel shield west had progressed a sufficient distance to erect a tunnel bulkhead, the face of the shield was bulkheaded and the roof was removed from the south caisson and the south tunnel shield east was erected. As soon as this shield was ready, the roof was replaced on the caisson and the shield was started eastward, so that at the close of 1923 two shields were tunneling eastward, and one westward…"

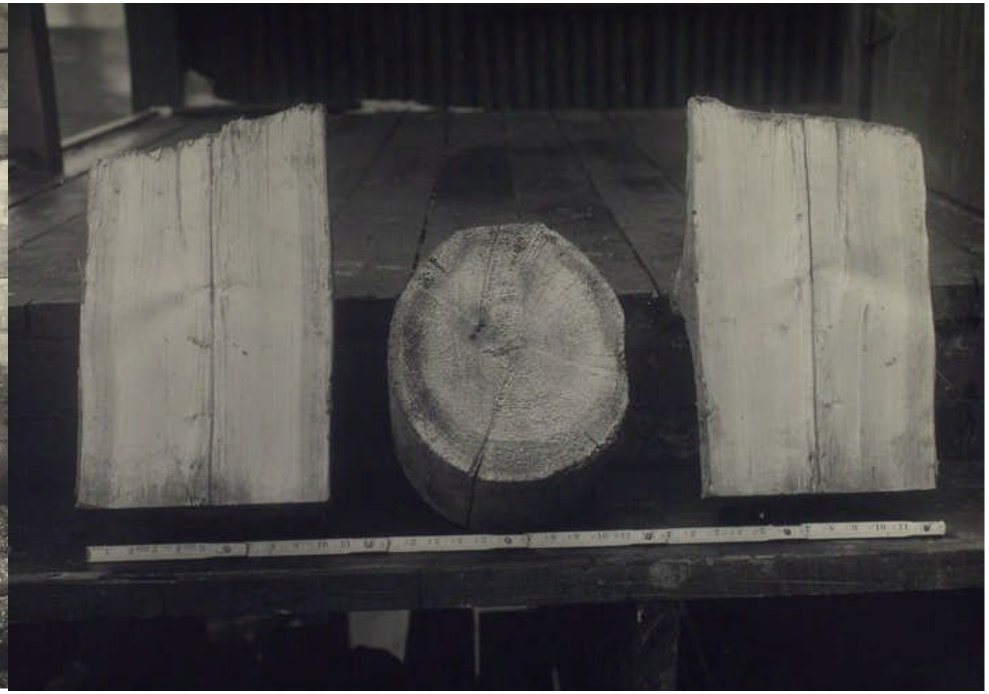
RE: excerpt from *The Eighth Wonder*

"…The method followed in starting these shields out of the shafts was similar to that already described for the New York shields, except that here it was not so difficult as there was adequate cover overhead. After the roof of the working chamber had been replaced, the girders in the side of the caisson, through which the shield was to be advanced, were burned out, after which the plates were removed from the invert to the springing line. The lower pockets of the shield were then bulkheaded and the space between the pockets and the exposed face was filled with clay. After this, the remaining plates were removed, proceeding upward from the springing line. A semicircular annular ring was cleared for the hood and packed with clay into which the hood was forced when the shield was advanced…"

RE: excerpt from *The Eighth Wonder*

"…The material at the face consisted of timber and riprap down to the springing line, similar to the material encountered in shaft sinking, making excavation very difficult. The stones in the crib varied from one-man stones to those three-quarters of a yard in size. The voids between the stones were filled with soft black mud, which did not offer sufficient resistance to prevent the escape of air, necessitating the mudding up of the entire face with clay. As the excavation was carried forward, the escape of air through the heading of the north tunnel at times taxed the full capacity of the power house, 40,000 cubic feet of free air per minute…"

RE: excerpt from *The Eighth Wonder*

"…On June 10, 1923, a small blow occurred at the face of the shield and it became necessary to drop the air pressure sufficiently to allow the water to flow into the tunnel before the blow could be stopped. The progress through the riprap was very slow, as extreme measures had to be taken to avoid blow-outs. After the shield had passed through the old timber and riprap crib, the river bulkhead was encountered which did not offer any unusual difficulties…"

RE: excerpt from *The Eighth Wonder*

Left: caption: "Interior view (in compressed air) North land shaft caisson, N.J. 11-18-22."

Right: caption: "View of old timber pile taken from North land shaft caisson, N.J. 1/10/23."

"…Before tunneling through similar material in the south tunnel east, 5,500 bags of 1:1 Portland cement grout were ejected through the east shield bulkhead of the south caisson and six pipes were sunk from the surface east of the caisson through which 140 bags of 1:1 Portland cement were placed. This grout displaced much of the soft mud and filled the voids in the riprap and greatly facilitated the driving of the shield so that very little air escaped through this material after it had been consolidated in grouting…"

RE: excerpt from *The Eighth Wonder*

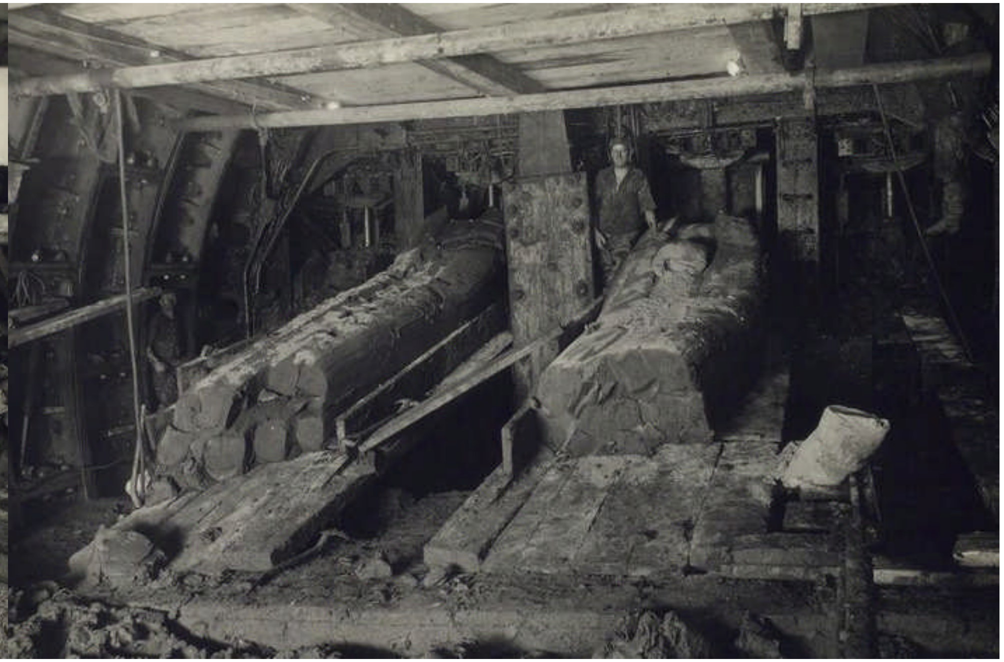
"…After about sixty rings were erected in each tunnel, the shields were stopped to build tunnel bulkheads and to install cages at the shafts and then tunneling was resumed. Immediately east of the river bulkhead soft mud, considerably lighter than Hudson River silt, was encountered in the upper part of the excavation. In this material the tunnel began to rise directly behind the shield and also to move northward…

RE: excerpt from *The Eighth Wonder*

<u>Left</u>: caption: "Tightening Bolts in Tunnel Lining, North Tunnel. By means of ratchet wrench. Each bolt weighs ten pounds."

"…To hold the shield and the tunnel to the proper grade, it was necessary to take in a certain amount of material through the shield. Accordingly, the shield was advanced with the top pockets bulkheaded and a large percentage of the excavation was permitted to enter the tunnel through openings in the lower part of the shield. This material had to be entirely removed after each shove before the erection of the cast-iron lining could proceed and slowed down progress. In addition it was desired to retain this material in the tunnel directly behind the shield so as to increase the weight of the tunnel and reduce the tendency to rise…"

RE: excerpt from *The Eighth Wonder*

"…To meet this situation a different method of tunneling was adopted. The work was stopped and a steel bulkhead semicircular in shape and fitting into the lower part of the tunnel was built to trail about 10 feet behind the shield, and the four pockets of the shield immediately above the springing line were equipped with hydraulically operated doors. When the shield advanced, these doors were opened varying amounts, depending upon conditions, to allow the material to flow through the shield into chutes which cropped the silt back of the trailing bulkhead. This method of tunneling permitted both the shield and the tunnel to be kept on grade…"

RE: excerpt from *The Eighth Wonder*

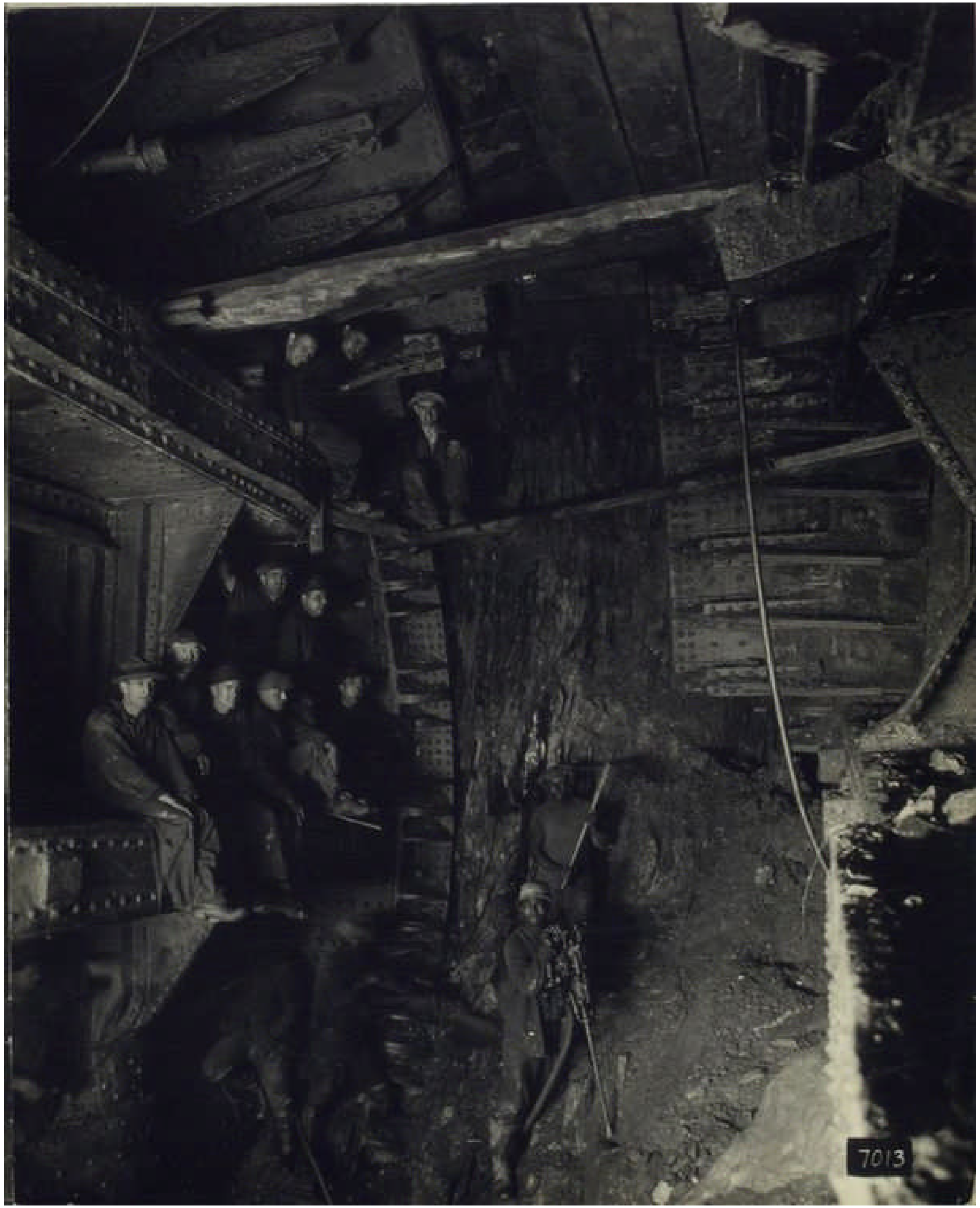
Left: caption: "North Tunnel East - silt from four pockets below the springing line, New Jersey. 9/13/ 23."

Right: caption: "South Tunnel East - muck coming through doors in shield New Jersey. 12/13/23"

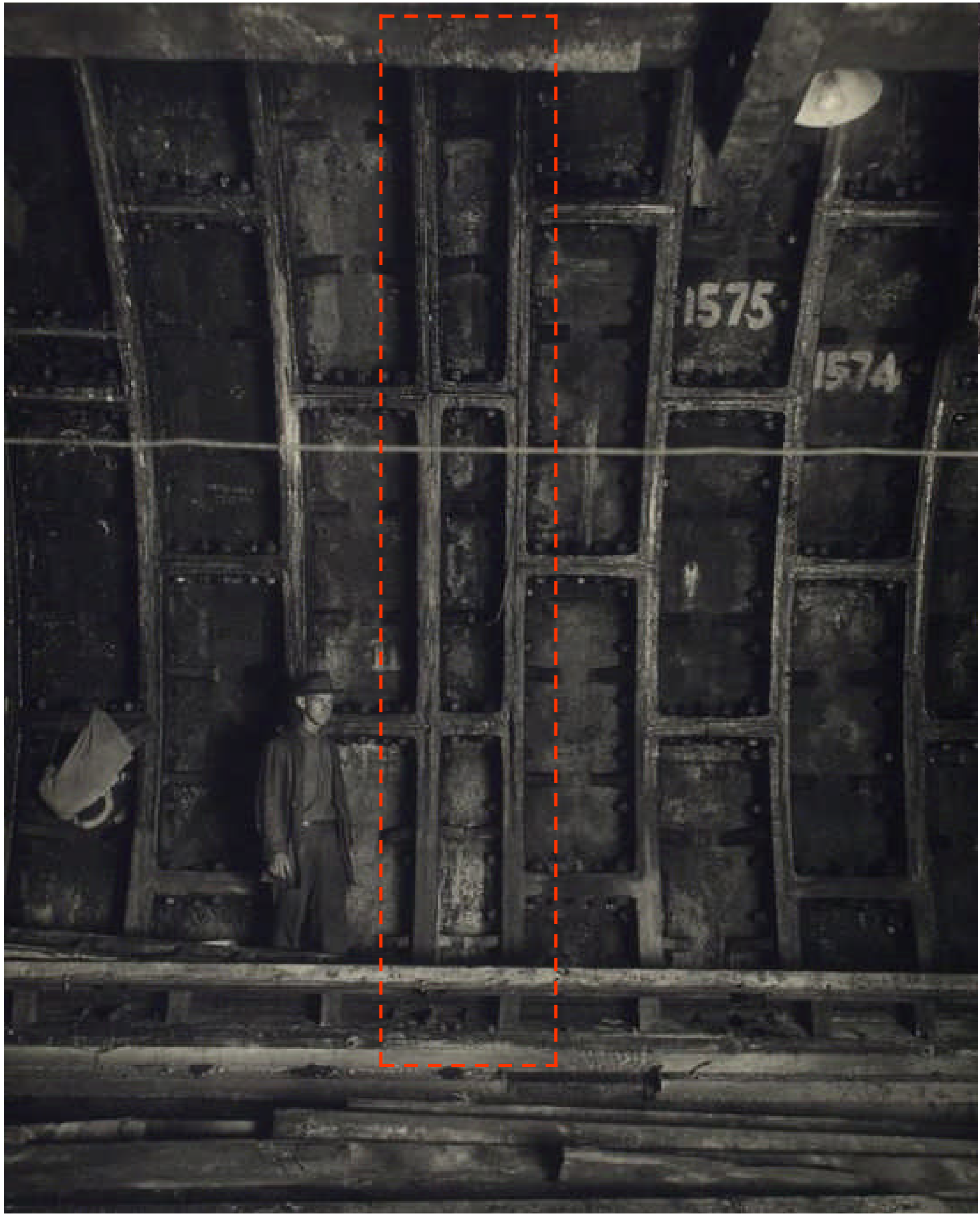
Junction

"…On October 22, 1924, shield driving was suspended in the North Tunnel from the New York side and a bottom heading or junction drift was started to meet a corresponding drift from the New Jersey heading. On October 29, the rock barrier remaining between these headings was blasted away. After this all tunneling operations were conducted from the New York side, as the junction was much nearer the New York shaft. The South Tunnel headings were joined on December 7, 1924. Work on the New York side was suspended and the New Jersey shield driven to meet the New York shield…"

RE: excerpt from *The Eighth Wonder*



<u>Left</u>: caption: "North Tunnel - New York and New Jersey shields the day prior to their junction"



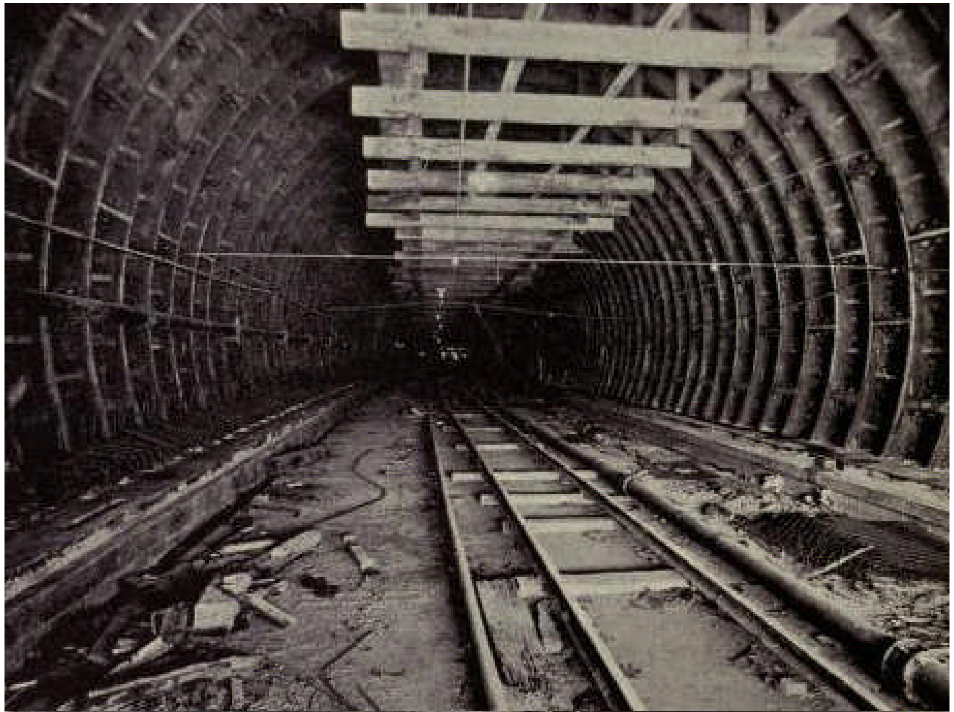
<u>Above</u>: caption: "Curve in South Tunnel, Under West Street, New York City (Radius 1,000 Feet). Showing completed rings of cast-iron lining"

<u>Left</u>: caption: "Closure Ring. North tunnel between N.Y. and N.J."

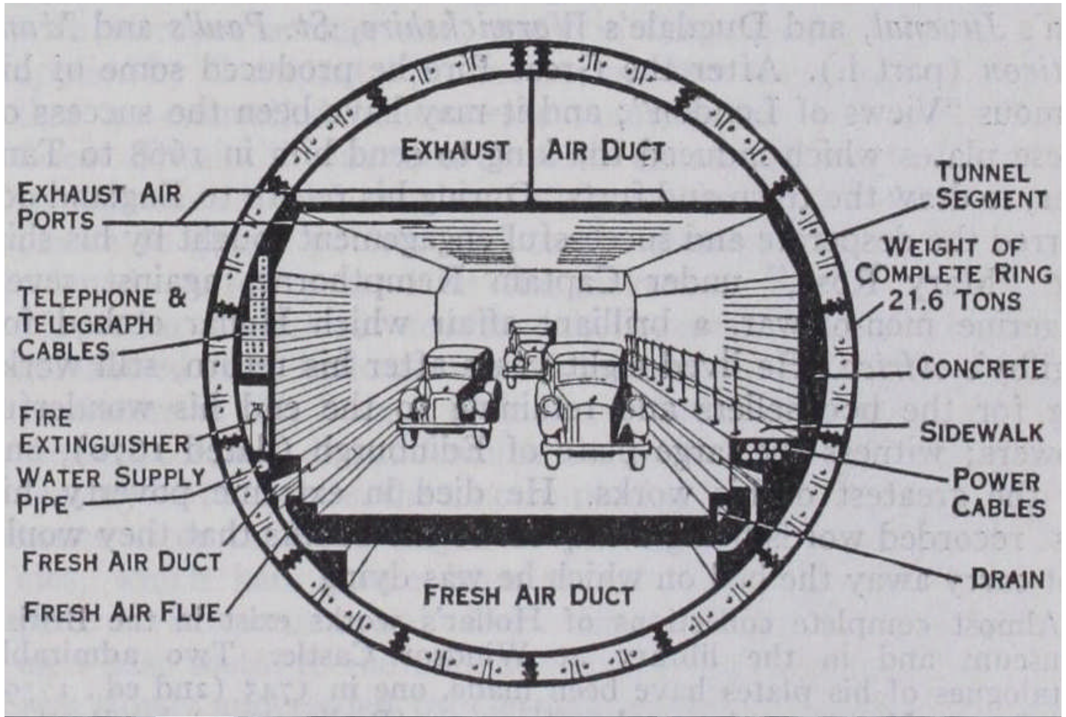
Concrete Lining

"…In July, 1924, the placing of the concrete lining forming the roadway and air ducts was started on the New York side in the North and South Tunnels between the land and river shafts. The concrete invert was first placed in both tunnels from the land shafts to the river shafts. The remaining concrete was then poured in nine operations. Five types of collapsible steel forms in 60-foot sections, afterward increased to 75 feet, supported and moved by carriages resting on previously placed concrete, were used…"

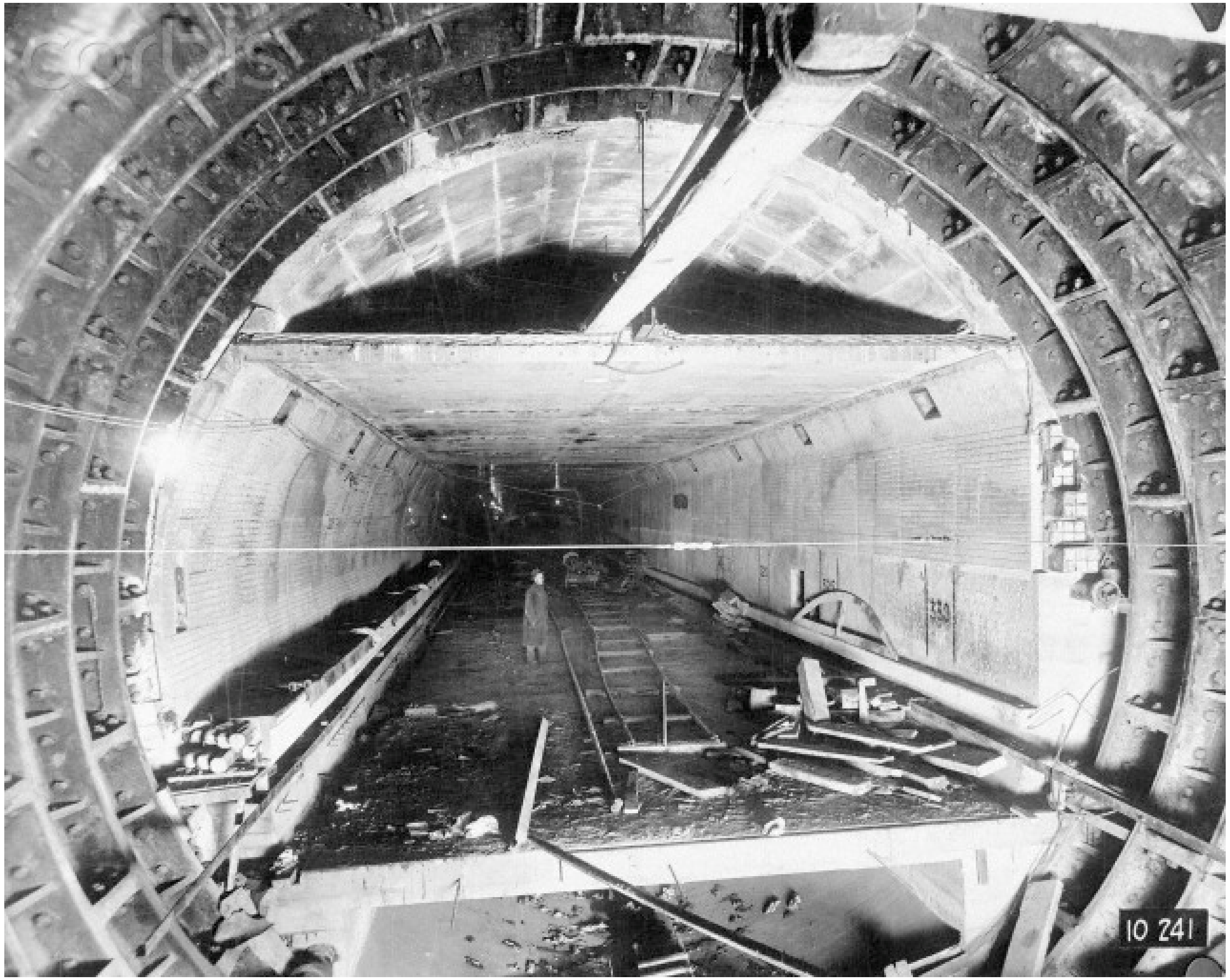
RE: excerpt from *The Eighth Wonder*




<u>Top</u>: caption: "Concrete Roadway. Beginning of side-walk, and reinforcing of side-walk, North Tunnel. View shows construction track on roadway and roof rebolting and caulking platform."
<u>Bottom</u>: caption: "Concrete roadway, sidewalk and north wall with low tension ducts (Spring Street). North Tunnel, west of Washington Street, New York. 9/19/24."


EXHAUST AIR DUCT
TUNNEL SEGMENT
EXHAUST AIR PORTS
WEIGHT OF COMPLETE RING 21.6 TONS
TELEPHONE & TELEGRAPH CABLES
CONCRETE
FIRE EXTINGUISHER
SIDEWALK
WATER SUPPLY PIPE
POWER CABLES
FRESH AIR DUCT
DRAIN
FRESH AIR FLUE
FRESH AIR DUCT

<u>Above</u>: caption: "Arch form, South Tunnel East, N.J. 3/25/25."
<u>Left</u>: caption: "Concreting methods, ceiling slab. North Tunnel East, Ring 350, N.J. 4/1/25."

