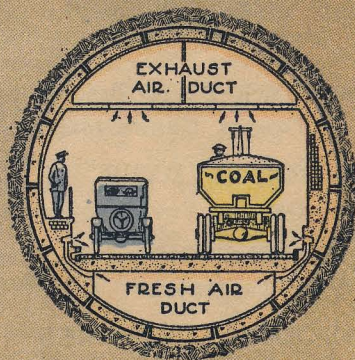
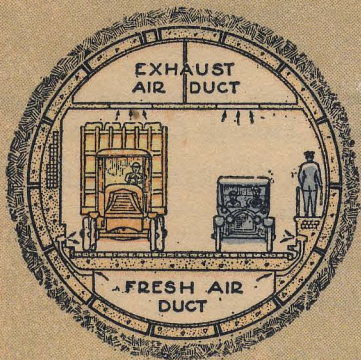

Effective November 13, 1927

THE HOLLAND TUNNEL



CROSS SECTION

External Diameter of Tunnel 29 Feet, 6 Inches.
Maximum Section 30 Feet, 4 Inches.

TOLL RATES

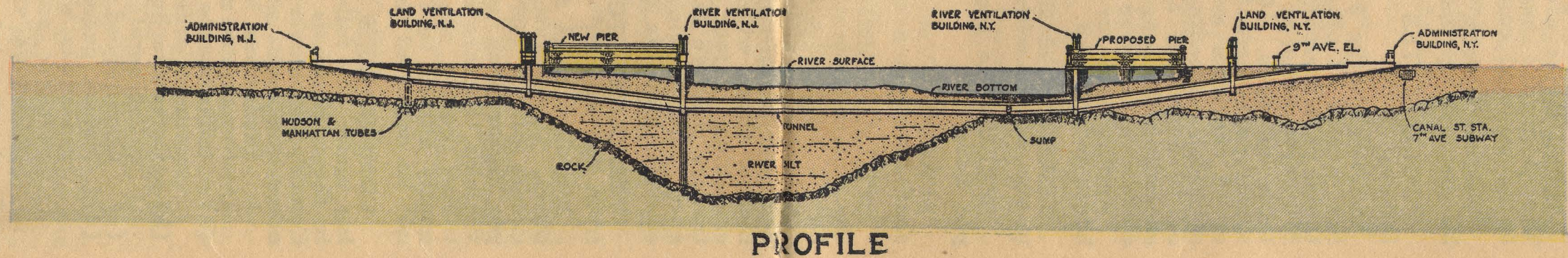