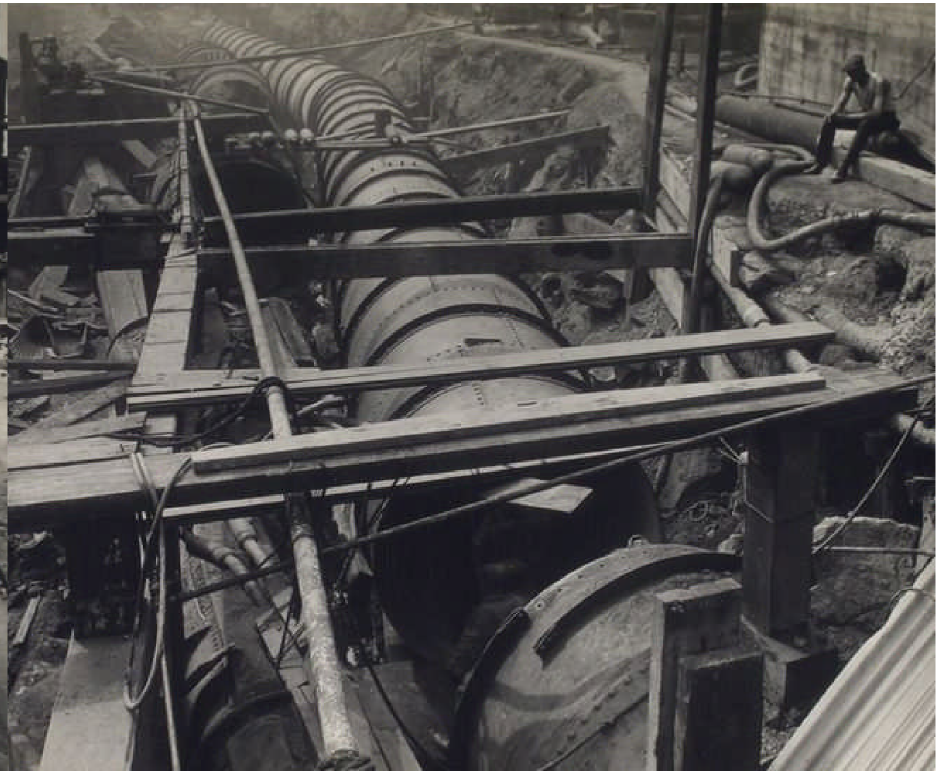

10 241

Approach Tunnels

"…The approach tunnels from the land shafts to the open approaches at Dominick and Hudson Streets, New York City, and at Provost Street, Jersey City, were built by the cut and cover method as usually em-ployed in subway construct-ion…"

RE: excerpt from *The Eighth Wonder*

Left: caption: "1926 - Holland Tunnel Construction, New York Entrance"

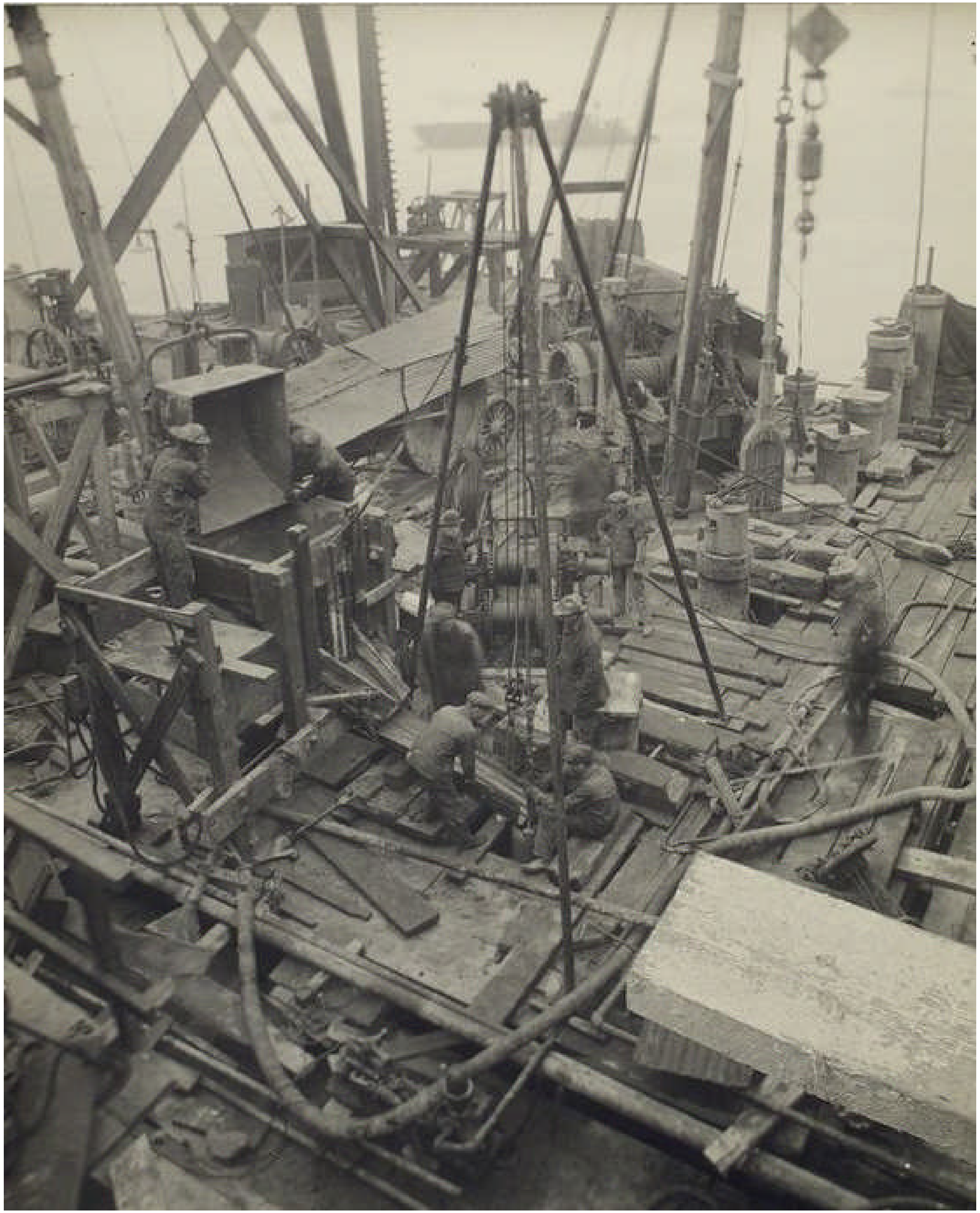


<u>Top Left</u>: caption: “Completed portion 5’ steel sewer, Jersey City, N.J. 5/21/25.”
<u>Top Right</u>: caption: “Reconstruction of 8’ steel sewer to clear way for South Tunnel approach. 6/3/25.”
<u>Left</u>: caption: “North approach, west of portal, Jersey City, N.J. 6/3/25.”

NJ River Caissons

"…The distance between the tubes on the New Jersey side required the sinking of two separate river ventilating shafts. This presented a problem due to depth of the bedrock, 250 feet as compared with 70 feet on the New York side. It was considered that the silt which overlies the bedrock would not afford satisfactory support. Accordingly, it was decided to support the shafts by means of steel casings 24 inches in diameter, filled with reinforced concrete, extending from the bottom of the shafts to ledge rock. They were made in lengths of 20 feet, threaded at both ends for couplings. Three lengths were connected and one end lowered into the silt. The silt inside the pipe was then loosened by churning with a 2,000 pound bit, and the mud and water bailed out. Excavation was continued in this manner to a depth of approximately 20 feet below the bottom of the pipe. The material was firm enough to prevent caving into the hold. Another section of pipe was then added and the entire section driven into the hole previously excavated…"

RE: excerpt from *The Eighth Wonder*



<u>**Left**</u>**: caption: “Reinforced Concrete piles, South River shaft. New Jersey. 5/15/23.”**

"…River-shaft caissons were built, launched, floated into position, and sunk, as on the New York side…"

RE: excerpt from *The Eighth Wonder*

<u>Left</u>: caption: "New Jersey River Shaft Caisson, just after leaving the Ways. Caisson launched at Mariner's Harbor, S.I., floated into position and sunk"

<u>Right</u>: caption: "View of launching of New Jersey (north) River Shaft Caisson. Staten Island Shipbuilding Co.'s Plant, Mariner's Harbor, S.I. 1/3/23."

Buried Alive

“Think twice, you only live once”

RE: expression used by the “sandhogs” - the name for the tunnel construction workers. The sandhogs removed mud, blasted through rock and bolted together the rings that formed the lining of the tunnel. They used a total of 115K-tons of cast-iron steel and 130K cubic-yards of concrete to line the *Holland Tunnel*. On a good day, the sandhogs progressed about 40-feet.

“Groping along like so many human moles, the Montague street tunnel crew pushed its way beneath the East river, separating Brooklyn and New York City. One moment the big cutting shield was boring steadily forward - the next, disaster struck with the fury of a tornado. The shield had cut through to the riverbed above! With terrific force the compressed air of the work chamber roared through the slit in the tunnel’s weakened ceiling. Three workmen, stationed near the spot, were scooped up by the force of the giant blast and hurled upward. Like shells from a gun they shot through the rift in the ceiling - up through the waters of the East river - to catapult fifty feet into the air with a force that killed two of them instantly…”

Modern Mechanix and Inventions, **June 1934**

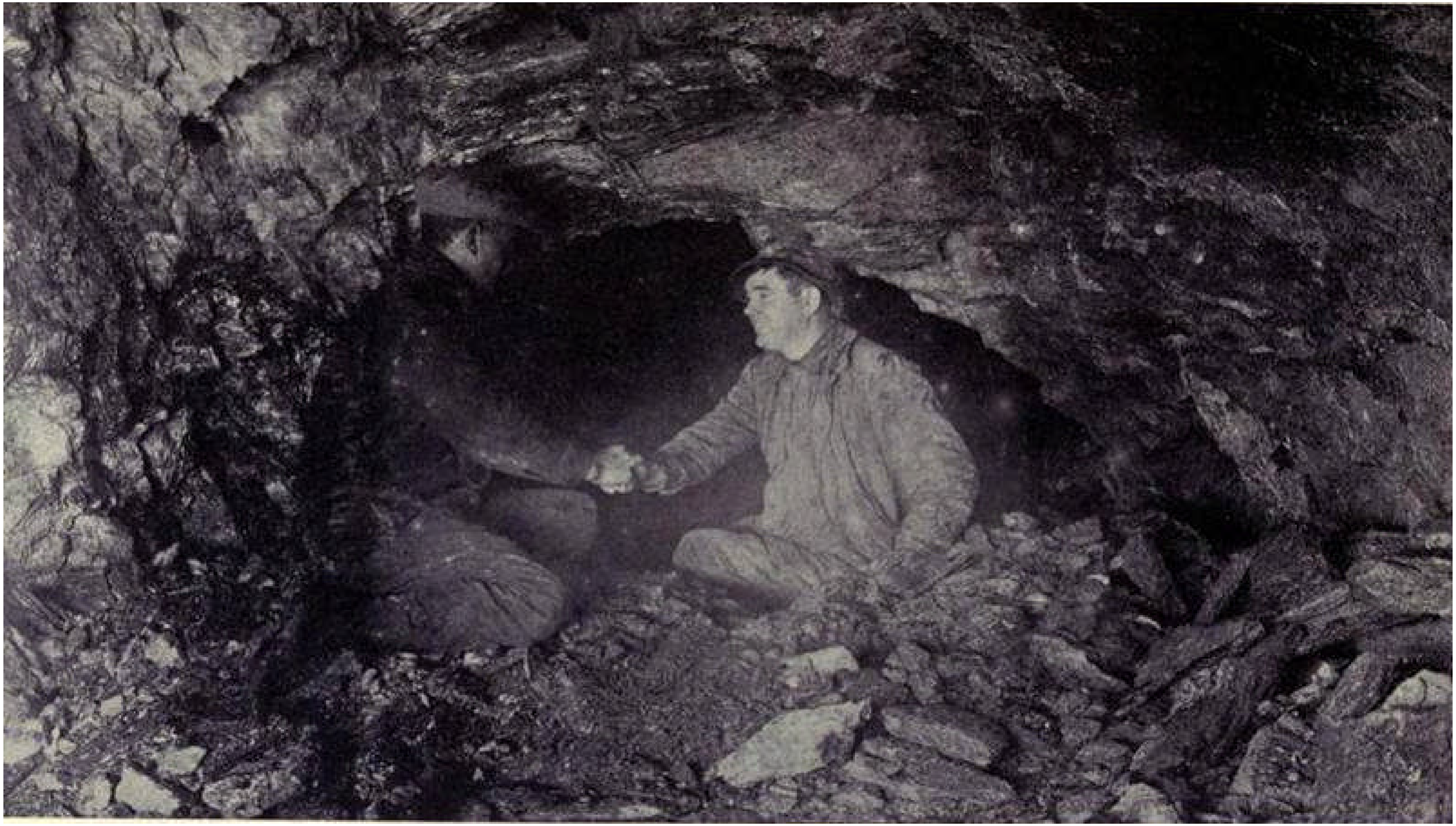
"…Next to these 'blows,' as they are called, the dread of the tunnel digger is the premature dynamite blast. During the construction of New York City Water Tunnel No. 2, driven in parts from 500 to 700 feet underground, over fifty workers and technicians were killed and hundreds were wounded. Yet despite the almost constant threat of death, the workers swear fiercely by their hazardous calling. The heritage of danger is handed down from father to son. Take the Redwood brothers, for instance - Harry, Norman and Walter - three rugged, death – defying tunnel shooters whose sons are following in their footsteps even as they followed father, grandfather and great-grandfather before them…"

Modern Mechanix and Inventions, **June 1934**

<u>Above</u>: caption: "Extreme air pressure allows tunnel builders to work only about one hour in five. A crew is shown coming off duty to rest five hours before re-entering the tunnel.[207] **Insert shows Walter Redwood, whose career is told in this story."**

“…The tunnel-building Redwoods are a famous clan. Expert workmen, they are practically without a peer when it comes to sinking a foundation shaft or driving tunnels through mountains or river beds. Building the Holland Tunnel it was Harry and Norman who jointly superintended the famous and extra-hazardous Holland Tunnel under the Hudson River. When the two huge cutting shields were finally joined - one forging its way from the Jersey side and the other from Manhattan - Harry and Norman reached across the submarine and underground boundary lines and shook hands, showing the exact precision with which these men work…”

***Modern Mechanix and Inventions,* June 1934**



<u>Above</u>: caption: "Holing Through! Tunnel superintendent Harry Redwood, of New York side, shaking hands with Norman Redwood, of New Jersey side, North Tunnel"

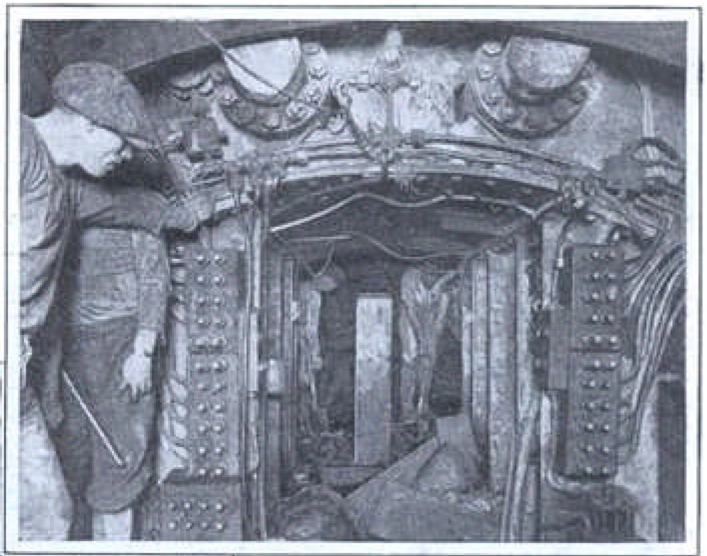
All in the Family

"…When a representative for Modern Mechanix and Inventions visited the Newark spot where the Passaic river bridge is being caissoned, he found eighteen members of the Redwood family working there. Walter, the youngest of the three veterans, finally revealed the history of his tunnel-digging family after considerable prompting had overcome his natural modesty. 'My great-grandfather, Robert Redwood, was first of the line of tunnel borers. We originated in England, you know. Then came my grandfather, also named Robert. He worked in the well-known and historic tunnel from England to Severn, under the water to Wales. My father, William, came by his tunnel-working inheritance quite naturally, and we have all followed suit. My mother's father was also a tunneler, by the way, and so were her eleven brothers. Our sisters are married to sandhogs, and our sons are in the same business. As a matter of fact, there hasn't been an outsider in our family for four generations. If you're not a sandhog, with a sandhog's blood in your veins, then you're not a Redwood. At least, not our Redwoods.'…"

“…Walter Redwood, who is forty-one, started his tunnel career at the age of thirteen in Birmingham, England, on a railroad bore. He was a dynamiter’s helper and got five cents an hour for his services. ‘In 1910 I came to New York City,’ he says. ‘There was a demand for tunnel experts in those days and in the following years I worked on practically every important tunnel job in New York City and the rivers which flank it.’…”

***Modern Mechanix and Invention,* June 1934**

Right: caption: "A rear view of the huge shield which is moved forward by a series of power-ful hydraulic ja-cks"



"…'This Newark contract is an air job, calling for work ninety feet under water. Because of the high air pressure under which we work, we put in one hour of actual work while we're off duty the next five. We work just two hours of a twelve-hour day under a pressure of thirty-four pou-nds to the square inch. This is about as perilous a job as I have ever worked on. We are working in a steel and concrete caisson, eighty by thirty feet. This caisson sinks with my crew of workers. That is, as we dig down and make room, the caisson wedges downward. Every pound of air that we put on takes 250 tons off the weight of the caisson. That is, each pound of compressed air lifts the equivalent of 250 tons weight in pushing the 'deck' or 'ceiling' of the caisson upwards. As soon as the air is dropped two or three pounds, the caisson drops right down. That is the terrific force of its weight. On this job I am in charge of the air-lock. I operate the compressed air instruments and you can easily understand what a slip or a flaw in judgment might mean…"

***Modern Mechanix and Invention,* June 1934**

Above: caption: "Above is shown a lock tender with his hand on the air valve which regulates the pressure in the air lock at the head of the stairway. Men enter this lock, where pressure is in-creased one pound per minute, to adjust their bodies to tun-nel conditions."

"…'The most common ailment from which the sandhog suffers is the 'bends.' This malady also affects deep-sea divers. It comes from a too sudden change in pressures. Either going from normal to under-pressure or vice versa has been too fast, and you get air-bubbles in your blood, preventing the normal flow. When the sandhog reports for work, he goes down the shaft and enters the air-lock. He sits there as the lock-tender works the pressure up to a point equal to that in the tunnel. The highest pressure he can work under is fifty pounds to the square inch. Under these conditions, he works for just half an hour, resting for the next five. After his time is up in the tunnel, the worker enters the airlock again where the pressure is reduced gradually until it is the same as that above ground.'…"

Modern Mechanix and Invention, **June 1934**

"…'Here is how we go about burrowing underground, and under a river at that. Deep shafts are sunk on either side of the river and elevators are built into them. A huge circular shield of steel about twenty feet in diameter is then lowered into each shaft. Working toward each other from their opposite terminals, the shields are started forward, pushing through rock, mud and gravel under the mighty force of compressed air. A meeting-place for the two shields has been designated at a point midway under the river. As the shield pushes its hood through the course of the proposed tunnel, the passage is filled with debris which the sandhogs tackle with pick and shovel and load onto cars which carry it back to the elevators where it is removed to the surface. When the tunnel is being driven, big steel rings, made up of radial plates, are bolted into place to form the strong ribs of the tunnel. When this set of rings is finished, the shield is then moved forward again, and then more rings are bolted into place. This process continues until the tunnel is holed through.'…"

Modern Mechanix and Invention, **June 1934**

<u>Left</u>: caption: "Artist's drawing: sinking of the preliminary shaft"

Blood Money

"…The average sandhog gets $7.50 an hour, or $15 for a two-hour day. The eldest of the Redwoods, Harry, has often been paid $100 a day for his services. But although the rewards are high, the penalties are even higher. Death lurks in the underground caverns and no man knows, going down to the airlock in the morning, whether or not he will return safely again that night…"

***Modern Mechanix and Invention,* June 1934**

RE: a total of fourteen workmen died during the seven years of construction for the *Holland Tunnel*

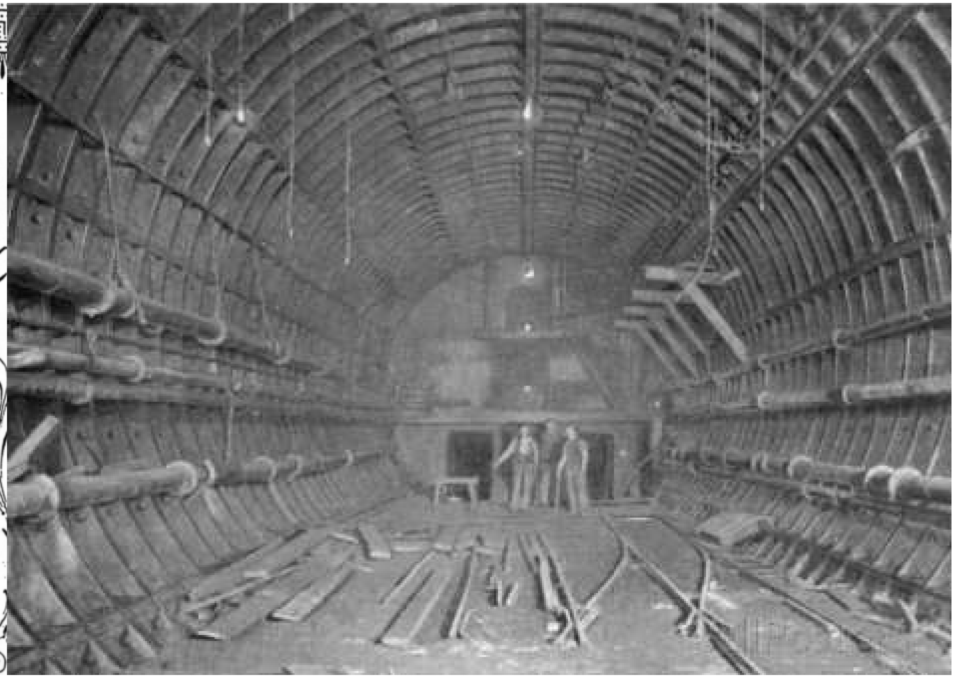
Part 5

The Air Down There

The Problem

"…The problem of ventilation of the Holland Tunnel was unlike any heretofore solved, both in character and magnitude. The only existing vehicular tunnels even approximately comparable to the Holland Tunnel are the Blackwall and Rotherhithe Tunnels under the Thames at London…"

RE: excerpt from *The Eighth Wonder.* Tunnels under the *Hudson River* were not new (the first trans-Hudson rail tunnel opened in 1910). However, the much larger diameter of vehicular tunnels, combined with the effects of vehicle exhaust on occupants, especially for those stuck in traffic inside the tunnel, presented new and challenging problems.



"…The Blackwall, opened for traffic in 1897, has an under-river length of 1,221 feet between shafts. It consists of a single tube 27 feet in diameter with a roadway acc-ommodating one line of traffic in each direction and two sidewalks. Traffic counts in 1920 showed that the maximum number of motor vehicles using the tunnel was less than 100 per hour…"

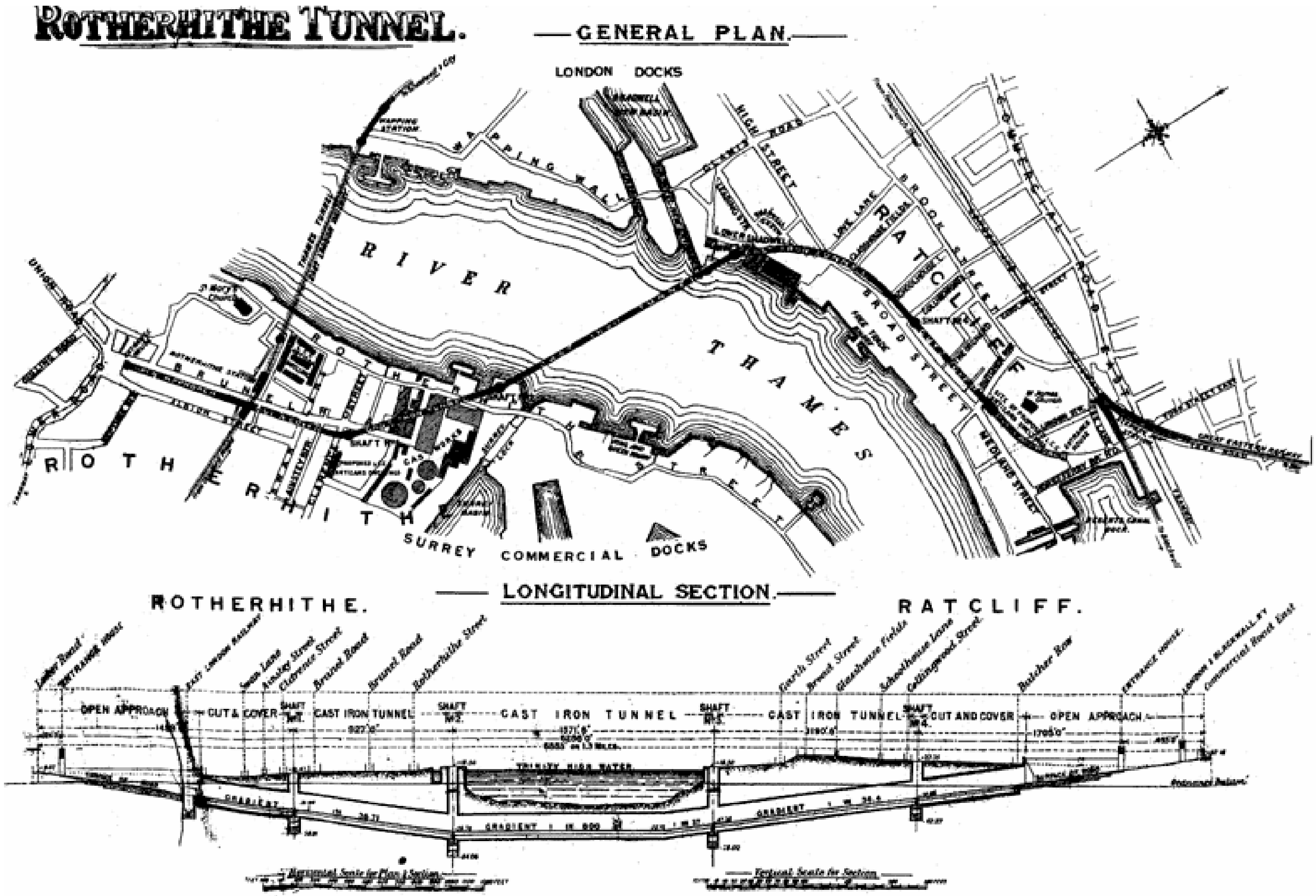
RE: excerpt from *The Eighth Wonder*

Left: caption: "Invitation to inspect the completed sub-aqueous portion of the Blackwall Tunnel"

Right: caption: "Interior of the Blackwall Tunnel during construction"


POPLAR


BLACKWALL TUNNEL
LONDON COUNTY COUNCIL
COMMENCED IN 1892
AND OPENED IN 1897
BY HIS ROYAL HIGHNESS
THE PRINCE OF WALES
HER MAJESTY THE QUEEN



"…The Rotherhithe is 30 feet in diameter, similar to the Blackwall in traffic facilities, with an under-river length between shafts of 1,570 feet. Both of these tunnels are ventilated by the natural movement of air through the shafts and portals…"

RE: excerpt from *The Eighth Wonder*

<u>Left</u>: caption: "Rotherhithe Tunnel General Plan and Longitudinal Section"

"…The Holland Tunnel, with a total length of 9,250 feet, an under-river length of 5,480 feet, and a capacity of 1,900 vehicles per hour in each direction, or 46,000 per day, obviously required something more than natural ven-tilation. To this end the ventilation of the tunnel was studied under three heads:

1. ***The amount and composition of exhaust gases from motor vehicles;***
2. ***The dilution necessary to render the exhaust gases harmless, and;***
3. ***The method and equipment necessary for adequate ventilation…"***

RE: excerpt from *The Eighth Wonder*

"…The impurities in the atmosphere of a tunnel used by motor vehicles are the product of the combustion of gasoline. If complete combustion occurred, the carbon content would be in the form of carbon dioxide, which can be tolerated in considerable quantity without injurious effects. In a gasoline engine, however, complete combustion seldom, if ever, takes place. The exhaust gases contain varying amounts of carbon monoxide, depending on such variable factors as the quality of the gasoline, conditions of carburetion, etc…"

RE: excerpt from *The Eighth Wonder.* Prior to construction, Holland's design team (headed by *Ole Singstad*) tested vehicles within closed chambers. After testing volunteer occupants in the cars to determine the effect of the fumes, the design team determined that air containing 0.5% carbon monoxide would be lethal.

A Highly Poisonous Gas

"…Carbon monoxide is a highly poisonous gas, injurious to health in minute quantities if breathed for a long time, and if present in large quantities is injurious even when breathed for a short time. Ventilation requirements are determined by the quantity of this gas in exhaust gases. If sufficient fresh air is supplied to reduce this gas to a safe percentage, other gases and impurities, such as carbon dioxide, methane, and smoke, will also be diluted sufficiently. The first consideration, therefore, was to determine the amount of carbon monoxide that would be liberated in the tunnel…"

RE: excerpt from *The Eighth Wonder*

“Only a small amount of experiments had been made on engine gases, and these results did not give the information necessary to serve as a basis for the planning of the ventilation of the tunnel”

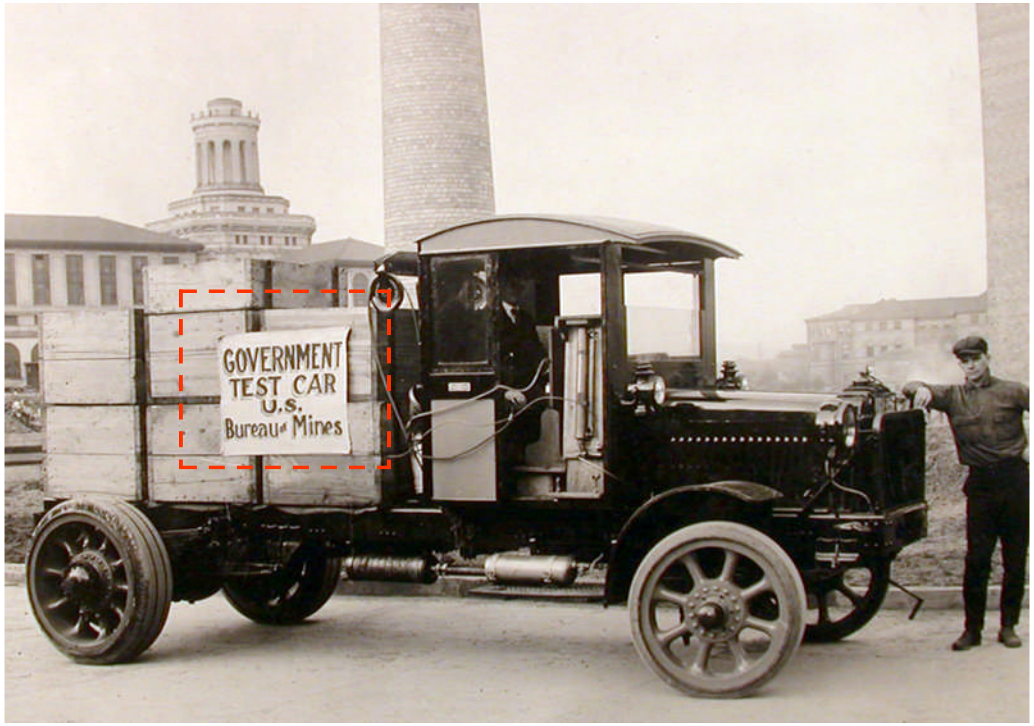
Ole Singstad, **Design Engineer**

"…Investigations were carried out at the Bureau of Mines Experiment Station at Pittsburgh. The schedule called for the testing of passenger cars and trucks of various makes and capacities. The tests were made with car loaded and light, standing with engine racing and idling, accelerating from rest on level grade and on maximum grade, running at three, six, ten, and fifteen miles per hour on level and up and down a grade of 3½% corresponding to the maximum tunnel grade. A total of 101 cars were tested. Gas samples were taken directly from the exhaust pipe throughout the entire duration of the test…"

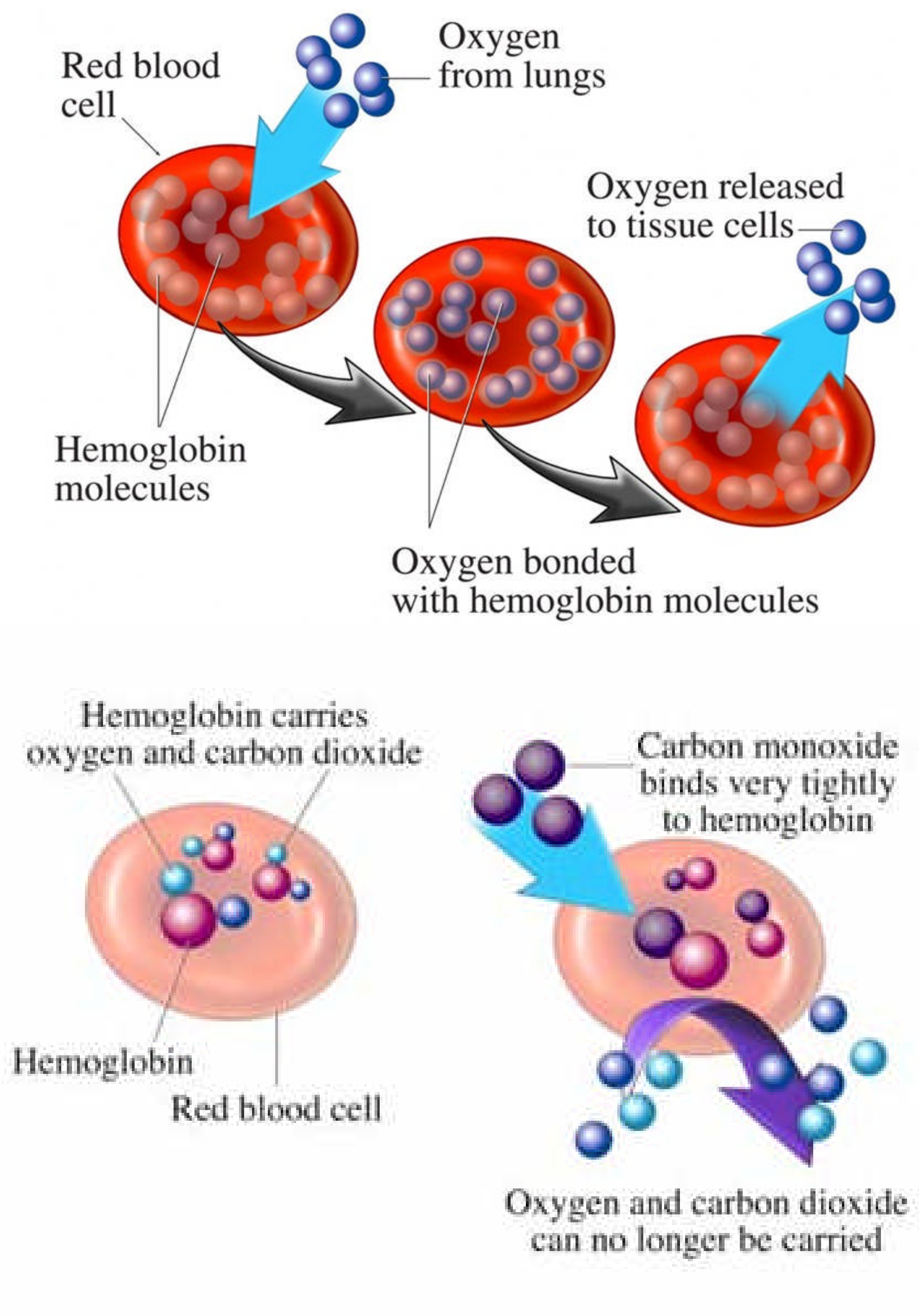
RE: excerpt from *The Eighth Wonder*

"…In general, the results showed that the exhaust gases contained about 6.8% carbon monoxide and 8.4% carbon dioxide, developing only 67% of the heat value of the gasoline. About one-third of the gasoline fuel was wasted through incomplete combustion. Experiments to determine the proper dilution to render the exhaust gases harmless were conducted at the Bureau of Mines Experiment Station at Yale. They were performed in a gas-tight chamber of 226 cubic feet capacity. Members of the staff spent periods of one hour in air containing amounts of carbon monoxide varying from two to ten parts in 10,000. In addition, tests were performed in a chamber of 12,000 cubic feet with an automobile engine exhausting into the chamber. The duration of all tests was one hour, whereas the length of time required to travel through the tunnel at a speed of only three miles per hour is but 31 minutes…"

RE: excerpt from *The Eighth Wonder*



In the early 1920s, the *New York and New Jersey Tunnel Commission/s* consulted the *U.S. Bureau of Mines* (USBM) on how to prevent deadly concentrations of exhaust fumes inside the tubes of the new *Hudson River* vehicular tunnel. The USBM's mining safety research in *Pittsburgh* had yielded extensive knowledge of tunnels and poisonous gases, thus it was well positioned to offer advice. The Tunnel Commission/s and the USBM embarked on a ventilation research program that resulted in the most comprehensive set of data and analyses that had ever been prepared on automotive exhaust gases and underground air circulation. The *Brockway* 5-ton truck shown above was one of over one-hundred vehicles USBM staff road-tested through the city's streets.



"…The results of the test showed that when an automobile engine is running properly, the exhaust contains no substance that is injurious to any appreciable extent except carbon monoxide. Gasoline engines with cylinders missing, or when cold, oversupplied with oil or gasoline, or smoking from any cause, may throw off disagreeable vapors irritating to the eyes and nauseating to some persons. The physiological effects of carbon monoxide are wholly due to the union of this gas with the hemoglobin of the blood. To the extent that hemoglobin is combined with carbon monoxide, it is by that amount incapable of transporting oxygen to the body. This combination of carbon monoxide with the hemoglobin is reversible, so that when a person returns to fresh air the carbon monoxide is gradually eliminated…"

***Ole Singstad,* Design Engineer**

"…Of all physical signs and tests of carbon monoxide poisoning, headache proved the most definite and reliable. Concentrations of gas too weak or periods of exposure too short to induce a headache are to be considered harmless. No one had this symptom to an appreciable degree after a period of one hour in the chamber with four parts of carbon monoxide. With six parts the effect was usually very slight, while with eight parts there was decided discomfort for some hours. Hence a uniform concentration of four parts carbon monoxide in 10,000 of air is designed to afford not only complete safety, but also comfort and freedom from disagreeable effects…"

Ole Singstad, **Design Engineer**

Above: caption: "Effects of Carbon Monoxide Poisoning"

The Longitudinal Method

"…By the longitudinal method of ventilation, the entire tunnel would be utilized as a duct for conveying air through the tunnel. Sufficient air would be supplied through blower fans near one portal and would enter the tunnel through a nozzle or nozzles at a velocity sufficient to force it through its entire length…"

RE: excerpt from *The Eighth Wonder*

"…if in a 29-foot tunnel the air were introduced into the north tube near one portal through a nozzle having a cross-sectional area of 74 square feet, and were exhausted through the opposite portal, the air would have a nozzle velocity of about 282 miles per hour. This would produce a velocity of 72 miles per hour at points where the roadway was occupied by a pleasure car and a truck abreast, or a velocity of 51 miles per hour where there were no vehicles. Such air velocities would be prohibitive in a vehicular tunnel, and the power required to handle the air would be excessive…"

RE: excerpt from *The Eighth Wonder*

<u>Above</u>: caption: "Portal Entry (Manhattan), Holland Tunnel"

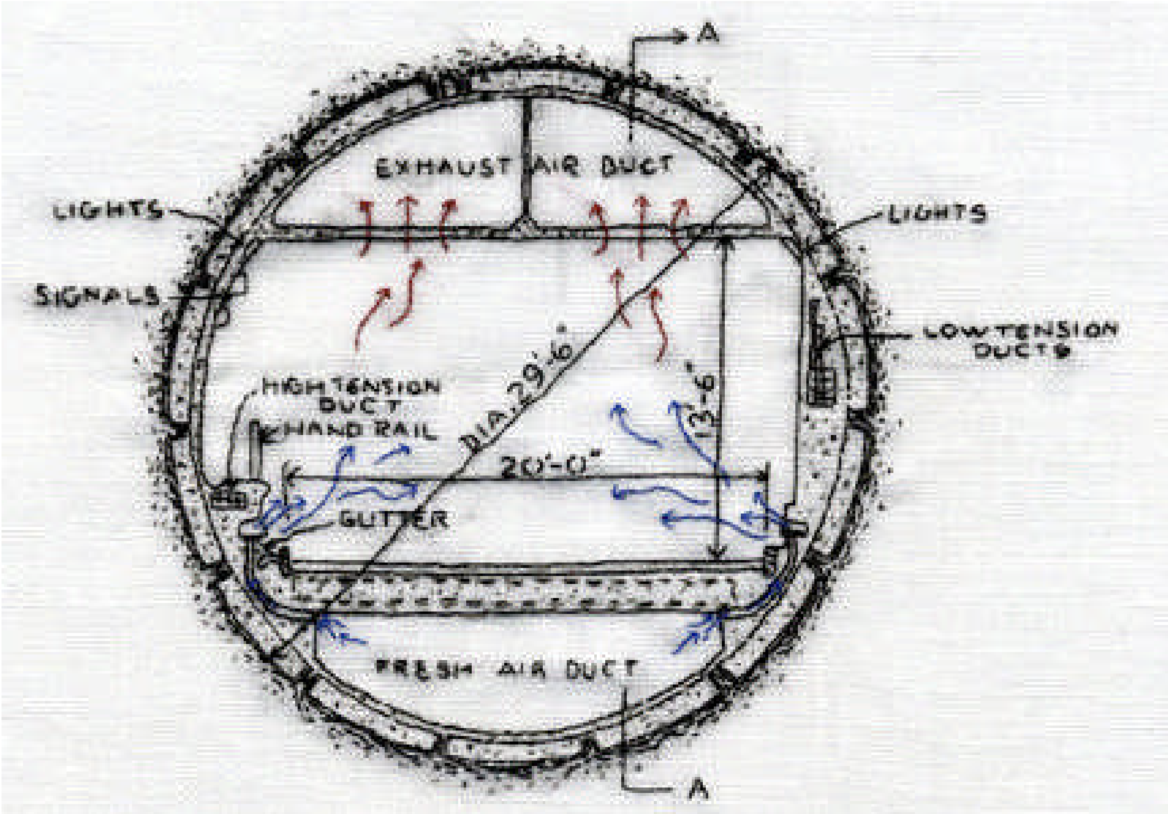
The Distributive Method

"…In the distributive method of ventilation adopted for the Holland Tunnel, the air is introduced into and exhausted from the tunnel through a number of openings at frequent intervals leading from the tunnel roadway. By this method fresh air is supplied at all points throughout the tunnel. The air at any point can be controlled. There is no discomfort or danger from high-velocity air currents. The ventilation is not affected by traffic or the direction of the wind. Exhaust gases are quickly diluted and removed. The space above and below the tunnel roadway is ideally suitable for air ducts. Fresh air, supplied by blower fans at the shafts, is discharged from the main duct under the roadway through adjustable openings into continuous expansion chambers on each side, thence through a continuous slot into the roadway. The air remains in the tunnel an average of one and one-half minutes as it slowly ascends to the ceiling…"

RE: excerpt from *The Eighth Wonder*

"In a tunnel of circular cross-section with the roadway located at an elevation giving maximum clearance for vehicles, there is space available for ventilating ducts both below and above the roadway, one for the fresh air and the other for the vitiated air…the methods of transverse air movement investigated were practicable for tunnel ventilation and that the best method from the standpoint of power saving and safety against fire hazard was the one in which the air is introduced from the duct under the roadway and exhausted through the duct above the ceiling"

Ole Singstad, **Design Engineer**



"…'Gale-jacketing' was the answer. A pumping chamber between the roadway floor and the circular outer shell of the tube and an exhaust chamber in the space between the ceiling and the top of the shell contain roaring air streams. The good air enters the tunnel from vents near the floor and is sucked up through exhaust vents overhead. Powerful blower fans in buildings on shore change the air completely 42 times an hour - about once every minute-and-a-half!..."

***Mechanix Illustrated,* June 1941**

"…Exhaust fans located in the same buildings with the blower fans draw the vitiated air through ports in the ceiling and thence through the upper duct above the roadway, delivering it through stacks to the outer atmosphere…"

RE: excerpt from *The Eighth Wonder*

<u>Above</u>: caption: "Vitiated air duct, North Tunnel, west of Spring Street Shaft, New York"

Coefficient of Friction

"…Experiments to determine the coefficient of friction for flow of air in concrete ducts, to verify formulae used in computing the power required for moving air through a duct from which air is taken off at intervals, and to determine the power losses in bends or elbows in concrete air ducts were conducted at the engineering experiment station at the University of Illinois. A concrete model, the linear dimensions of which were one-half those of the lower duct of the tunnel, and 300 feet in length, was used for direct tests. Outlets with adjustable shutters to control the flow of air were provided at uniform intervals on each side. Measurements of air velocity and static pressure were made at three locations in the duct, one five feet from each end and one midway. Tests were run with all side ports closed and port pockets open at various intervals, and with air velocities ranging from 1,000 feet to 6,000 feet per minute. A total of 186 blowing tests and 17 exhausting tests were run from which to determine the coefficient of friction…"

RE: excerpt from *The Eighth Wonder*

In designing the ventilation equipment it was necessary to know the coefficient of friction for the flow of air in the concrete ducts such as planned for the tunnel and the power losses where air is taken from or supplied to a duct. No assurance could be found as to any reliable bases for the existing formulas, and it was deemed necessary to verify them by independent tests on large scale models before accepting them as a basis for the design of the ventilation equipment for a project of this magnitude. The *New York State Bridge and Tunnel Commission* and the *New Jersey Interstate Bridge and Tunnel Commission* accordingly entered into a contract with the USBM to conduct these tests. Studies to determine the amount and composition of exhaust gases from motor vehicles were carried out at the USBM experiment station in *Pittsburgh*. A study of the effects of motor exhaust gases was made at the USBM experiment station at *Yale University*.

"…On a full-size model of the expansion chamber proposed for the tunnel, tests were made to determine the proper shape of the chamber and the shape and size of the slot which would give a direction of air flow high enough not to raise dust from the roadway and low enough not to short circuit the fresh air to the inlets into the vitiated air duct over the roadway. These experiments also gave the minimum static pressure required to discharge the requisite quantities of air through the slots at different locations in the tunnel. A total of 112 tests were made on various shapes of expansion chambers and various widths of slot under the several conditions to be met in the tunnel. Experiments on elbows were made in two parts: on galvanized iron single and compound elbows constructed to one-tenth the interior dimensions of the elbows to be used in the tunnel, and on concrete compound elbows to one-half the interior dimensions of those planned for the tunnel ducts…"

RE: excerpt from *The Eighth Wonder*

Bruceton

"…To verify under-tunnel conditions the amount of carbon monoxide produced by automobiles and the physiological effect of exhaust gases, an experimental tunnel was constructed in the workings of a coal mine at Bruceton, Pa. It was located about 1,000 feet from the entrance to the mine and about 135 feet from the surface. The tunnel had a driveway 8 feet by 9 feet wide, with continuous air ducts above the ceiling and below the roadway. It was oval in plan, with a major axis of approximately 135 feet and a minor axis of approximately 110 feet, giving a roadway length of 400 feet…"

RE: excerpt from *The Eighth Wonder*

Above: caption: "In 1921, the USBM's *Pittsburgh Experiment Station* helped develop a safe ventilation system for the new trans-Hudson tunnel. Testing was done at the USBM's *Bruceton Experimental Mine*, shown above."

"…Air for the test was supplied by the mine fan, belt-connected to a steam engine and operated outside the mines. The fan operated normally exhausting, giving upward ventilation in the tunnel. Downward ventilation was acc-omplished by reversing the direction of the air currents through the reversible housing of the fan, which then operated as a blower. In the upward ventilation system, air entered the duct under the roadway, passed through adjustable port openings into the continuous expansion chambers on either side of the roadway, thence into the driveway. In the downward system, air was delivered to the duct in the ceiling, thence through the ports into the upper expansion chambers from which it entered the roadway…"

RE: excerpt from *The Eighth Wonder*

"…A total of seventeen tests were run with cars varying in number from 1 to 8, with concentrations of carbon monoxide in the driveway from 0.5 to 9.4 in 10,000 parts of air, at various temperatures and humidities, and various methods of transverse ventilation. The tests verified the earlier conclusions, and demonstrated that with upward ventilation the exhaust gases crossed the breathing plane of persons in the tunnel but once, while with downward ventilation they crossed this plane twice. There was also a lower concentration of carbon monoxide with upward than with downward ventilation…"

RE: excerpt from *The Eighth Wonder*

The Lungs of the Tunnel

"Air is supplied to the tunnel from the fresh air duct located under the roadway. The air is taken off from this duct through flues 10 feet to 15 feet apart, provided with adjustable dampers and leading into continuous expansion chambers located just above the roadway, one on each side. From these chambers, two continuous transverse fresh air streams sweep across the roadway and dilute the exhaust gases. The air then slowly ascends to the ceiling where it is drawn through adjustable openings, located from 10 to 15 feet apart, into the exhaust duct."

Ole Singstad, **Design Engineer**

"…Valuable and necessary as were the experiments required to determine the various factors involved in the problem of adequate ventilation for the Holland Tunnel, the data resulting from these preliminary investigations had to be crystallized into tangible units of ventilating equipment. These are the eighty-four giant Sturtevant Silentvane Fans which are the very lungs of the tunnel, Without such fans blowing in fresh air and exhausting the vitiated air the tunnel could not be made to function…"

RE: excerpt from *The Eighth Wonder.* Holland and his design team developed a revolutionary two-duct system; a system that utilized one duct to draw in fresh air and the other to suck out exhaust air, that would be adopted for vehicular tunnels worldwide. To facilitate the exchange of clean and vitiated (dirty) air, the team developed a system of ventilator fans and airshafts to circulate clean air throughout the length of the tunnel. This air is moved by 42 blowing fans and 42 exhaust fans - totaling 6K-hp, arranged in four ventilation buildings (only 56 out of the total 84 fans are in operation at any time, the other 28 fans are reserved for emergencies). It takes approximately 90 seconds to completely change the air in the tunnel.

"…Mr. B.F. Sturtevant, the founder of the company which constructed the fans, was a Maine shoemaker of inventive genius. He had devised a machine to shave a ribbon of wood from a log, form it into pegs, and drive them into shoes. This process, however, created a dust which bothered his workmen. Accordingly, he next constructed a fan which performed as an exhauster and removed the dust. Thus the first fan was created..."

RE: excerpt from *The Eighth Wonder*

Left: *Benjamin Franklin Sturtevant*

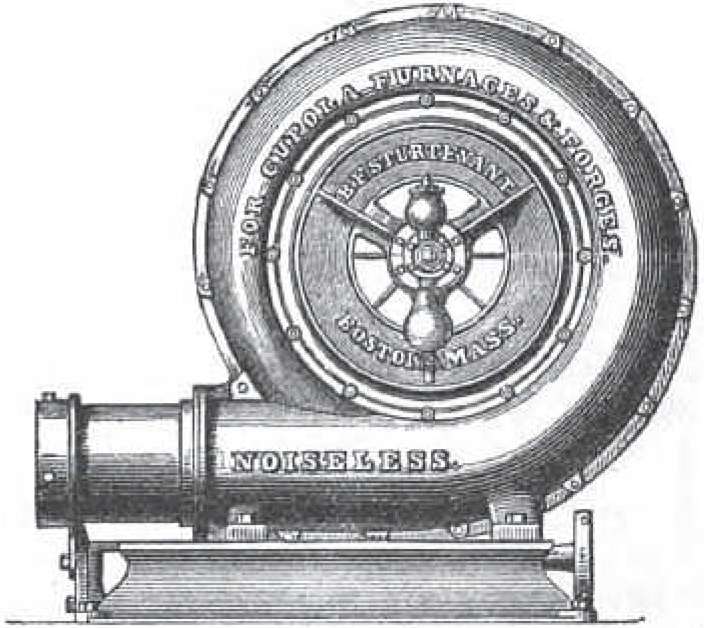
"…Concentrating on this latter invention, he established what grew into the B.F. Sturtevant Company, with its great plants and offices, research laboratories and corps of engineers, and its wide variety of products in the field of fans, blowers, and allied air-moving equipment…"

RE: excerpt from *The Eighth Wonder*

The centrifugal fan, or fan blower, was not a new idea. As applied for the purposes of ventilation, it dates back to the *16th Century*. There were tentative steps in the early *19th Century* to use it as an auxiliary or replacement for chimney draft, but engine speeds and steam pressures were too low. The demand for accelerated combustion wasn't urgent and there was only rudimentary knowledge about the proper application of fans for forced draft. As a consequence, this economic improvement - of critical importance in later years, was ignored. Its natural advantages of low noise and minimum friction (versus piston operated blowers) had been overshadowed by their blast of air. While sufficient for forges and heating furnaces, they were inadequate for industrial processes. By careful attention to correcting the design flaws in the casing and impeller, *B.F. Sturtevant* transformed the simple fan blower into a pressure blower that became a boon to industry. Being the first to apply sound engineering principles to these early crude devices at a critical point in the industrial revolution, Sturtevant became the father of the American fan industry, having built the first commercially successful blower in 1864. A market developed for his blowers for conveying materials and for furnishing draft for forges, cupolas and boilers. In the latter application, forcing combustion air into ashpits allowed the burning of cheap grades of fuel which had previously been impossible with ordinary chimney draft. By 1866, the business had grown to the point where Sturtevant was employing nearly fifty men. Equipping the U.S. Capitol with ventilating fans that year was one of the more notable early installations. In 1869, the modern heating era began with Sturtevant's introduction of a hot blast system. The "Sturtevant System," as it became known, consisted of a steam engine driven fan passing large volumes of air through steel pipe heater coils and distributing it within a factory or building via ductwork. Unlike passive direct radiation and indirect where a radiator was placed in a flue and air allowed to pass over it and into a room, the Sturtevant approach of forced circulation was an efficient, integrated system that could be used for any combination of ventilation, heating, cooling and/or air cleaning demands.

STURTEVANT

Patent Improved Pressure Blower,

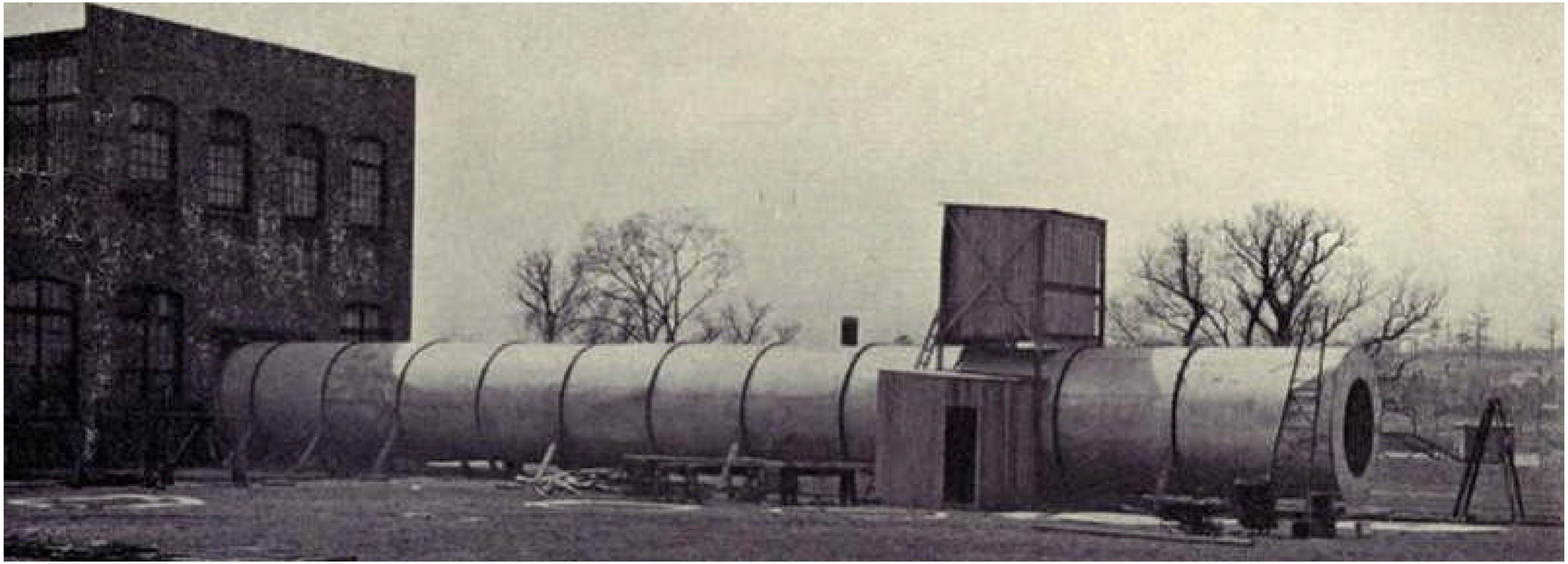


FOR CUPOLA FURNACES AND FORGES.

Also, Fan Blowers for Blast under Boilers, Puddling and Heating Furnaces, and Ventilation of Mines and Public Buildings, and Hot Blast Apparatus for Dry-Houses.

Send for Illustrated Catalogue.

B. F. STURTEVANT, Patentee and Sole Manufacturer, **72 SUDBURY ST., BOSTON, MASS.**



"…A difference of opinion arose as to the type of fan best suited for ventilating the tunnels. This question was definitely settled in the laboratory of the company in tests made by the engineers of the tunnel and of the company. A further problem arose in that the resistance to the flow of air which would be encountered in the actual installation were entirely frictional. There was a great dearth of information about the frictional resistance of ducts, and the company's research department was able to outline a series of model tests for the determination of the factors necessary for the solution of this extremely important point. These tests were later very ably carried out by the tunnel engineers and Professor Willard of the University of Illinois…"

RE: excerpt from *The Eighth Wonder*

Above: caption: "Special Apparatus Erected at Hyde Park Plant of B.F. Sturtevant Company. Used in testing Sturtevant Silentvane Fans for the Holland Tunnel."

"…The selection of the proper type of fans to be used and the determination of the resistances against which they would operate were the two most important requirements of this unprecedented ventilation problem. In addition, through the extended experience of the company's research department, proper methods for installing the equipment were de-termined, and suitable motors for driving the fans and suitable connections to ducts were selected, all of which assured the final success of the installation as a whole…"

RE: excerpt from *The Eighth Wonder*

A Matter of Industrial Pride

"…The company and its engineers felt that, as the largest manufacturers of ventilating equipment in the world, they were directly concerned with the success of the greatest ventilation project in the world. It was a matter of industrial pride on the part of the company and its engineers to do all they could to insure its final success…"

RE: excerpt from *The Eighth Wonder*

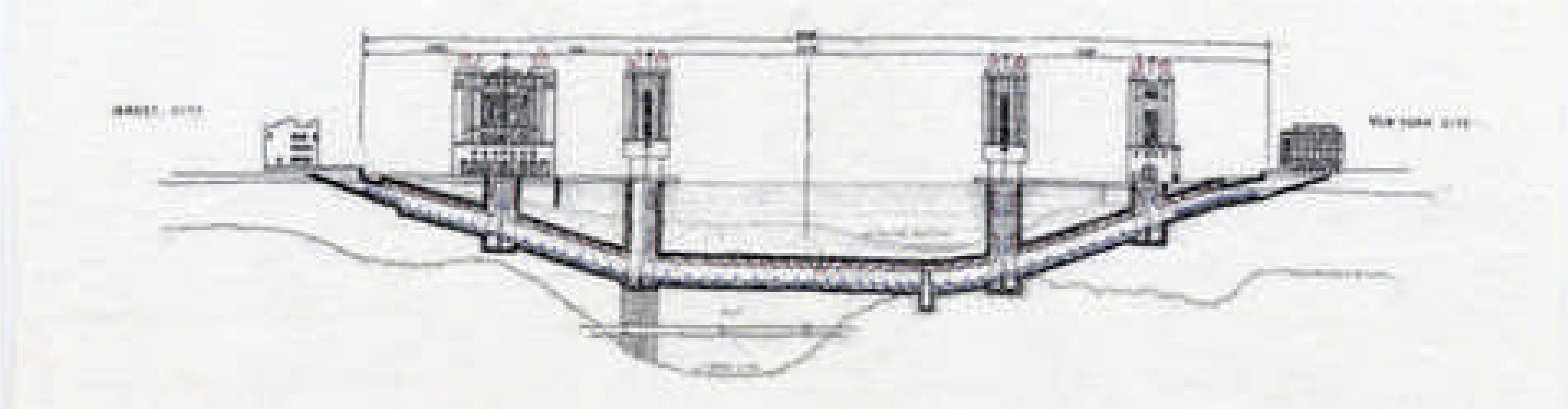
"…In the final bidding the company proved its right to be considered a leader in the industry…The Sturtevant Silent-vane Fan is an outstanding achievement, since it has demonstrated under a variety of tests efficiencies greater than any other type of centrifugal fan. For the work of ventilating the Holland Tunnel it showed efficiencies varying from 15% to 20% higher than any other fan that could have been used for the purpose, and by reducing the amount of power required, the investment in motors was correspondingly less. Its selection was therefore inevitable…"

RE: excerpt from *The Eighth Wonder*

Ventilation Buildings

“The power required to move the large quantities of air is an important factor, and it was found economical to divide the tunnel ducts into a number of sections by locating the ventilation equipment in four shafts, two on each side of the river. Navigation requirements did not permit the location of any shafts beyond the pierhead lines, which at the site of the tunnel are about 3,200 feet apart.”

Ole Singstad, **Design Engineer**



"…The Sturtevant Silentvane Fans are installed in the ventilation buildings, of which there are two on each side of the river, one at the pierhead line and the other inland. Each land shaft ventilated four sections of tunnel – the adjoining portal sections of each tube, the whole intermediate section to the pierhead shaft where traffic is on a down-grade, and one-half of the parallel section where it is on an upgrade. The buildings over these shafts contain four independent sets of blower and exhaust fans. The pierhead shafts ventilate three sections of tunnel – one-half of each of the 3,400-foot river sections and one-half of the inter-mediate section where traffic is on an upgrade. In all there are 14 sets of blowers and 14 sets of exhaust fans. Dividing the upgrade sections of the tunnels into three parts gives added ventilation where the greatest amount of carbon monoxide is expected…"

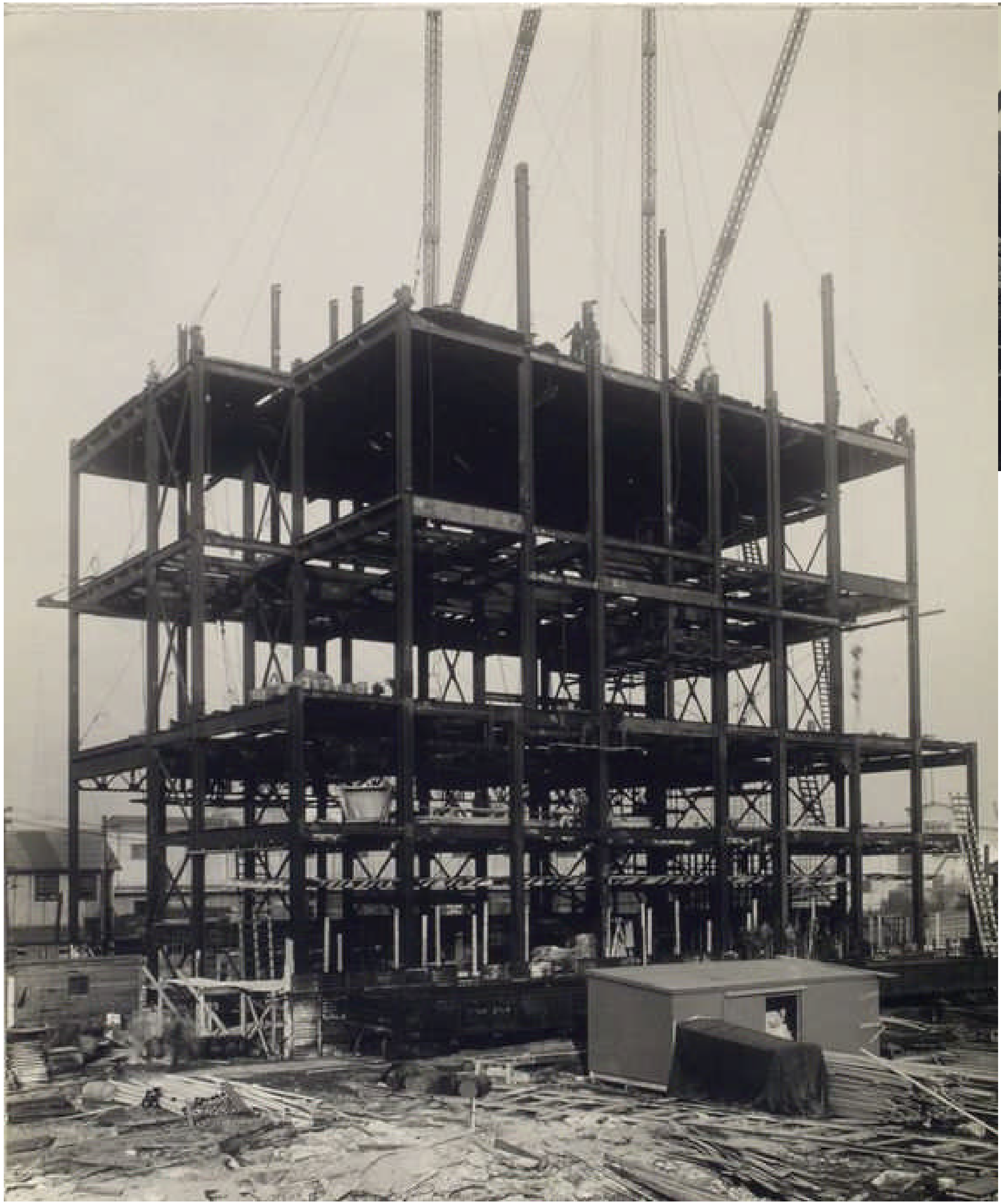
RE: excerpt from *The Eighth Wonder*

"In the four ventilation buildings are located blower fans connecting through downcast ducts with the fresh air ducts in the tunnel. These fans take air from the fan rooms, the air entering the rooms through large louvred openings in the sides of the buildings. In the same buildings the exhaust fans are located in airtight rooms which are connected through ducts with the exhaust duct in the tunnel. The exhaust fans connect to vertical expanding stacks extending above the roofs of the buildings, through which the vitiated air is expelled to the outside atmosphere. The ventilation ducts in each tube are divided into seven sections by transverse bulkheads, so that the equipment in each building ventilates sections of the tunnel extending from the building to the portal or half-way to the next building except in the case of the entrance downgrade between the land and river buildings in each tube, which is ventilated from the land building alone. Each duct section has three fans, two of them required to be operated at full speed to supply the normal maximum ventilation requirements, the third unit constituting the reserve."

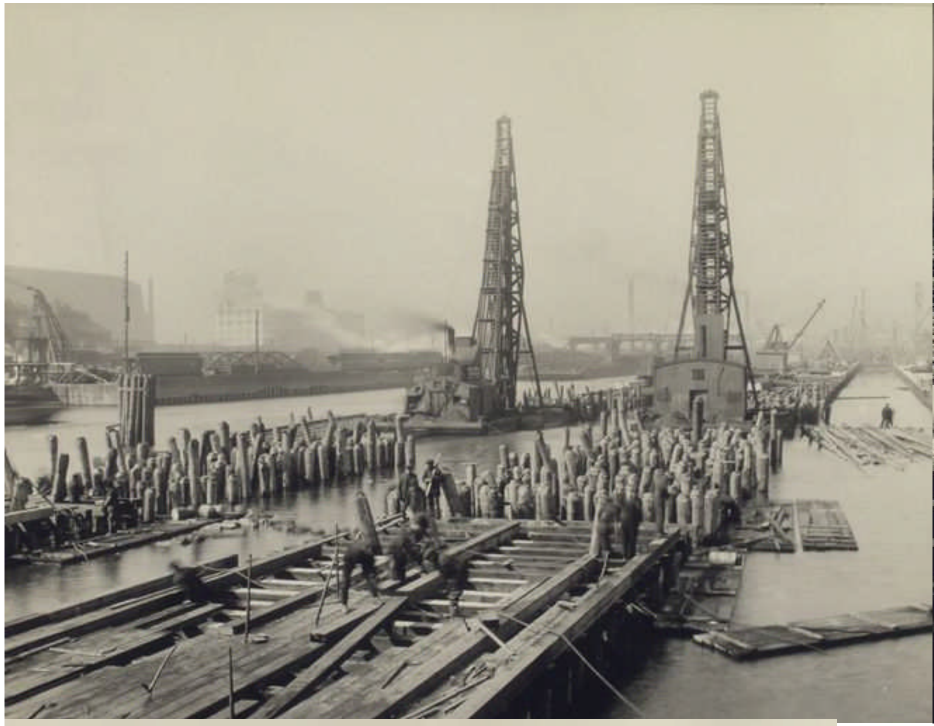
***Ole Singstad,* Design Engineer**

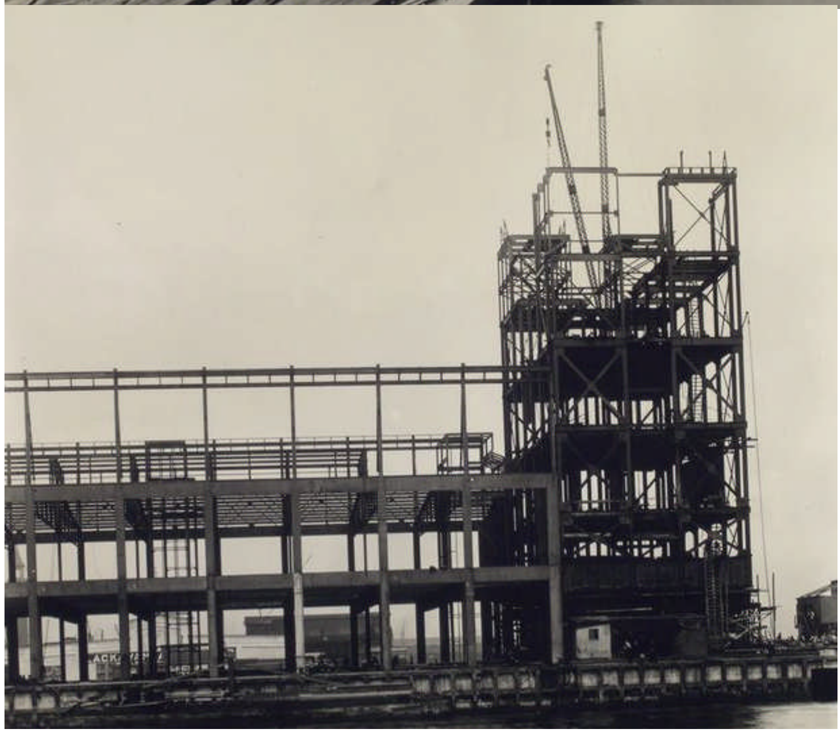
<u>Left</u>: caption: "Brick work - Land Ventilation Building. North side of Canal Street, west side Washington Street, New York. 10/7/26."

<u>Above</u>: caption: "Brick work complete, Land Ventilation Building, west of Washington Street, between Spring and Canal Streets, New York. 11/17/26."

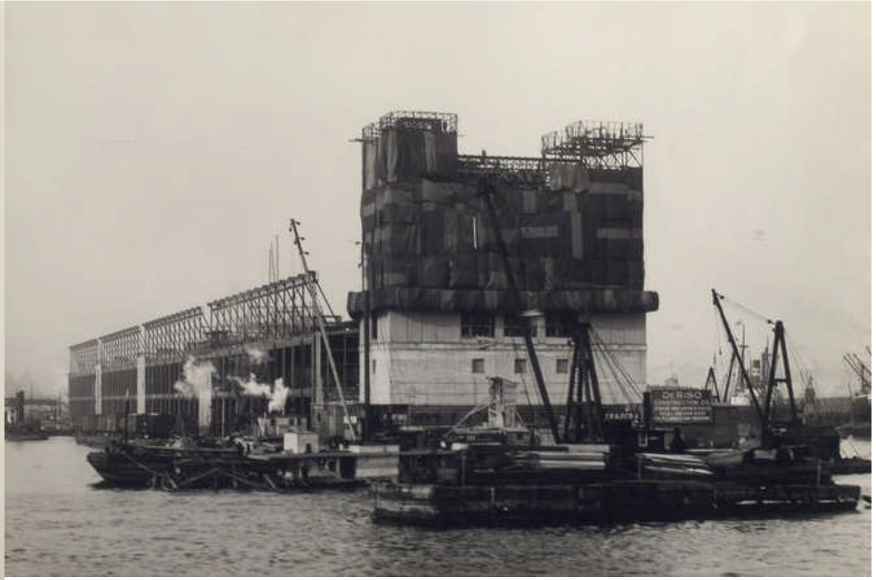


<u>Above</u>: caption: "Excavation and timbering for air duct, east of land shaft to proposed ventilation building, New Jersey. 4/1/25."
<u>Left</u>: caption: "Erection of steel framing. Land ventilation building, New Jersey. 11/22/26".



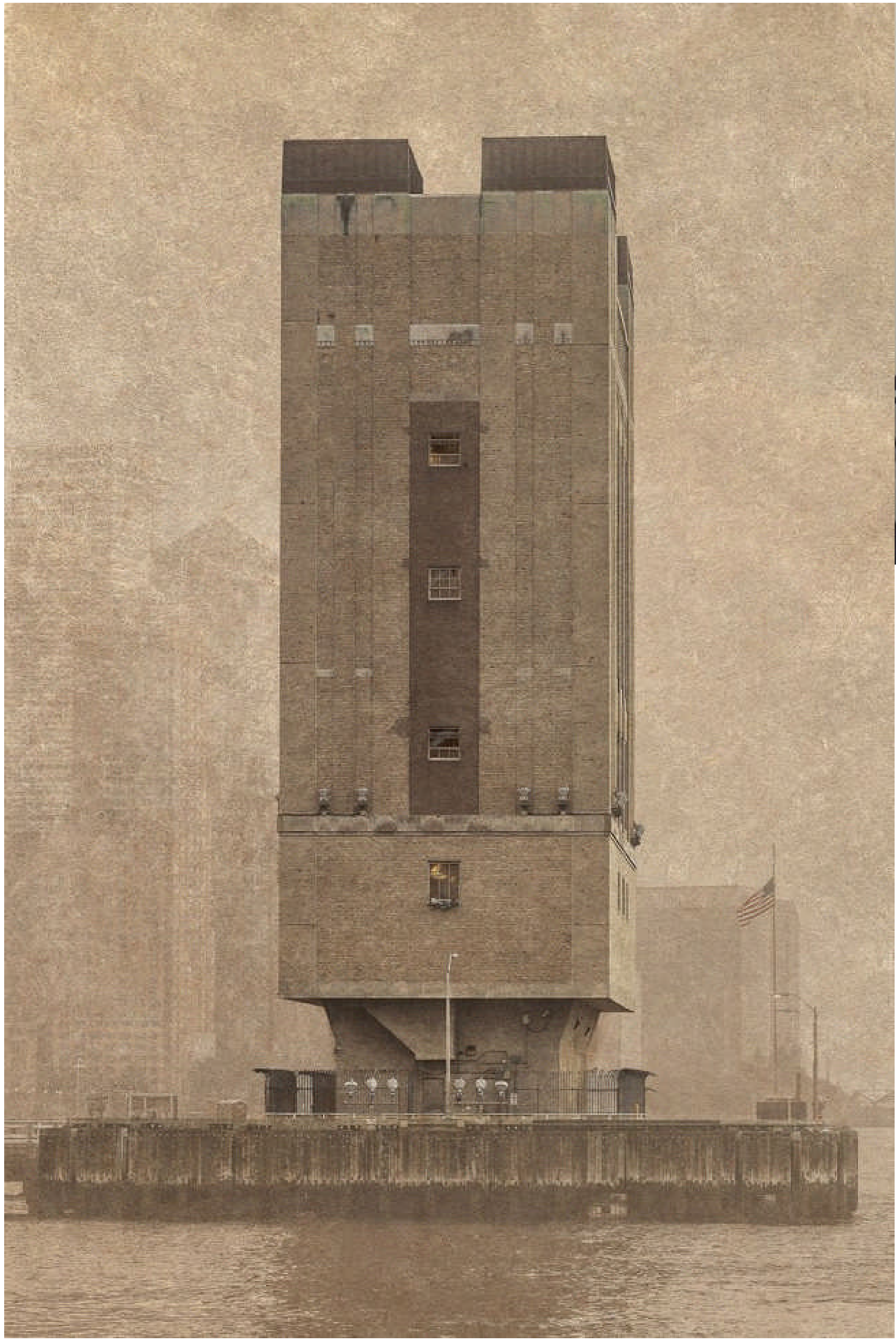


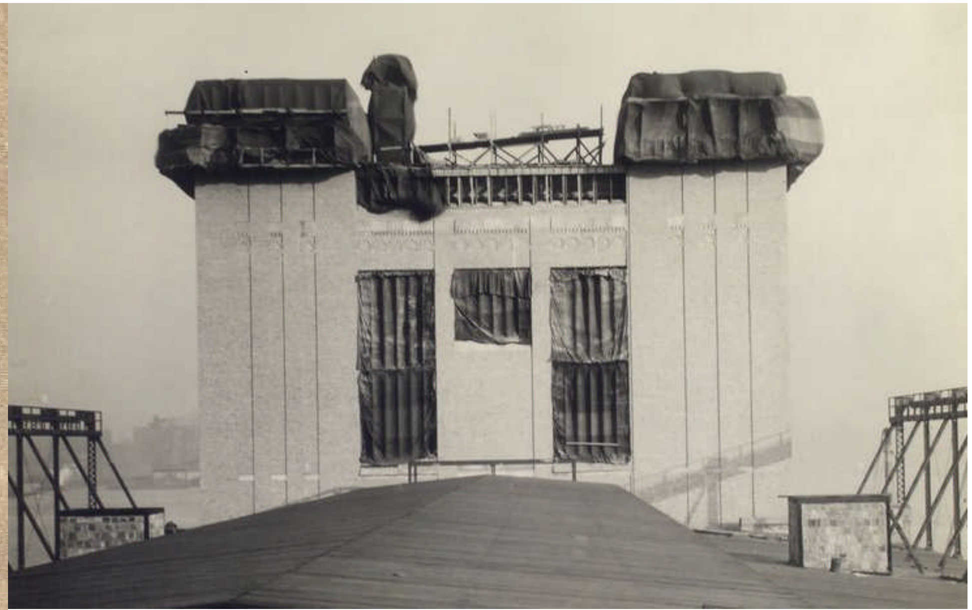
<u>Top Left</u>: caption: "New Erie Pier No. 9, New Jersey. 3/10/26."
<u>Top Right</u>: caption: "New Erie Pier No. 9, Jersey City, N.J. 4/15/26."
<u>Left</u>: caption: "Exterior view of steel erection - River Ventilation Building, New Jersey. 10/7/26."



<u>Left</u>: caption: “Steel framing - River Ventilation Building, New Jersey. 11/22/26.”

<u>Above</u>: caption: “Concrete & brick work - River Ventilation Building, New Jersey.12/9/26.”





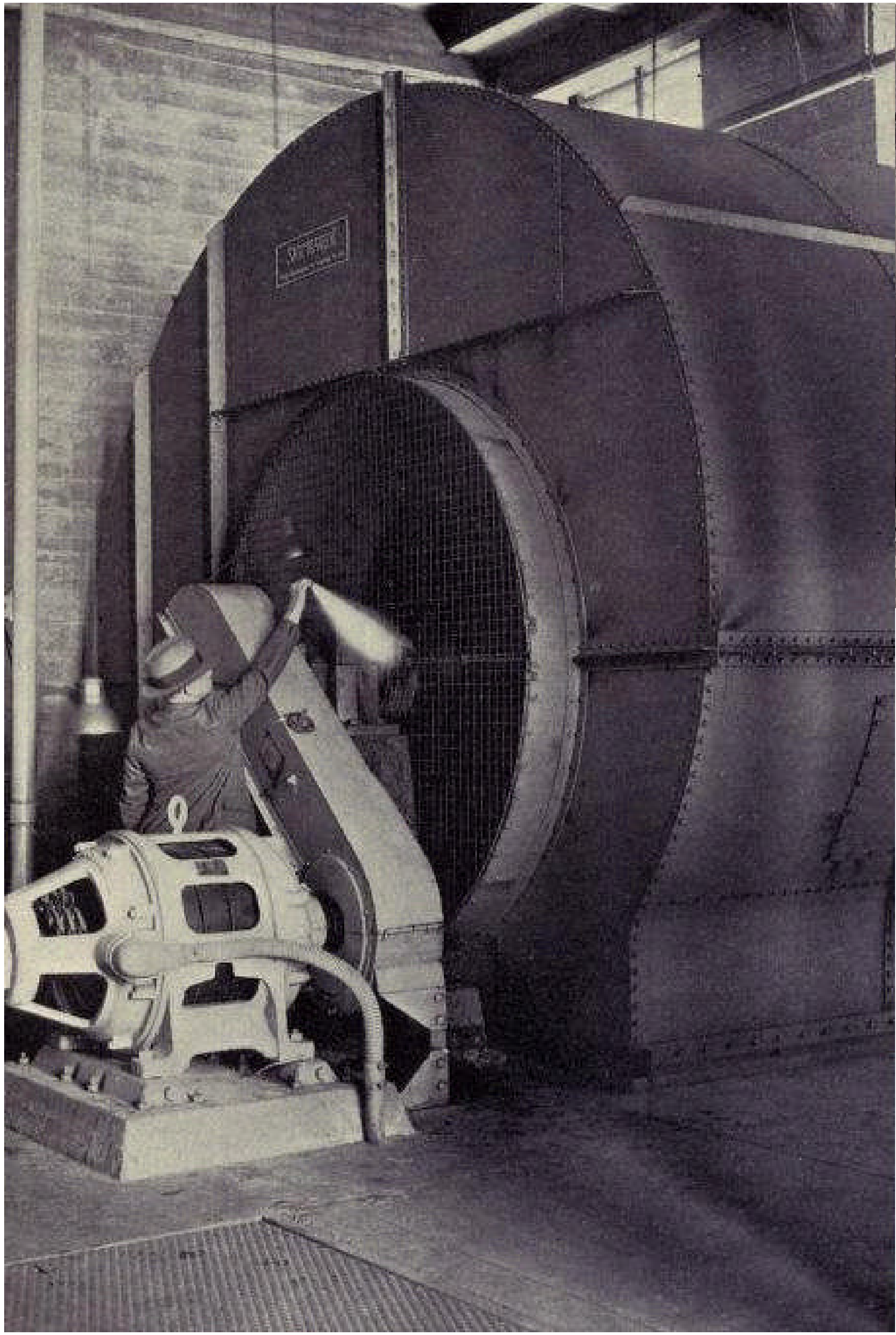
<u>Above</u>: caption: "West side of River Ventilation Bldg. and East End of Erie Pier No. 9, Jersey City. 1/6/27."
<u>Left</u>: caption: "Holland Tunnel Ventilation Tower"

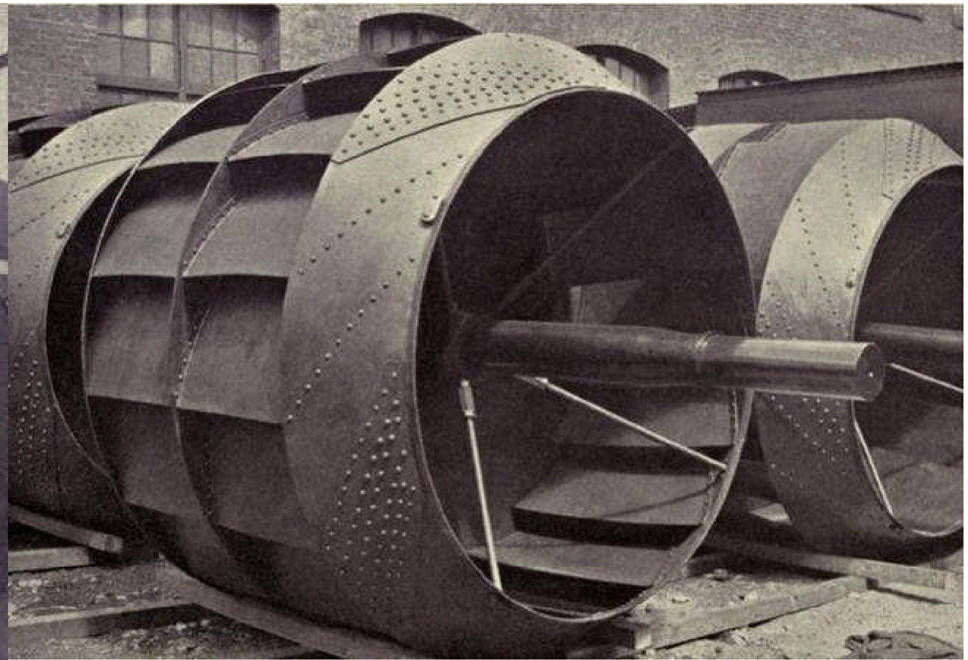
"…There are 28 ducts, 14 blower and 14 exhaust, connecting the various sections of the tunnels with the ventilating buildings. Each duct is equipped with three fans, two of which, when operated together, will supply the maximum quantity of air required. Their capacities range from 81,000 to 227,000 cubic feet per minute and they operate at static pressures varying from 0.6 to 3.75 inches of water. This range in pressure and capacity is due to the great difference in length of tunnel ventilated by different sets, those at the outside of the pierhead shafts having 1,700 feet to serve while the inside fans have only 700 or 800 feet. These fans, during an hour of heavy traffic, will handle 84,000 tons of air, or 1,400 tons per minute. They provide for changing the air in the tunnel 42 times per hour…"

RE: excerpt from *The Eighth Wonder*

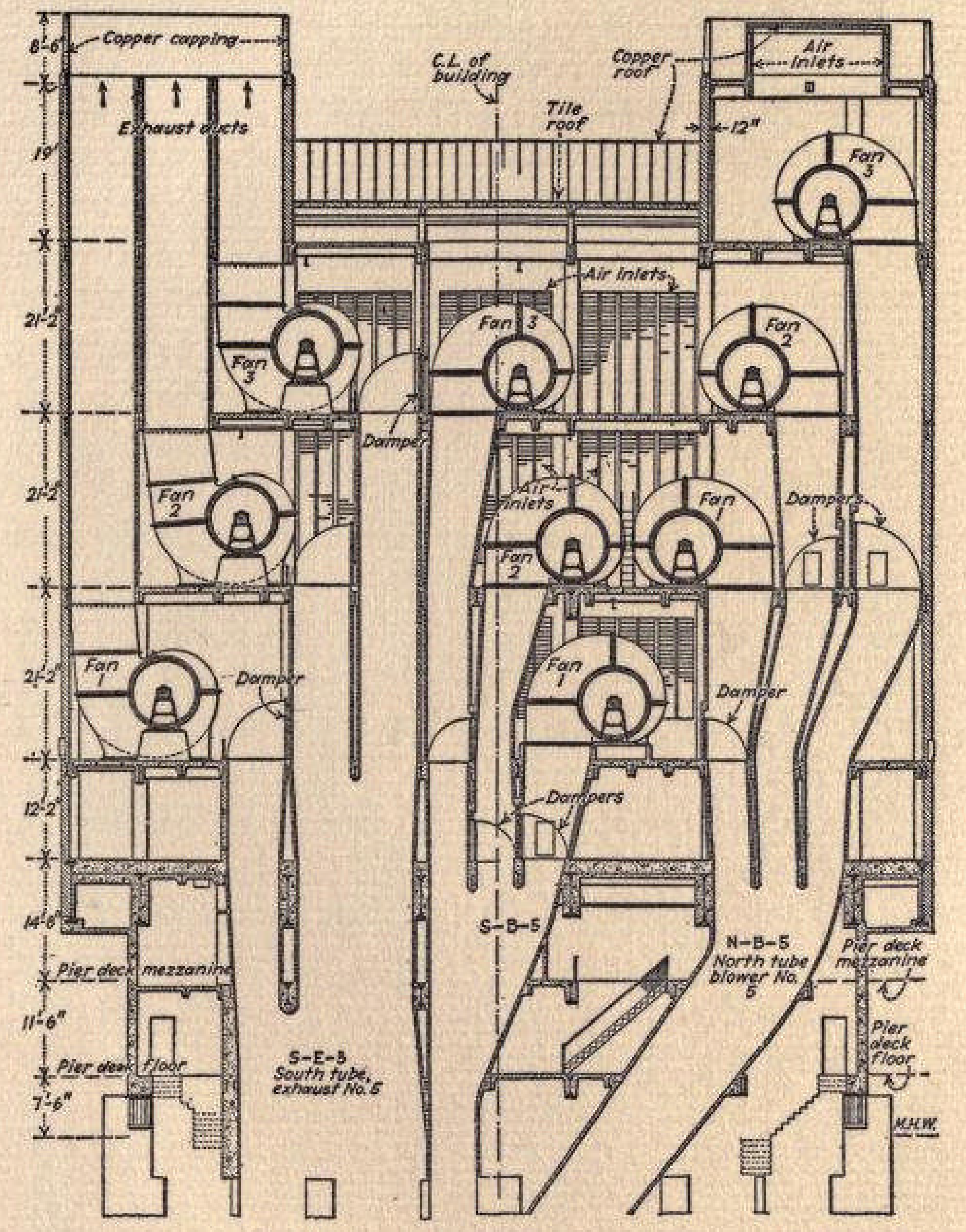
"…The fans are of the backward curved-blade type. Under different conditions, one, two, or three fans may be operated on one tunnel duct at any one time. By the use of the Sturtevant Silentvane, assurance is given that they will operate satisfactorily when run in parallel without the danger of any one fan assuming more than its share of the load and overloading the motor. They will also maintain satisfactory efficiency for any stage of loading from 35% to full load. They are electrically driven by wound-rotor motors with resistance in the circuit to make it possible to run them at variable speeds. The combined capacities of the motors is approximately 6,000 horse power, two-thirds of which will be in operation at times of maximum load and one-third in reserve. Chain drives are to be used to make possible speed adjustments or changes in the motors as well as on account of the space limitations in the ventilating buildings…"

RE: excerpt from *The Eighth Wonder*





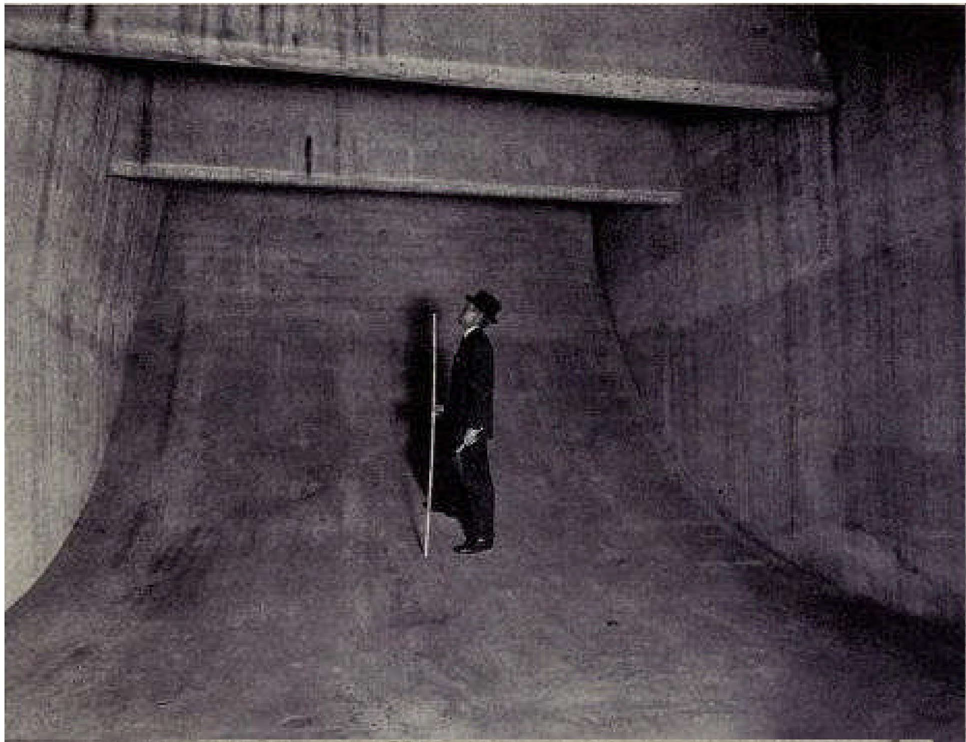
<u>Above</u>: caption: “Sturtevant Silentvane Fan Wheels for the Holland Tunnel”
<u>Left</u>: caption: “One of the 84 Sturtevant Silentvane Fans. Which are the lungs of the Holland Tunnel”

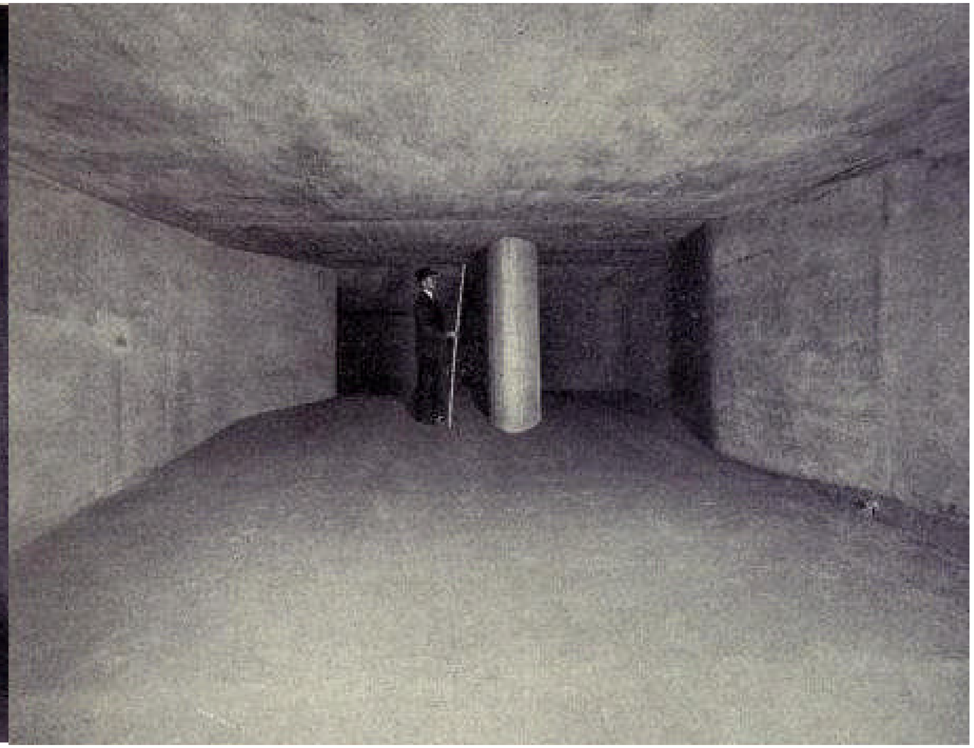


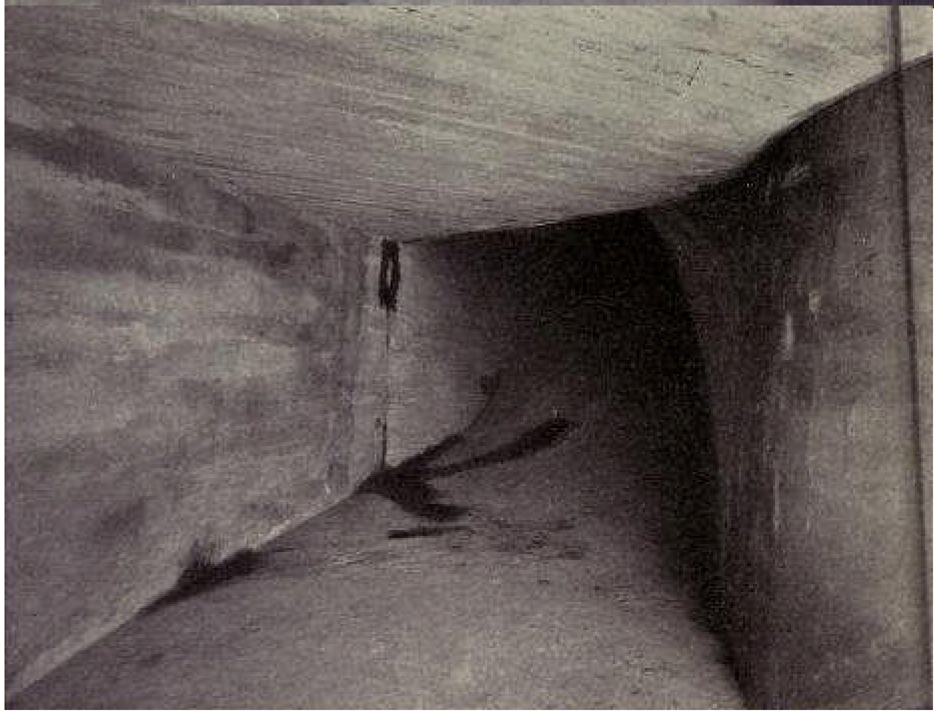
TYPICAL VERTICAL SECTION THROUGH VENTILATING BUILDING

"…The placing of the fans is varied to suit the local conditions in the individual buildings. Generally, the exhaust ducts are at the corners of the buildings and supply ducts are in the central portion. Consequently the compartments containing the exhaust fans are located near the corners under the exhaust stacks, leaving the central portion of the fan floors free for intake fans, and the central section of each outer wall for the air intakes. The intakes are made sufficiently large to give low velocities through the louvres…"

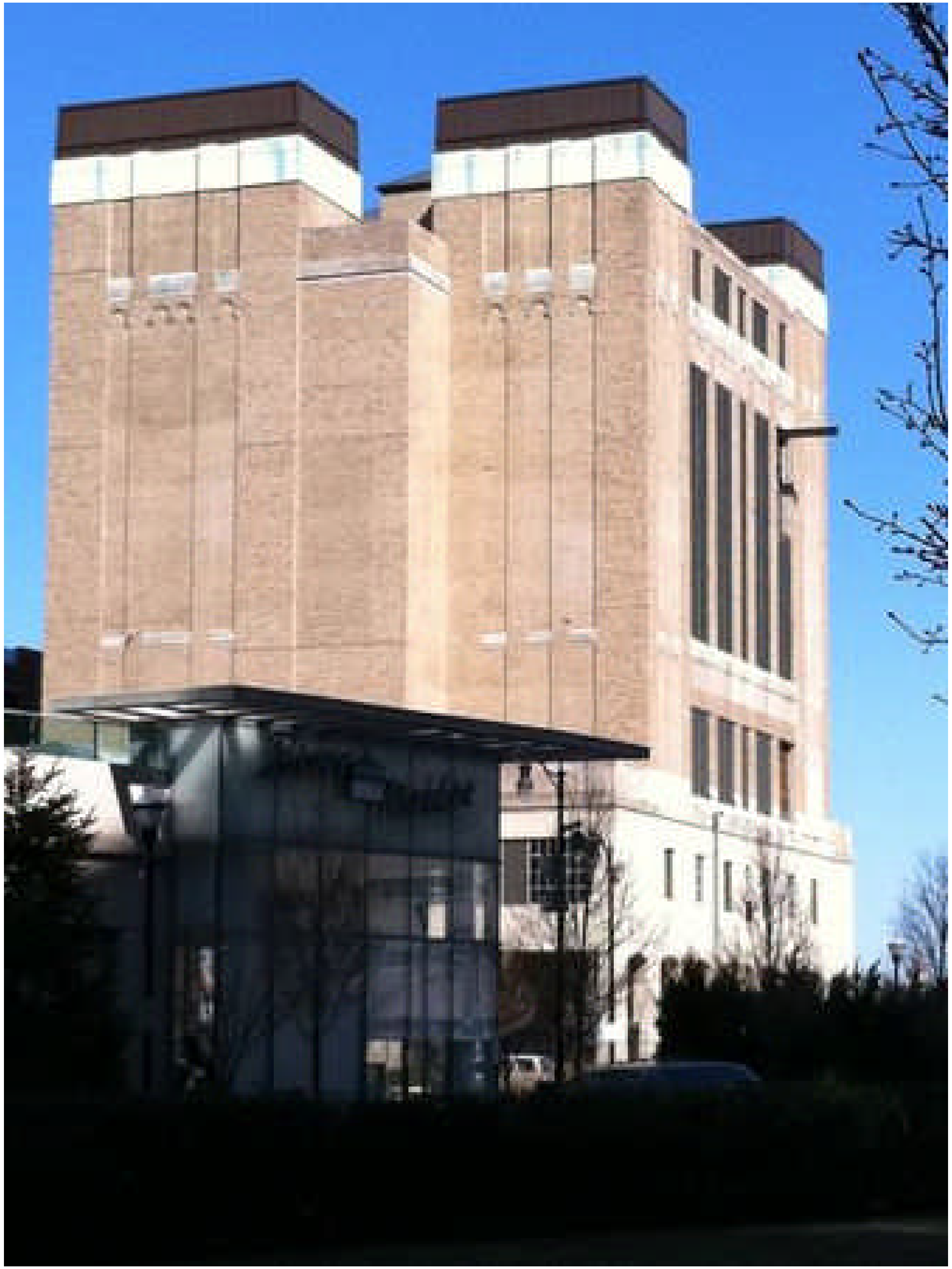
RE: excerpt from *The Eighth Wonder*







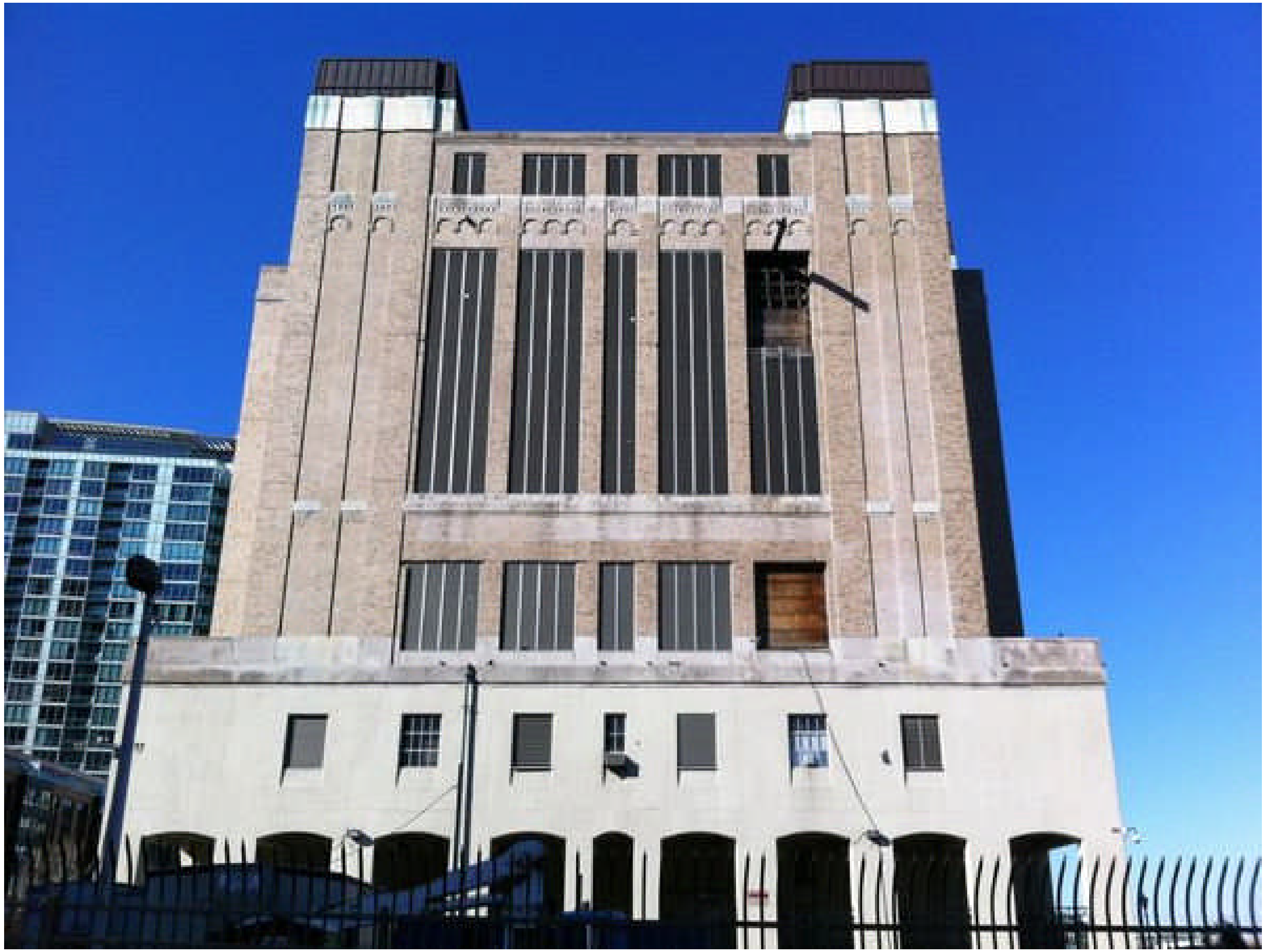
<u>Top Left</u>: caption: "East Blower Air Duct. In Land Ventilation Building, New York City, showing curved back and vanes."
<u>Top Right</u>: caption: "East Blower Air Duct. Land Ventilation Building, New York City."
<u>Left</u>: caption: "Fresh Air Duct in South Tunnel, N.J. Side. Showing the beginning of the transition from its position under the roadway to its position alongside the tunnel."



"…The louvre blades are made of heavy wire glass to give light to the interior of the buildings as they take up most of the space otherwise available for windows. Heavy bronze scr-eens protect them and also serve to keep out birds. The arrangement whereby fresh air is drawn in through louvres high upon the sides of the buildings and exhaust air is forced out through stacks which extend 20 feet above the roof insures a complete sep-aration of fresh and vitiated air…"

RE: excerpt from *The Eighth Wonder*

<u>Left</u>: caption: "NJ Land Ventilation Building, side view"



<u>Above</u>: caption: “River Ventilation Building. Pier-head line between piers 34 and 35, North River, New York City”
<u>Left</u>: caption: “Land Ventilation Building. West side of Washington Street, Canal to Spring Sts., New York City”


VENTILATION BUILDING

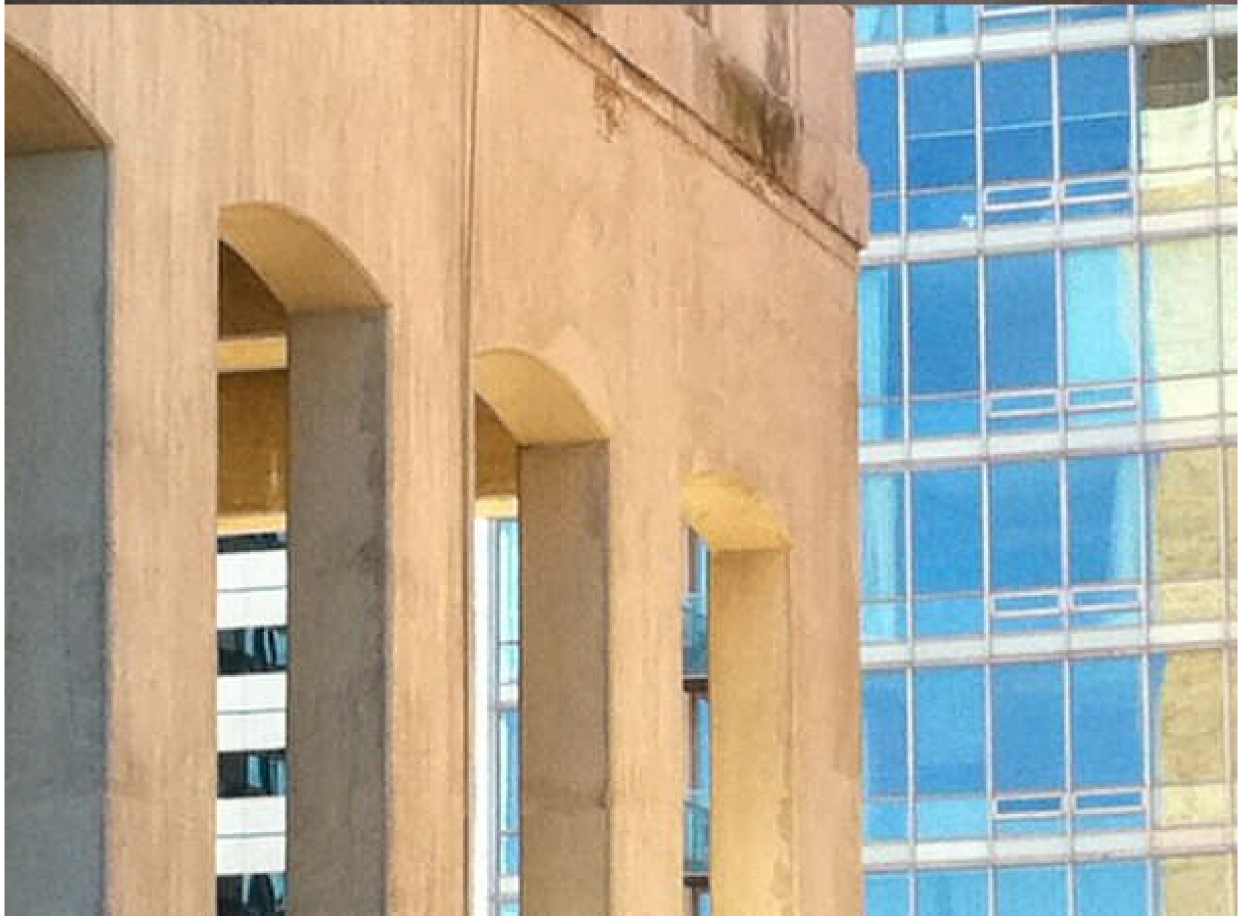
<u>Left</u>: *Erling Owre*, Architect (1877-1961). Born and trained in *Norway*, Owre was hired by Chief Engineer *Clifford Holland* to design and supervise the construction of the sophisticated ventilation towers. His monumental steel, concrete and brick towers, soldiered across the *Jersey City-Manhattan* land and water axis, contrast with the era's predominant *Art Moderne* architectural style.

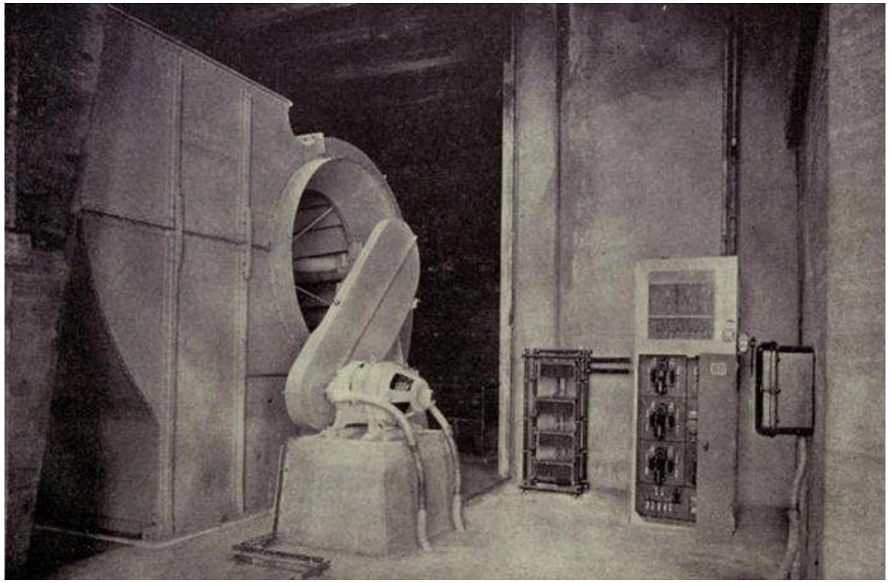
<u>Above</u>: caption: “Holland Tunnel ventilation tower in Newport, Jersey City. Between 1921-1927, Norwegian architect Erling Owre designed four innovative 10-story ventilation structures, two of which were placed in the water with steel foundation piles reaching far down into the Hudson River’s bedrock. Owre graced the towers with Byzantine elements only visible up close. However, it is the combined influence of architects Le Corbusier and Frank Lloyd Wright that looms and lingers.”

<u>Left</u>: caption: “Land Ventilation Building, New York.”

<u>Above</u>: caption: “Aerial view of the Holland Tunnel River Ventilation Tower, with Downtown Jersey City in the background”

<u>Left</u>: caption: “New Jersey Land Ventilation Building, East and South sides, Holland Tunnel. This 10-story ventilation tower is located at the intersection of what is now River Drive and Newport Parkway in the Newport section of Jersey City.





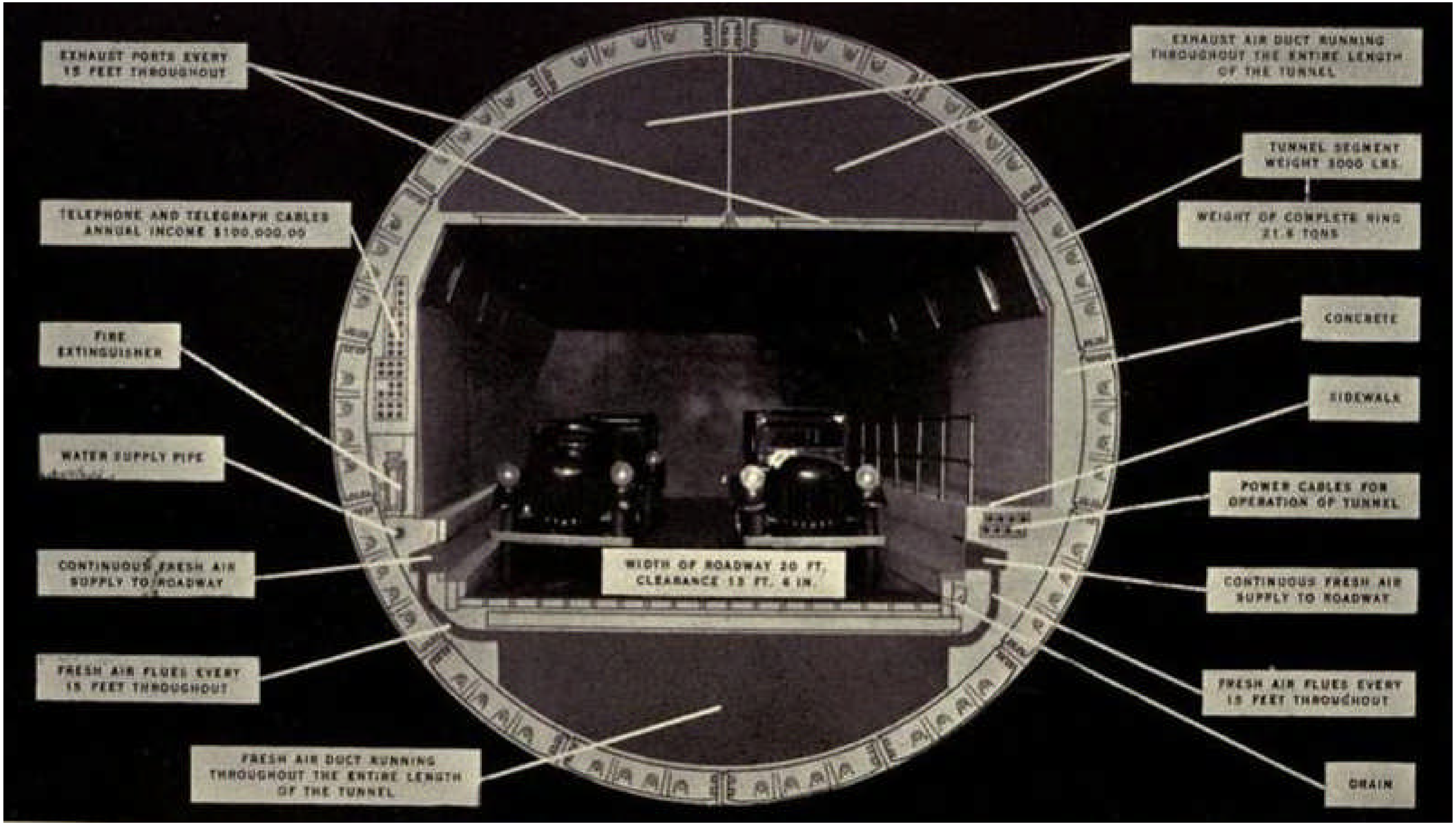
"…The intake fans and their motors are situated in the open portions of the fan floors where they are accessible. The exhaust fans are, of necessity, inside of chambers at the top of the ducts, Their motors, however, are out on the main floor, the drive shafts being run in to the fans through close-fitting collars in the side plates of the duct. Access to the fans is provided through air locks equipped with airtight doors which can be opened against the unequal pressure by wedge latches which force the doors open sufficiently to break the seal. Each duct is equipped with a damper which may be closed when the fan is shut down so that air from the other fans will not be short-circuited through the idle fan. These dampers are motor operated from the control room and are equipped with limit switches…"

RE: excerpt from *The Eighth Wonder*

Above: caption: "Exhaust Fan Unit in N.J. Land Ventilation Building. Showing typical arrangement of exhaust fan, motor, chain casing, resistors, control cabinet, and local control box."

"…Air from the intake fans is forced down into the longitudinal duct under the roadway of the tunnel. From there it is fed through flues 10 to 15 feet apart into a continuous expansion chamber above the curb line at each side of the roadway, the flow of air into this chamber being controlled by adjustable slides over the flue openings. The outer side of the expansion chamber is a copper-steel plate which can be adjusted to give an opening of widths varying from ¾ inches to 1¾ inches through which fresh air flows into the tunnel. Vitiated air is drawn off through openings through the ceiling into the exhaust ducts. These openings are spaced 10 to 15 feet apart and are from 3 to 6 feet long, They also, are provided with slides by which the opening can be adjusted to meet the local requirements for air circulation. By this arrangement of supply and exhaust ports, fresh air supplied to the roadway mixes with the warmer gases and rises to the ceiling where the exhaust ports are located…"

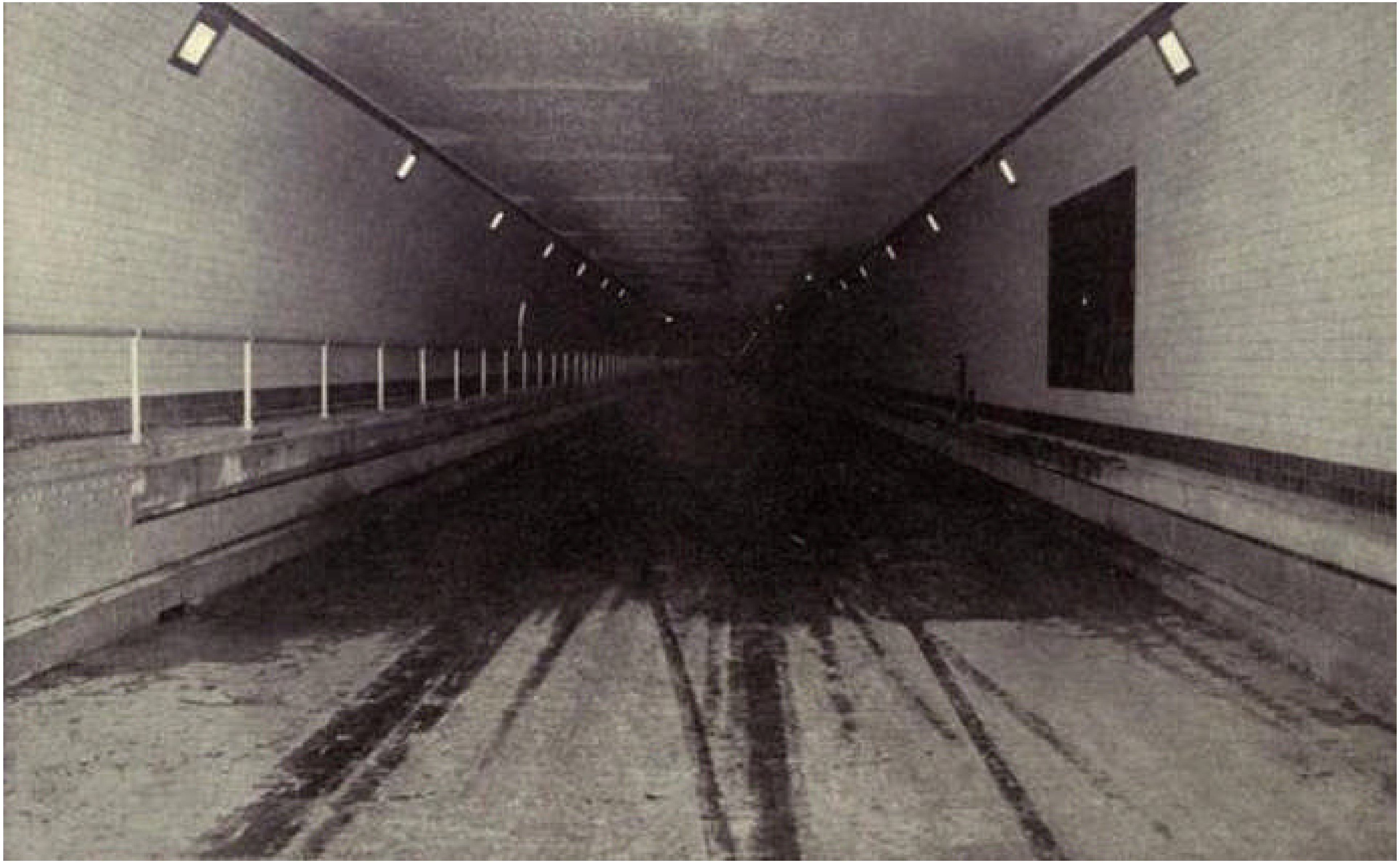
RE: excerpt from *The Eighth Wonder*



<u>Above</u>: caption: "Model of the Holland Tunnel showing many of the hidden details"

"…There will be no longitudinal movement of air in the tunnels except that induced by the movement of vehicles, nor will there be any objectionable winds such as would be created by longitudinal ventilation. Test made with smoke bombs showed that even large quantities of smoke will not spread far from the point of origin, but will rise quickly to the ceiling and be taken out. Similarly, in case of a fire the hot gases will rise to the ceiling, where they will be drawn off. There will not be the same danger of spreading the fire from car to car as there would be with longitudinal ventilation…"

RE: excerpt from *The Eighth Wonder*



<u>**Above**</u>**: caption: “Condensation in North Tunnel. View showing dry conditions of roadway east of air duct bulkhead where fans were in operation, and wet conditions on roadway west of air duct bulkhead where fans were not in operation.”**

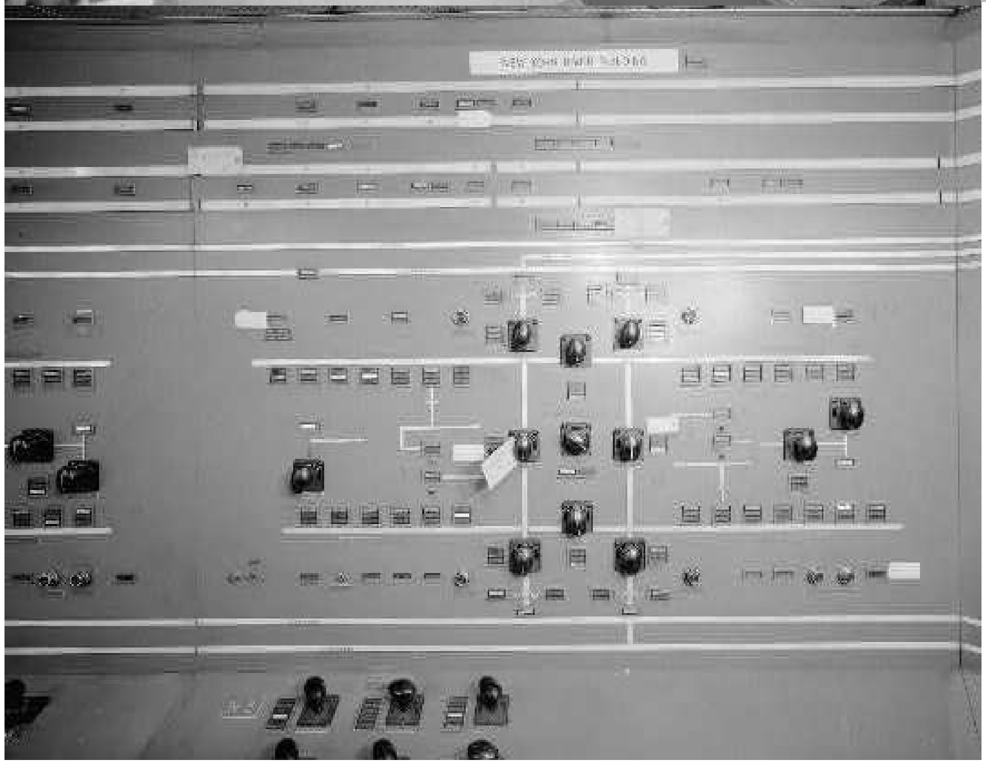
"…As a check upon air conditions in the tunnel, automatic carbon monoxide recording devices are installed in each exhaust duct which will make a continuous analysis of the gases and record it graphically in the control room of the administration building in New York. There, by observing the chart, the operator can increase or decrease the fresh-air supply as traffic conditions change in the tunnel…"

RE: excerpt from *The Eighth Wonder*

<u>Left</u>: caption: "Steel framing - Administration building, south side Canal Street and west side of Varick Street and north side Vestry Street, New York City. 12/9/26."


THE HOLLAND TUNNEL
NO TRESPASSING





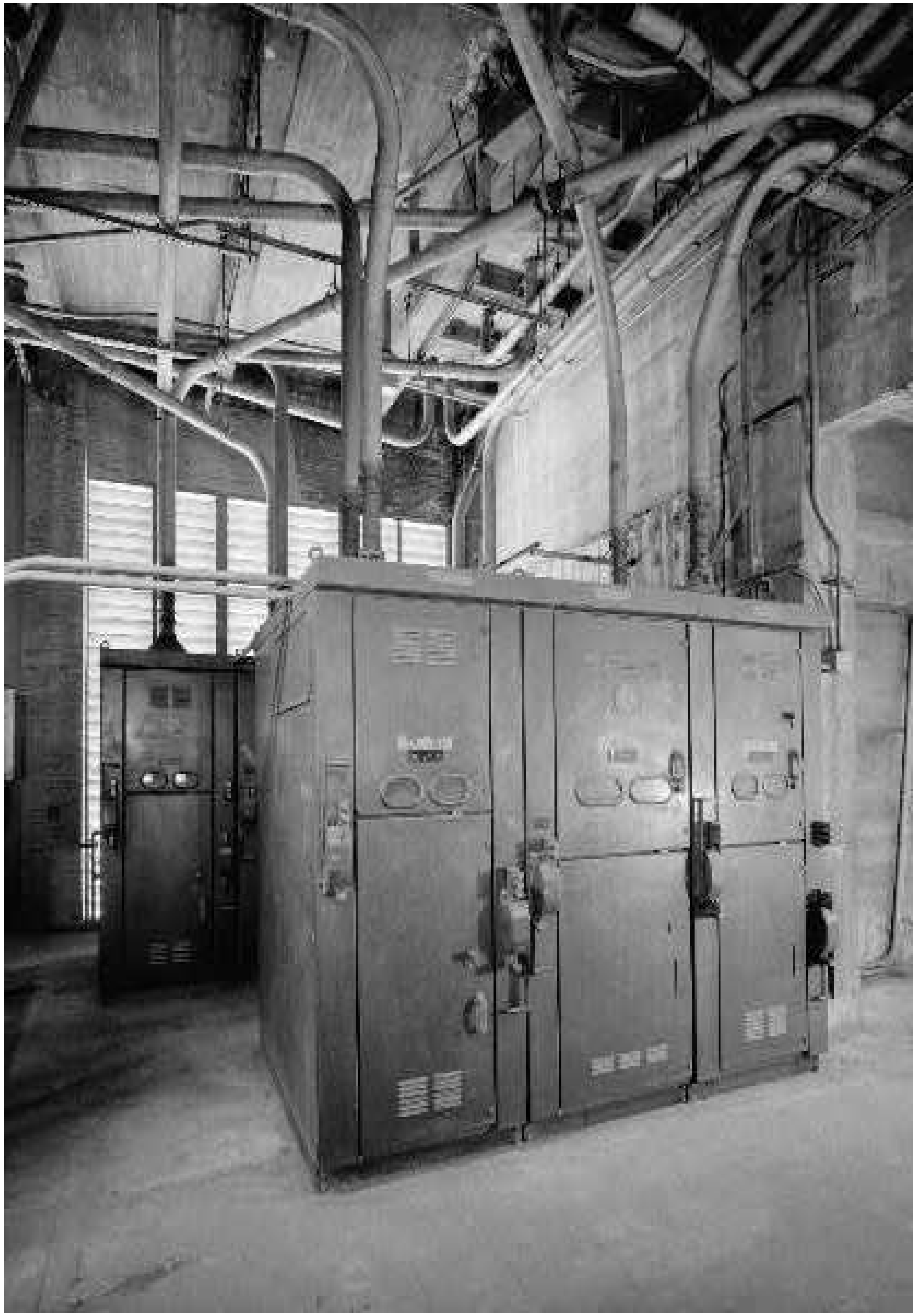
<u>Top Left</u>: caption: "Headquarters and Maintenance Building, Traffic Monitoring Room"

<u>Top Right</u>: caption: " Headquarters and Maintenance Building, Main Control Room for All Ventilation, Mechanical and Electrical Systems"

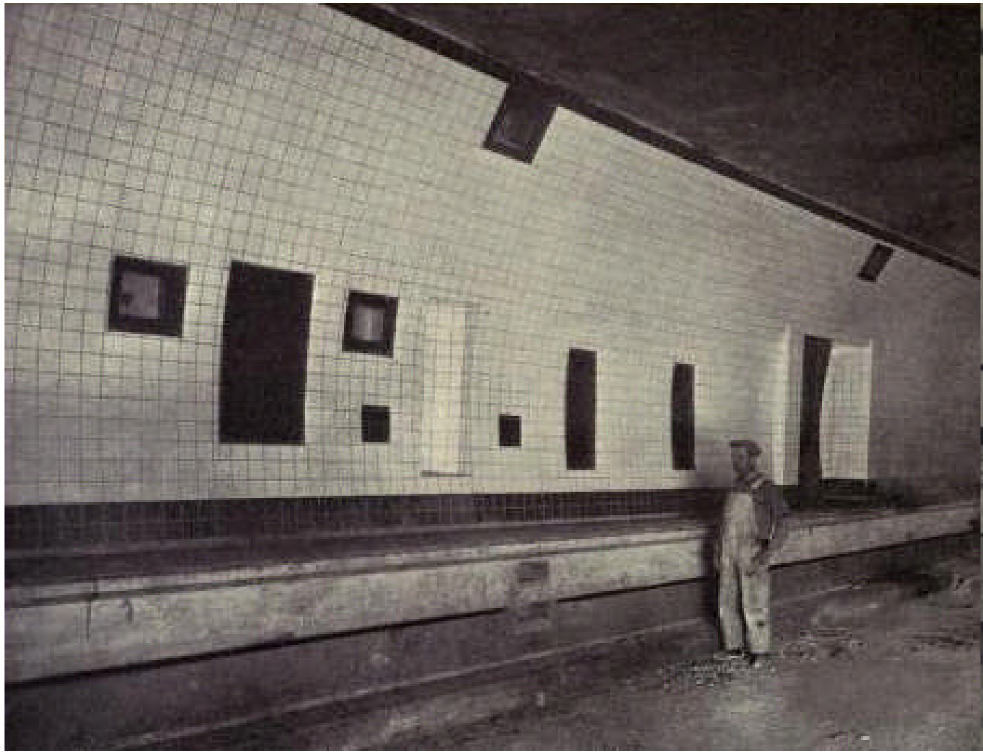
<u>Left</u>: caption: "Headquarters and Maintenance Building, Close-up of Control Room Panels for New York (side) River Building"

"…An unusually flexible system of power supply has been worked out based on the facts that all the motors are in groups of three, also that the maximum power requirements are less than the capacity of the minimum size power cables installed by the local companies. Three cable from the New York side and three from the New Jersey side are run to the bus bars in each ventilating building, thus giving one motor in each set a separate cable connection to power supply on each side of the river. Interconnection at the bus bars makes it possible to cut in any or all motors on each cable. This connected, each motor may be supplied with power by six independent cables, each capable of carrying the entire tunnel load; and, as there are at least two independent sources of power at each end of the tunnel, continuity of power supply is absolutely assured. As the transformers are located in the ventilating buildings where smoke from an oil fire might be drawn into the ventilating system, air-cooled instead of oil-cooled transformers are used. Each fan is provided with a control switch at the motor for emergency or repair use. Further local control is provided at the switchboard in each ventilating building where, by a system of signal lights, it will be possible, at all times, to tell what motors are in operation…"

RE: excerpt from *The Eighth Wonder*



__Left__: caption: “New York Land Ventilation Building, 4th Floor, Detail Showing Main Feeder Station”

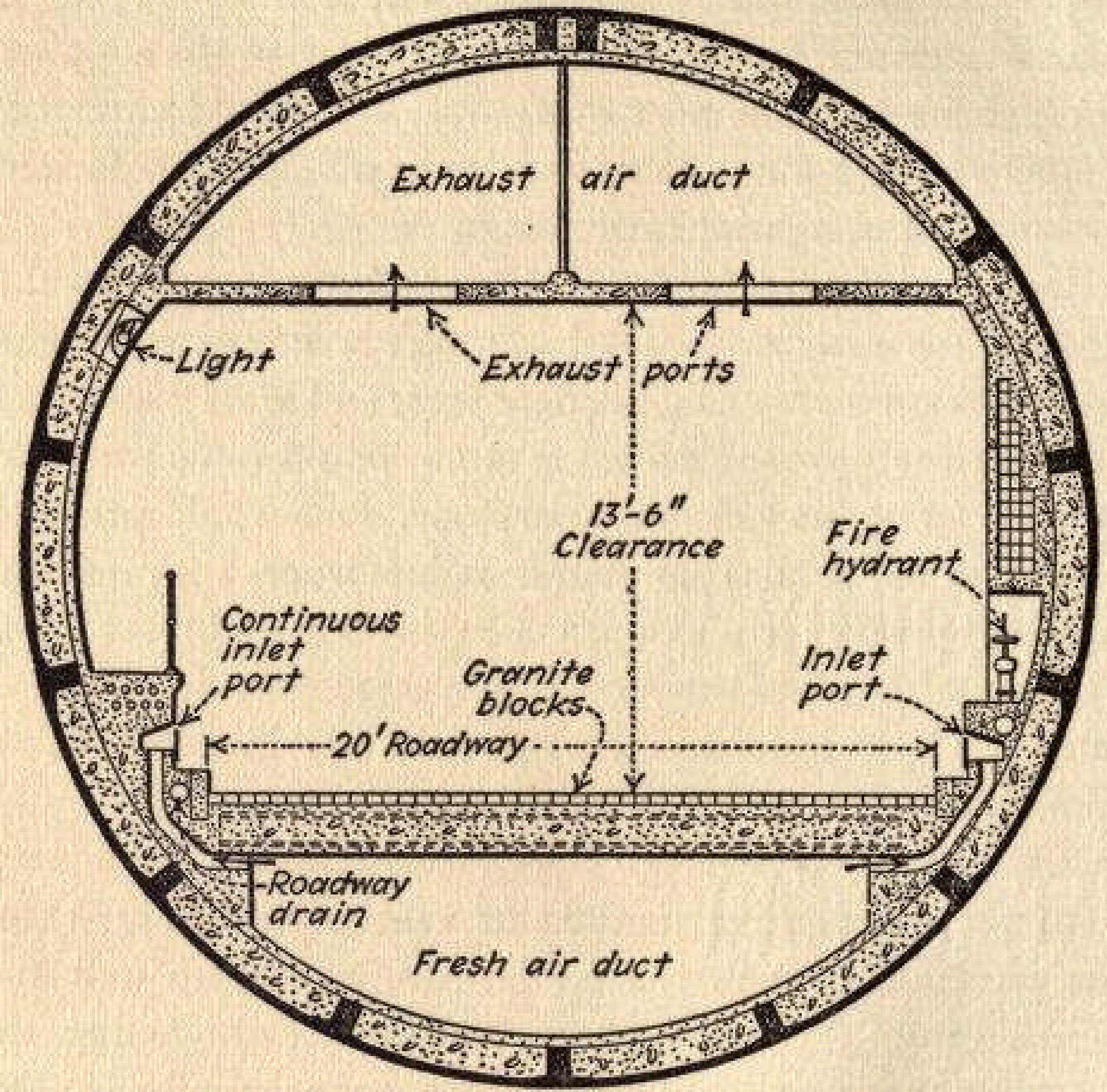
 

"…As part of the studies for the ventilating equipment numerous tests in relation to fire were made, both in the test tunnel at Bruceton and at the laboratories of manufacturers of fire-fighting equipment. These tests included the burning of an automobile drenched with gasoline and with gasoline spilling from a hole in the tank on the car to determine how quickly such a fire could be put out with the hand extinguishers to be placed in the tunnel…"

RE: excerpt from *The Eighth Wonder*

<u>Left</u>: caption: "Tile and Bronze Work. (Left to right) Bronze door to relay niche with telephone and fire alarm boxes on each side; tiled refuge niche with fresh-air outlet on each side, two fire extinguisher niches; tiled opening to mid-river sump."

<u>Right</u>: caption: "North Tunnel, west of Spring Street shaft, New York, Inspection Party. 2/10/25."



CROSS SECTION — ONE TUBE OF HOLLAND TUNNEL

Police Car Rides Narrow-Gauge-Track "Catwalk" in Tunnel

Patrolmen who regulate the flow of traffic through the Holland Tunnel recently tested a miniature electric car that rolls along the tunnel's "catwalk." The car is designed to give the officers greater control over traffic by permitting them to cover tunnel posts faster. It was tested on a 2200-foot run of miniature railroad track. Only two feet wide, the 1300-pound car can be driven in either direction from a swivel seat inside the glass-enclosed cab. Push buttons control the speed at six or twelve miles per hour. A 240-volt, three-horsepower motor powers the car.


EXTINGUISHER
KEEP IN LANE
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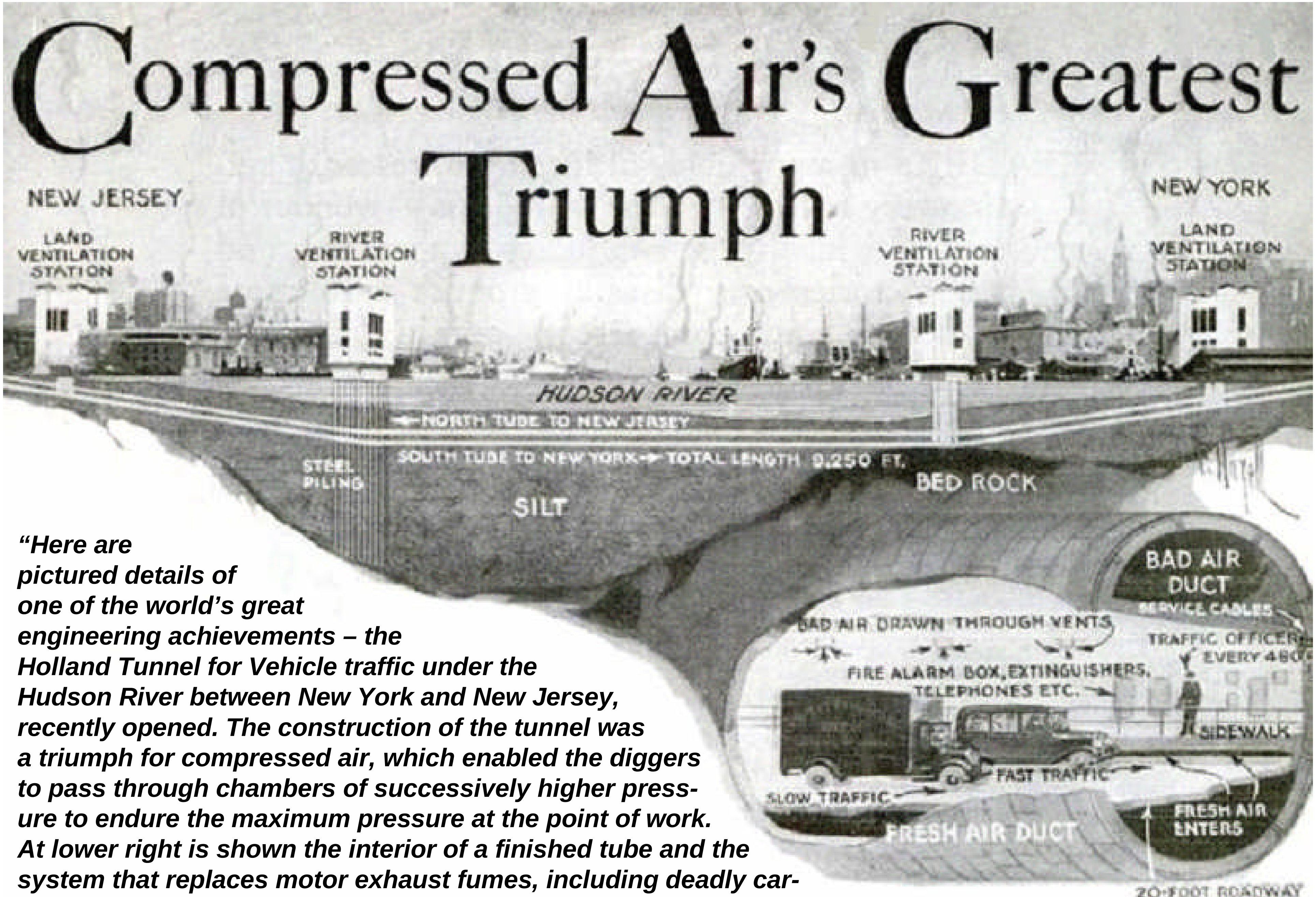
Part 6

Greatest Triumph



"Here are pictured details of one of the world's great engineering achievements – the Holland Tunnel for Vehicle traffic under the Hudson River between New York and New Jersey, recently opened. The construction of the tunnel was a triumph for compressed air, which enabled the diggers to pass through chambers of successively higher pressure to endure the maximum pressure at the point of work. At lower right is shown the interior of a finished tube and the system that replaces motor exhaust fumes, including deadly carbon monoxide, with fresh air. Above, general diagram view of $50,000,000 tunnel's twin tubes accommodating 3,800 vehicles an hour. The tunnel required seven years to construct."

***Popular Science,* January 1928**

Wedded


NOVEMBER 13, 1927.

GREAT CROWD TREKS INTO HOLLAND TUBES AFTER GALA OPENING

Thousands Pour In as Coolidge on Yacht Turns Switch With Golden Key.

AUTOS START AT MIDNIGHT

Hundreds of Honking Cars Rush Through Tunnels From New York and Jersey Sides.

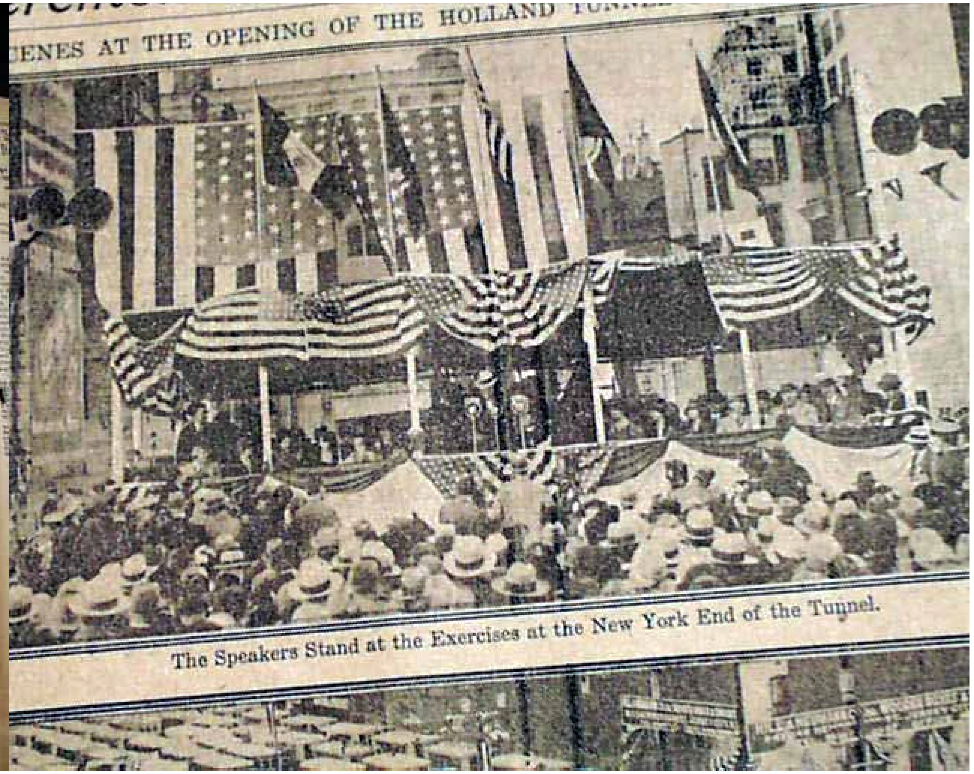
OFFICIALS HAIL THE EVENT

Governor Smith, Governor Moore, Edwards, Edge and Others Extol Engineering Triumph.

The Holland Vehicular Tunnel was officially opened at 4:55 o'clock yesterday afternoon by President Coolidge aboard his yacht, the May-

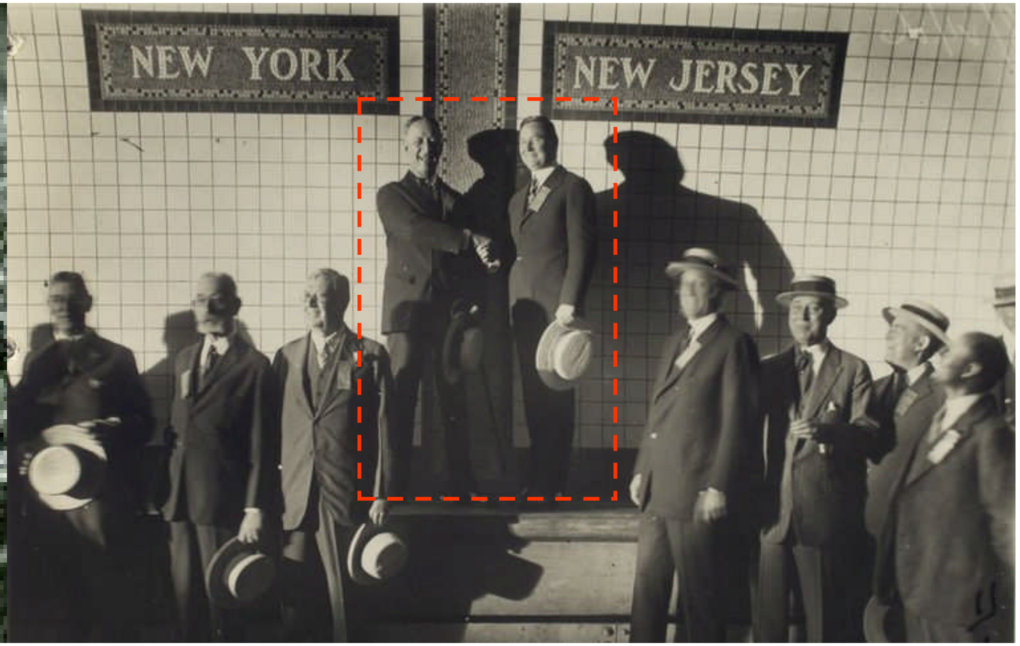
"The Holland Vehicular Tunnel was officially opened at 4:55 o'clock yesterday afternoon by President Coolidge aboard his yacht, the Mayflower, at anchor in the Potomac River. With the golden telegraph key used by President Wilson to explode the charge that opened the panama Canal, President Coolidge turned on the electric current that drew aside from the New York and Jersey City entrances to the tunnel two huge American flags, thus completing the elaborate ceremonies attendant upon what Governor Smith called 'the wedding of the two Commonwealths.'…"

***The New York Times*, Sunday, November 13th 1927**



"…When the two flags had parted before the New York entrance, there surged beneath their drawn folds and on into the chill depths of the white-tiled, brilliantly lighted sub-aqueous thoroughfare, an almost solid mass of pedestrians eager to make the trip from shore to shore afoot. It was estimated that within an hour 20,000 or more persons had walked the entire 9,250 feet from entrance to exit, and the stream of humanity, thinning a little toward the last, continued to traverse the tunnel until 7 P.M., when it was closed until 12:01 A.M. the hour set for the vehicular traffic to begin its regular, paid passage…"

The New York Times, **Sunday, November 13th 1927**



"…The pedestrians in the tunnel furnished the most spontaneous celebrative touch of an entire afternoon of ceremonies conducted on both shores. They literally took possession of the tunnel…A holiday spirit prevailed and the tunnel became, for the time, a new toy with which the crowds played like delighted children. They stopped to feel the air coming through the vents near the roadbed, they discussed the possibilities of establishing restaurants along the tunnel's sides, they shook hands with each other at the State line, some standing in New Jersey and gripping the hands of others standing in New York…"

The New York Times, **Sunday, November 13th 1927**

Left: caption: "Holland Tunnel opening ceremony, November 12, 1927"

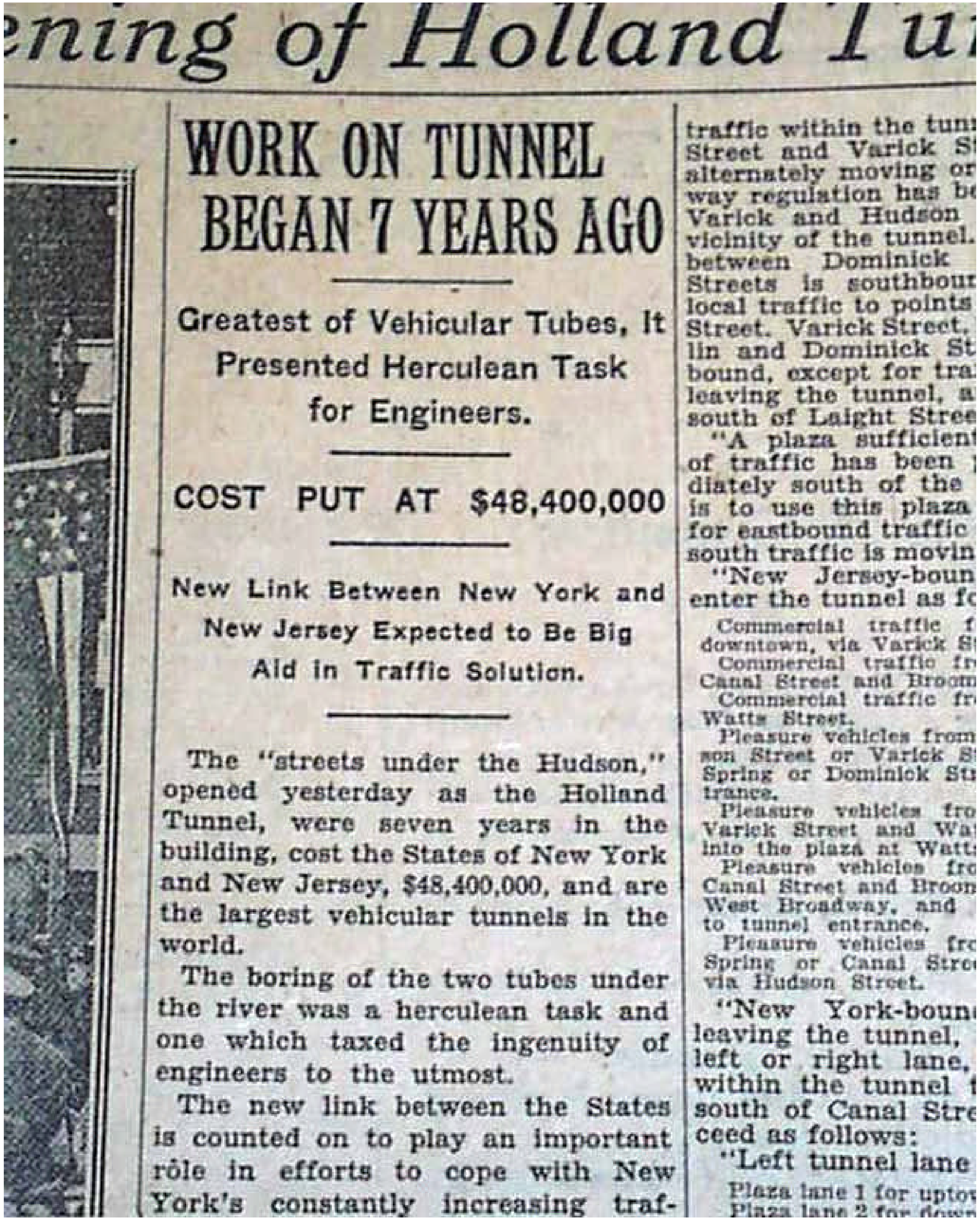
Right: caption: "New York meets New Jersey in The Holland Tunnel, November 12, 1927 (pictured: NY and NJ Governors Al Smith and A. Harry Moore)"

"…Vehicular traffic began pouring into the two tubes promptly at 12:01 A.M., when the first 'fixed crossing' between Manhattan and New Jersey was thrown open for regular paying business. Lines of honking cars were waiting at both the New York and Jersey City entrances…"

***The New York Times,* Sunday, November 13th 1927**

<u>Left T&B</u>: the Governors of NY and NJ during opening day ceremonies

The Streets Under the Hudson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WORK ON TUNNEL BEGAN 7 YEARS AGO

Greatest of Vehicular Tubes, It Presented Herculean Task for Engineers.

COST PUT AT $48,400,000

New Link Between New York and New Jersey Expected to Be Big Aid in Traffic Solution.

The "streets under the Hudson," opened yesterday as the Holland Tunnel, were seven years in the building, cost the States of New York and New Jersey, $48,400,000, and are the largest vehicular tunnels in the world.

The boring of the two tubes under the river was a herculean task and one which taxed the ingenuity of engineers to the utmost.

The new link between the States is counted on to play an important rôle in efforts to cope with New York's constantly increasing traf-

traffic within the tun
Street and Varick S
alternately moving or
way regulation has b
Varick and Hudson
vicinity of the tunnel.
between Dominick
Streets is southbou
local traffic to points
Street. Varick Street,
lin and Dominick St
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leaving the tunnel, a
south of Laight Stree
"A plaza sufficient
of traffic has been
diately south of the
is to use this plaza
for eastbound traffic
south traffic is movin
"New Jersey-boun
enter the tunnel as fo
Commercial traffic f
downtown, via Varick S
Commercial traffic fr
Canal Street and Broom
Commercial traffic fr
Watts Street.
Pleasure vehicles from
son Street or Varick S
Spring or Dominick St
trance.
Pleasure vehicles fro
Varick Street and Wa
into the plaza at Watts
Pleasure vehicles fro
Canal Street and Broom
West Broadway, and
to tunnel entrance.
Pleasure vehicles fro
Spring or Canal Stre
via Hudson Street.
"New York-boun
leaving the tunnel,
left or right lane,
within the tunnel
south of Canal Stre
ceed as follows:
"Left tunnel lane
Plaza lane 1 for upto
Plaza lane 2 for down

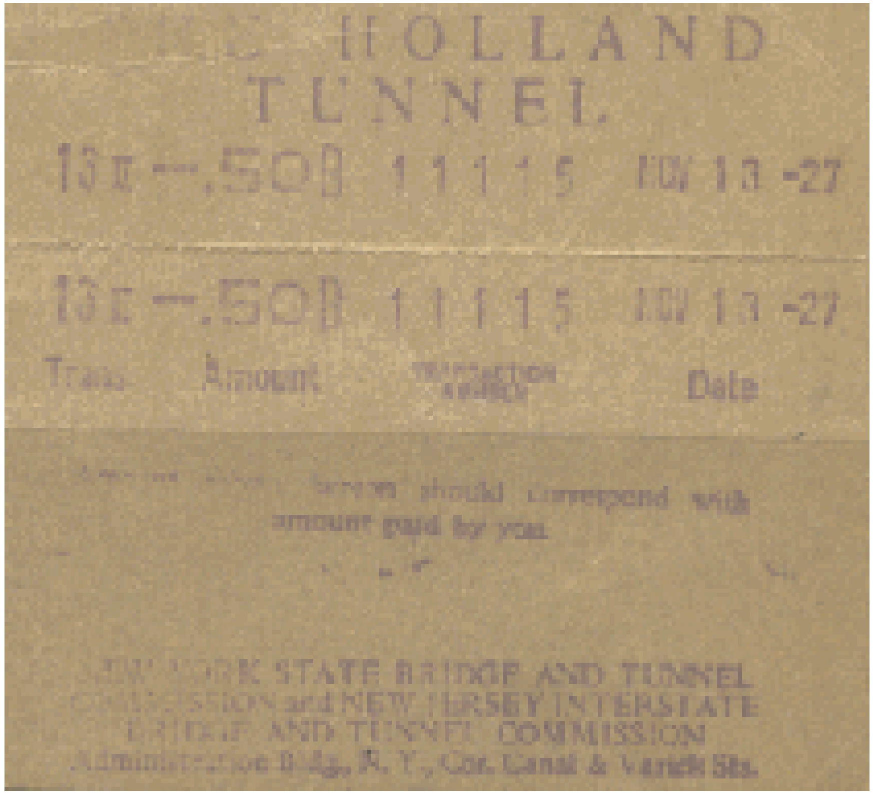
"The 'streets under the Hudson,' opened yesterday as the Holland Tunnel, seven years in the building, cost the States of New York and New Jersey, $48,400,000, and are the largest vehicular tunnels in the world. The boring of the two tubes under the river was a Herculean task and one which taxed the ingenuity of engineers to the utmost…"

The New York Times, **November 14th 1927**

The *Holland Tunnel* opened at midnight on November 13th 1927, providing the first fixed vehicular crossing between *New York City* and *New Jersey*, at a cost of $48,400,000. POTUS *Calvin Coolidge* formally opened the tunnel with the same key that opened the *Panama Canal* in 1914. At one minute past midnight, a truck making a shipment to *Bloomingdale's Department Store* in *Manhattan* was the first non-official vehicle through the *Holland Tunnel* and was the first vehicle to pay the toll at the *Canal Street* toll plaza. In its first day of operation, the tunnel saw 52K vehicles pass through its twin tubes. The *Port of New York Authority* (later the *Port Authority of New York and New Jersey*) took over jurisdiction of the Holland Tunnel in 1931. In 1934, *Julius Henry Cohen*, the financial counsel of the Port Authority, issued new Port Authority bonds in a unique financing proposal. The new "General Issue" bonds took the surpluses generated by the Holland Tunnel to finance the money-losing *Staten Island-New Jersey* bridges (*Goethals* and *Outerbridge Crossing*) as well as for the future construction of a second *Hudson River* vehicular tunnel (the *Lincoln Tunnel*).

<u>Above L&R</u>: caption: "Holland Tunnel toll booths (1927)"

<u>Above</u>: caption: "Lincoln Tunnel First Toll Coll-ected"
<u>Left</u>: caption: "Holland Tunnel Toll Booth, 1927"


THE HOLLAND
TUNNEL
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NEW YORK STATE BRIDGE AND TUNNEL COMMISSION and NEW JERSEY INTERSTATE BRIDGE AND TUNNEL COMMISSION
Administration Bldg., N. Y., Cor. Canal & Varick Sts.

From a purely financial point of view, the tunnel was a great success. Whereas its total cost (not including interest during construction) was $48,400,000, profit over operating costs was more than $3,500,000 during the first year (one-half going to each state). For the first year the tunnel operated at about one-half of estimated capacity. However, traffic has been at near capacity since the middle thirties and the tunnel was fully paid for out of toll charges by the end of 1940.

<u>Left</u>: caption: "First toll receipt: November 13, 1927"

No Easy Task

"…That the construction of the Holland Tunnel was no easy task is evidenced by the great increase in both time and money required for its completion. The original plans called for an expenditure of approximately $28,000,000 and for completion in 1924, or three and one-half years. Actual expenditures have run 50% greater, and as this is written, the opening will not be until the fall of 1927…"

RE: excerpt from *The Eighth Wonder*

"…many difficulties had to be overcome in bringing the work to a successful conclusion. The proceedings involved in the taking of real property at entrances and exits, changes in the grades of streets, the closing of a portion of 11th Street in Jersey City, negotiations with the railroads at the Jersey City end for the acquisition of parts of the railroad yards, all took time. It was not always easy to harmonize the views of the State Commissions. Alterations necessarily had to be made in the preliminary plans as further information resulted from investigation and experience…"

RE: excerpt from *The Eighth Wonder*

<u>Above</u>: caption: "Holland Tunnel (New Jersey Entrance), 1927"
<u>Left T&B</u>: during the 1970's, a new nine-lane toll plaza was built in *Jersey City* to collect tolls in the eastbound direction only (westbound motorists no longer had to pay a toll). Until that time, scattered booths on the *New York* side of the tunnel collected tolls in both directions, causing serious traffic jams throughout lower *Manhattan* and inside the eastbound tube.

"…That the undertaking cost the lives of its first two chief engineers – not from accident, but from the drain on their vital energy – is perhaps the most striking evidence of the magnitude of the undertaking…"

RE: excerpt from *The Eighth Wonder*

Left: caption: "Clifford Milburn Holland, 1883-1924"

"During the first twelve-month period, ending in November, 1928, a total of 8,517,689 vehicles used the tunnel. Of this number nearly 80 per cent were passenger cars. The average daily traffic was 23,372, while the average Sunday and holiday traffic was 36,391. The tunnel took about 43 per cent of the auto traffic crossing the Hudson, a figure far in excess of the estimate made in the plans. There was no shutdown except for a few hours on certain nights when the north tunnel was closed in order to take accurate readings of the distribution of air in the various parts of the tube. There was no serious accident, largely because of rigid enforcement of traffic regulations, brilliant illumination, and prompt handling of stoppages in the tunnel."

Ole Singstad, **Chief Engineer (November 1928)**

A Modern Wonder

"…Doubtless other tunnels under the Hudson will be built. Other problems in successful ventilation will be solved. The Sturtevant Silentvane Fan will be put to other uses of equal importance to humanity. But for many years to come the Holland Tunnel will remain one of the modern wonders of the world – a triumph in the science of ventilation."

RE: excerpt from *The Eighth Wonder*

<u>Above</u>: caption: "The Holland Tunnel Completed. Seven years of study, re-search and labor"

The real test of the tunnel's performance concerned the revolutionary ventilation system. Orders were given to operate at a normal maximum capacity on the first day. About 3,760,000 cubic feet of fresh air per minute was provided. Nearly 52K vehicles, of which about 98% were passenger cars, went through the tube. The average carbon monoxide content in both tunnels was 0.69 part per 10K parts of air. The highest was 1.60 parts per 10K (the permissible standard was 4 parts per 10K parts of air). The longitudinal air draft caused by vehicular movement at times reached 10 mph. It was found, too, that there was never enough fog or smoke to interfere with safe traffic and, in fact, the public and the press proclaimed air conditions were actually better in the tube than in some streets of *New York City*. The general cleanliness of the tunnel was also praised by the traveling public and press.

Like the Flaming Tail of a Comet

“Moving traffic lights, probably the first of their kind in the world, have just been installed experimentally in the Holland Tunnel between New Jersey and New York. Unlike ordinary traffic signals, they are designed to speed up passing drivers, replacing the frantic gestures of tunnel policemen. Because this vehicular tube beneath the Hudson River has become more and more frequently choked with traffic, the odd scheme was decided upon in an effort to increase its capacity. Tunnel engineers installed a 1,000-foot row of ten-watt bulbs along the footwalk on the New York-bound side of the tunnel for the tests. They also designed and built a control system similar to that used in animated electric signs. A motorist entering the tunnel during rush hours sees a yellowish flash of light racing along the wall beside him, like the flaming tail of a comet. It is traveling at thirty miles an hour, and he is expected to keep up with it. Seventy-five feet ahead of him, and behind, similar lights guide other drivers. Thus they stimulate laggards, admonish speeders, and also aid in keeping cars the legal distance apart in the tunnel. Officials are reserving their plans for completing the system until further tests, but it is said to have worked with encouraging success. At this writing it was planned to distribute cards to patrons of the tunnel, explaining the purpose of the lights. A woman driver, frightened by the new lights, crossed the center line of the double-lane tube in defiance of regulations. Questioned by the police, she explained that she thought the tunnel was on fire.”

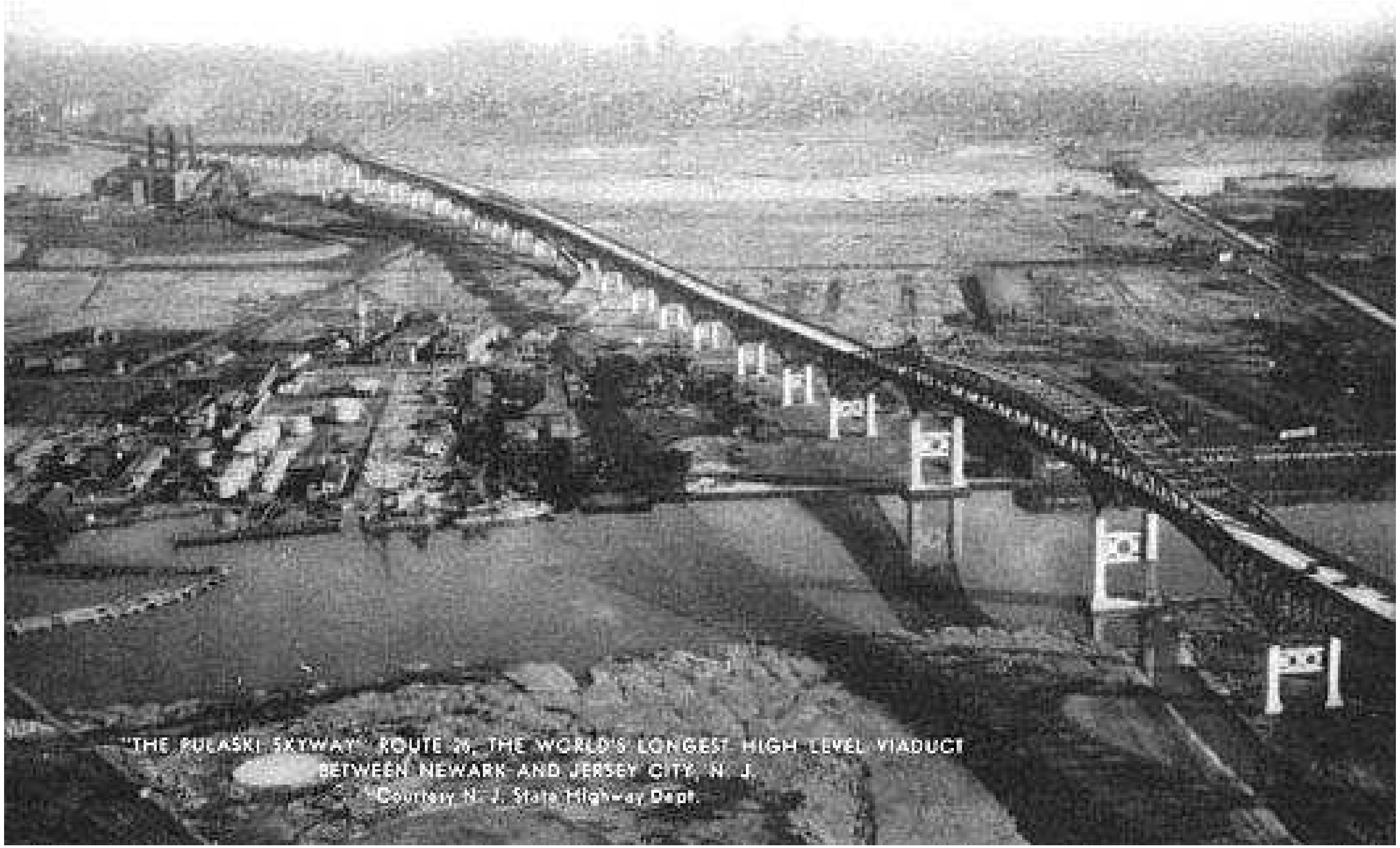
Popular Science, **March 1932**

Skyway

“A thirteen-mile superhighway linking two of the nation’s greatest cities has just been opened between New York City and Newark, N.J. Starting at the New Jersey end of the Holland vehicular tunnel, its steel-and-concrete viaduct soars across rivers, marshes and crossroads to permit high-speed motor traffic. By this route, mail trucks from the trans-continental airport at Newark will reach New York in a fraction of the time now required. Shown at left in a striking aerial view, the $21,000,000 highway is called the costliest per mile ever built but the densely populated section it serves is said to justify the expense.”

Popular Science, **February 1933**

RE: opened in 1932, the *Pulaski Skyway* spans the *Passaic* and *Hackensack River/s*, connecting *Newark* and *Jersey City*


"THE PULASKI SKYWAY" ROUTE 25, THE WORLD'S LONGEST HIGH LEVEL VIADUCT
BETWEEN NEWARK AND JERSEY CITY, N. J.
Courtesy N. J. State Highway Dept.

Fire in the Hole

“Nearly 200 fires broke out in vehicles that were going through the tunnel. All fires, however, were extinguished by policemen using chemical fire extinguishers, and without the aid of a special fire-fighting apparatus mounted on an emergency truck. Over 2,000 disabled vehicles were towed out of the tunnel, and a number of arrests were made, summonses and warnings issued.”

Ole Singstad, **Chief Engineer (November 1928)**

RE: statistics concerning the Holland Tunnel’s first year of operation

“…Fully enclosed trailer carrying eighty 55-gallon drums of carbon disulfide entered the New Jersey portal of tunnel, in violation of Port Authority regulations and allegedly un-placarded in violation of ICC regulations, in very heavy, slow traffic approximately 8:30 AM. The drums broke free and ignited upon striking roadway approximately 2,900 feet into tunnel. A truck rolled to a stop in left lane. Four trucks caught fire and were abandoned adjacent to the trailer in the right lane. Five additional trucks stopped 350 feet to the rear grouped tightly in right lane also ignited. Approximately 125 automobiles, buses, and trucks filled both lanes back to New Jersey portal…A three-man emergency crew drove west through eastbound tube on wrecker and jeep upon receiving the 8:56 AM fire alarm, and commenced fighting the fire with a 1-inch-diameter hose and spray nozzle. They assisted two tunnel patrolmen overcome by smoke, extinguished fires in two trucks of eastern group, and towed one to the New York portal. An FDNY rescue company and battalion chief drove west through westbound tube, and crossed to the fire scene to relieve the tunnel emergency crew. Some firemen in distress recovered by breathing at the curb-level fresh air ducts…Ten trucks and cargoes completely destroyed, 13 others damaged. 600 feet of tunnel wall and ceiling demolished; walls spalled in places to cast iron tube plates. 650 tons of debris removed from tunnel. Tube reopened to traffic 56 hours after fire started. All cable and wire connections through tube disrupted at fire. Total damage estimated at $1 million…66 injuries, 27 requiring hospitalization; no fatalities.”

Federal Highway Administration

RE: on May 13th 1949, a chemical truck loaded with eighty drums of carbon disulfide burned on the *New Jersey* side of the south tube of the *Holland Tunnel*

Top: caption: “Photo shows the damage done to a large section of the Holland Tunnel, which links New York and New Jersey, when a chemical-laden truck caught fire and exploded. Twenty other trucks and cars were burned by the blast, and seventy persons were hospitalized for gas poisoning.”
Bottom: caption: “Holland Tunnel emergency vehicles, 1950”

On March 25th 2002, a multiple-alarm fire at an abandoned warehouse and storage facility in *Jersey City* threatened the western portals of the *Holland Tunnel*, including the toll plaza. For several days, the Port Authority closed the tunnel to all traffic while firefighting operations were underway.

<u>Above</u>: caption: “The Mecca & Sons warehouse at the Holland Tunnel entrance plaza caught fire on March 25, 2002 and was demolished in the following weeks”

Legacy

"There are going to be a lot more tunnels built in this country in the future. I don't mean they will replace bridges entirely, of course. But we have proved pretty conclusively that, especially in large cities, the tunnel in the long run is the most economical method of spanning a body of water. It comes down to this: a bridge requires approaches nearly a mile in length. Not only are they unsightly affairs but they damage, if not totally destroy, real estate values in the area. A tunnel needs an approach of only a block or two - and no overhead structure. Surrounding property is hardly disturbed at all by tunnel approaches…The field is expanding rapidly and will expand still further. Moreover, tunnel work gives employment for a number of years on one job alone. If I were back in engineering school again, I'd make it my business to specialize in tunnel building right from the start. It's a fascinating career! "

Ole Singstad, **Tunnel Engineer (1941)**

"…Twice the cost, twice the operating fees, twice the difficulty to engineer, and half the traffic…"

RE: excerpt from a 1941 *Triborough Bridge and Tunnel Authority* publication. In the late 1930s, a controversy raged over whether an additional vehicular link between *Brooklyn* and lower *Manhattan* should be built as a bridge or a tunnel. The "Brooklyn-Battery Bridge" would have decimated *Battery Park* and encroached on the financial district. The bridge was opposed by the *Regional Plan Association* (RPA), historical preservationists, *Wall Street* financial interests, property owners, various high society people (including *Eleanor Roosevelt*), the Manhattan Borough President, Mayor *Fiorello LaGuardia* and NYS Governor *Herbert H. Lehman*. Despite this formidable opposition, Moses favored a bridge. More traffic also meant more tolls, which meant funding for Moses' projects. He also clashed with *Ole Singstad*, Chief Engineer of the project, who preferred a tunnel. It was only a lack of federal approval that thwarted the bridge project. POTUS *Frankin Roosevelt* ordered the *War Department* to assert that the sabotage of bridge in that location would block *East River* access to the *Brooklyn Navy Yard* upstream (despite the fact that the *Brooklyn* and *Manhattan Bridge/s* were also upstream). Moses was forced to settle for a tunnel: the *Brooklyn–Battery Tunnel* (officially the "Hugh L. Carey Tunnel").

"…tiled ventilated vehicular bathroom smelling faintly of monoxide and inviting claustrophobia"
Robert Moses

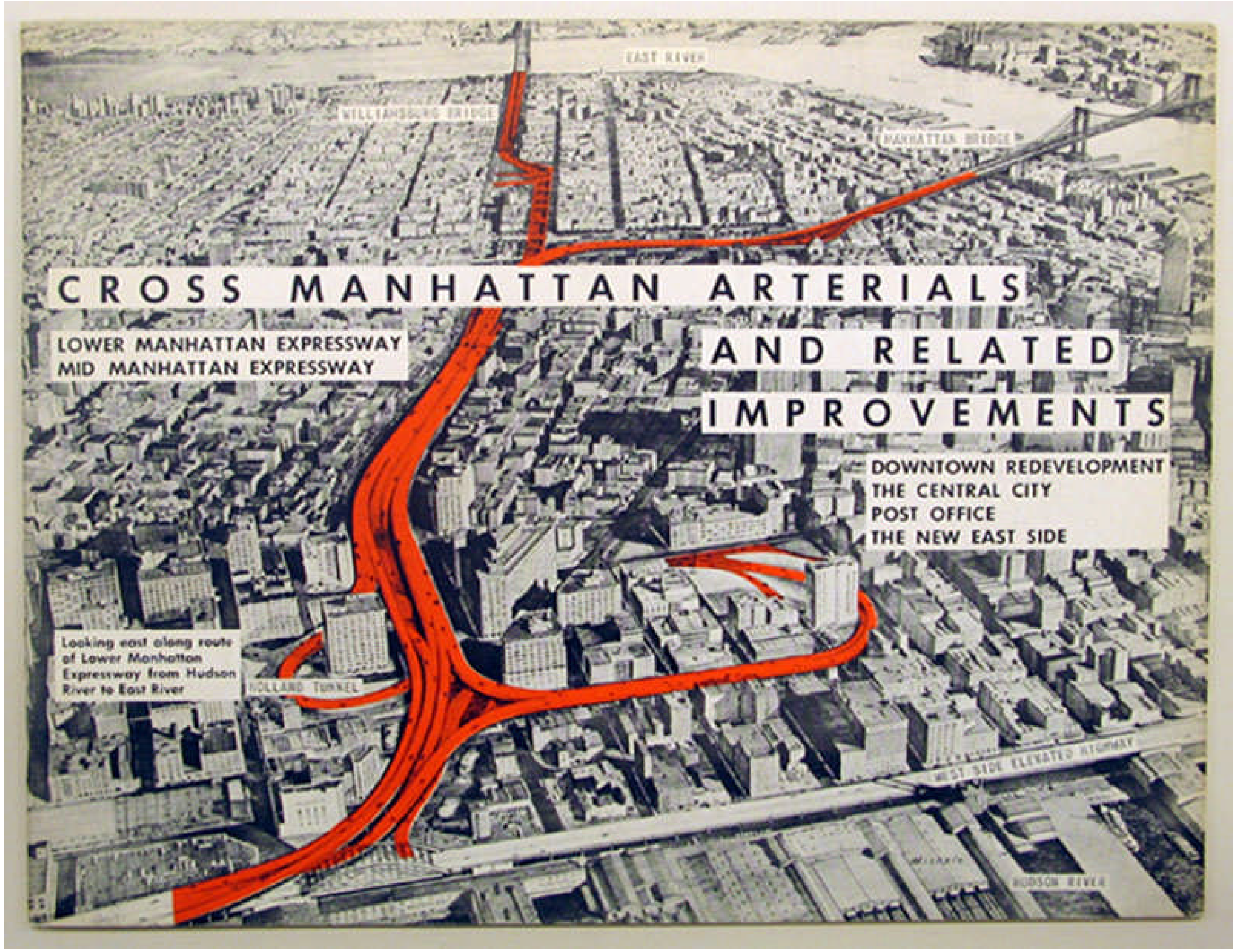
RE: his opinion of tunnels. The *Brooklyn-Battery Bridge* project would not be the only time Moses pressed for a bridge over a tunnel. He clashed again with *Ole Singstad* and tried to upstage the tunnel authority when the *Queens-Midtown Tunnel* was being planned a few years later. He raised the same arguments, which failed due to their lack of political support.

<u>Left</u>: caption: "Robert Moses with a model of his proposed Brooklyn-Battery Bridge"

LOMEX

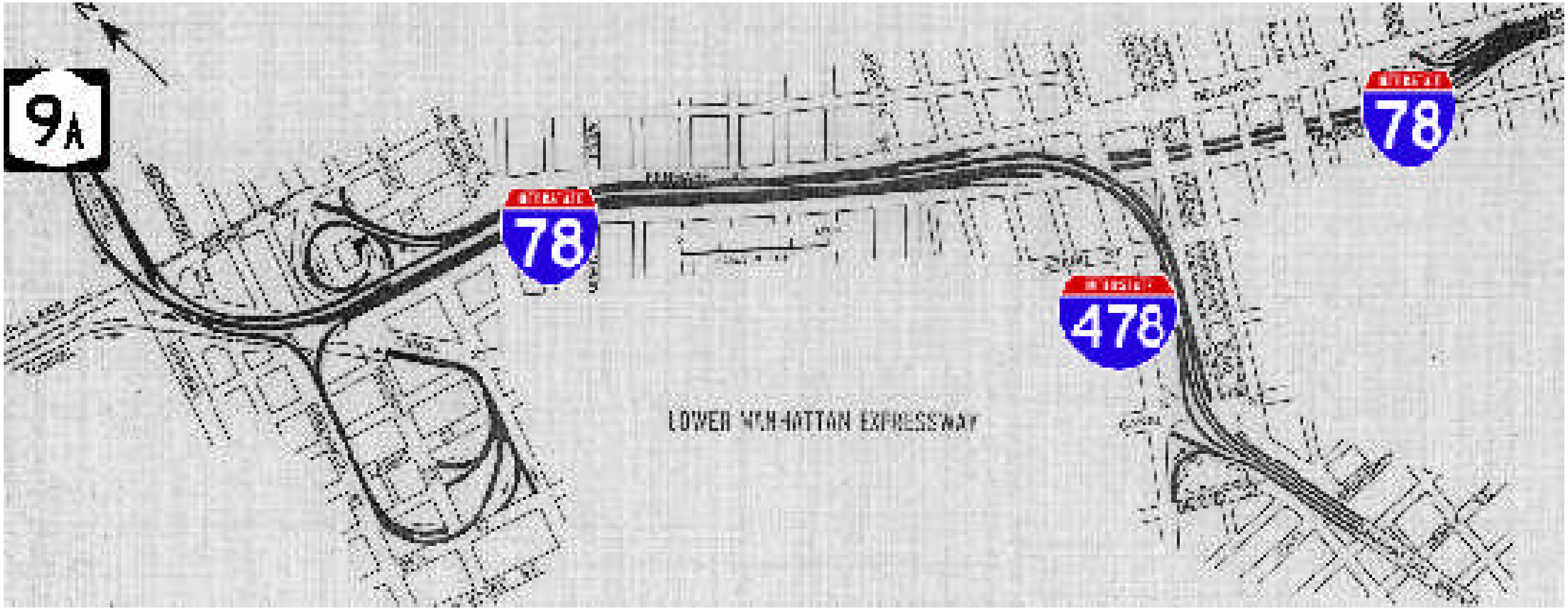
“Lower Manhattan Crosstown Highway: This is a much-needed crosstown connection between the Manhattan and Williamsburg bridges, and the Holland Tunnel, serving local cross-Manhattan traffic as well as traffic from the bridges and the tunnel. This connection would not only provide additional needed capacity for crosstown traffic, but would also help relieve congestion on north-south streets by minimizing delays at heavily traveled crosstown streets, such as Canal Street. Several agencies have made studies of this improvement, and have recommended various routes and types of construction. While the Commission is definitely in accord with the principle of providing an express crosstown highway in the area indicated, it does not now recommend any particular route or type of construction.”

RE: 1941 description of the *Lower Manhattan Expressway* (a.k.a. “LOMEX”). The first proposal for a controlled-access highway across lower *Manhattan* appeared in the 1929 *Regional Plan Association* (RPA) report: “Plan of New York and Its Environs.” As an integral part of the tri-state network of expressways and parkways, the Lower Manhattan Expressway was to connect the *Holland Tunnel* with *Brooklyn*.


EAST RIVER
WILLIAMSBURG BRIDGE
MANHATTAN BRIDGE
CROSS MANHATTAN ARTERIALS
LOWER MANHATTAN EXPRESSWAY
MID MANHATTAN EXPRESSWAY
AND RELATED
IMPROVEMENTS
DOWNTOWN REDEVELOPMENT
THE CENTRAL CITY
POST OFFICE
THE NEW EAST SIDE
Looking east along route of Lower Manhattan Expressway from Hudson River to East River
HOLLAND TUNNEL
WEST SIDE ELEVATED HIGHWAY
HUDSON RIVER

Robert Moses **recommended that construction of the road be expedited not only to relieve congestion, but also to serve defense needs. In 1943, the** ***NYC Planning Department*** **floated six different proposals for LOMEX. The cost of the proposal, including construction and right-of-way acquisition, was estimated at $23.0 million. However, city officials recommended postponing the LOMEX project until the** ***Brooklyn-Battery Tunnel*****,** ***FDR*** **(*****East River*****)** ***Drive*** **and** ***Harlem River Drive*** **projects were completed. In 1946, Moses resurrected LOMEX, this time proposing a direct route between the** ***Holland Tunnel*****,** ***Williamsburg Bridge*** **and** ***Manhattan Bridge*****. The proposal was the subject of a 1949 study. In 1955, It was the subject of the "Joint Study of Arterial Facilities" conducted by the** ***Triborough Bridge and Tunnel Authority*** **and the** ***Port of New York Authority*****.**

<u>Above</u>: caption: “Artist's conception from the 1950’s shows the elevated Lower Manhattan Expressway looking east. In the foreground is the interchange with the Holland Tunnel, with the elevated West Side Highway running along the bottom of the photo. In the distance are connections with the Williamsburg Bridge (top center) and the Manhattan Bridge (top right).”



<u>Above</u>: the segment of LOMEX from the *Holland Tunnel* to the *Williamsburg Bridge* received the *I-78* designation, while the spur to the *Manhattan Bridge* received the *I-478* designation. The three connecting river crossings also received Interstate designations, making the entire LOMEX project, then estimated at $104 million, eligible for 90% Federal funding. State and city officials were under pressure to build the expressway: if it were not built, Federal funding for the connecting river crossings would have been reduced from 90% to 50%. To accommodate future traffic along the lower *Manhattan* corridor, Moses proposed construction of a third tube to the Holland Tunnel. The third tube, which would allow four lanes of traffic in one direction during rush-hour periods, was to be constructed in conjunction with the expressway. While the PA voiced support for an eventual third tube, it did not allocate funds for the proposal.

The Meat Ax

"You can draw any kind of pictures you like on a clean slate and indulge your every whim in the wilderness in laying out a New Delhi, Canberra and Brasilia, but when you operate in an overbuilt metropolis you have to hack your way with a meat ax…The route of the proposed expressway passes through a deteriorating area with low property values due in considerable part to heavy traffic that now clogs the surface streets. Construction of the expressway will relieve traffic on these streets and allow this locality to develop in a normal manner that will encourage improved housing, increased business activity, higher property values, a general rise in the prosperity of the area, and an increase in real estate tax revenues. This has been the experience again and again in localities in the city where modern parkways and expressways have been built. The Grand Central Parkway and the Belt Parkway have produced these results, and it is now happening along the Long Island Expressway. There is every reason to expect that it will also happen in the case of the Lower Manhattan Expressway."

Robert Moses

RE: by the 1960s, public hearings on the LOMEX project had become more contentious. Construction of the expressway was to have displaced 1,972 families and 804 businesses. Moses planned construction of new apartment units for those displaced by the expressway, but remained intransigent regarding his controversial methods of achieving his goals.

NYC Mayor *John Lindsay* and *Robert Moses* had based their claim on the need for LOMEX on two studies undertaken by the engineering firm of *Madigan-Hyland*. The studies were based on 1958 traffic counts, meaningless by 1968 when the project won *Bureau of Public Roads* (BPR) approval (even more so by 1978 when the expressway would be open for traffic). These concerns, along with a November 1968 study predicting increased carbon monoxide levels in the vicinity of the proposed road, sealed the doom of the *Lower Manhattan Expressway*. The NYC *Board of Estimate* de-mapped the project in August 1969 and on March 24th 1971, NYS Governor *Nelson Rockefeller* officially killed LOMEX. Interstate funding for this highway and the *I-478* designation, were subsequently transferred to the *West Side Highway* reconstruction (a.k.a. "Westway").

"Apparently the expressway has been shelved for the present. On the other hand, most of the parties concerned, including the Downtown Manhattan Association, the Regional Plan Association and others, agree that there must eventually be a Lower Manhattan Expressway. Nobody knows how access to the Holland Tunnel will be provided, how access to the new Battery complex will be provided, how the tenants will be moved, where and at whose expense, or how the pollution issue will be resolved."

Robert Moses

RE: in 1998, discussions focused on reviving plans for *I-78* through NYC began, but opposition remains strong to the various schemes proposed

Above: caption: "Artist's conception from 1959 showing the elevated Lower Manhattan Expressway from street level"

Recognition

The *Holland Tunnel* was formally designated a "National Historic Civil and Mechanical Engineering Landmark" on May 2nd 1984 at ceremonies attended by officials of the two national Societies and the *Port Authority of New York & New Jersey*. A commemorative bronze plaque mounted on a five-foot high granite pedestal (above) was unveiled at the *New York Plaza* of the Holland Tunnel (west side of *Varick Street* between *Watts* and *Broome Street/s*, near the entrance to the north tube).

According to the Port Authority, the *Holland Tunnel* carries approximately 100K vehicles per day between *Jersey City, New Jersey* and *Canal Street* in lower *Manhattan*. Originally part of the easternmost section of the transcontinental *Lincoln Highway* (*U.S. 30*), the Holland Tunnel connects to *I-78*, *Business US 1-US 9* and *NJ 139* in Jersey City. According to the *New York State Department of Transportation* (NYSDOT), the I-78 designation actually continues one-half mile past the New Jersey-New York border. However, signs leading to the tunnel on either side of the Hudson do not have I-78 shields. The designation was part of the legacy of *Robert Moses*' LOMEX plan to continue I-78 across lower Manhattan into *Brooklyn,* which would have required construction of a third tube for the Holland Tunnel).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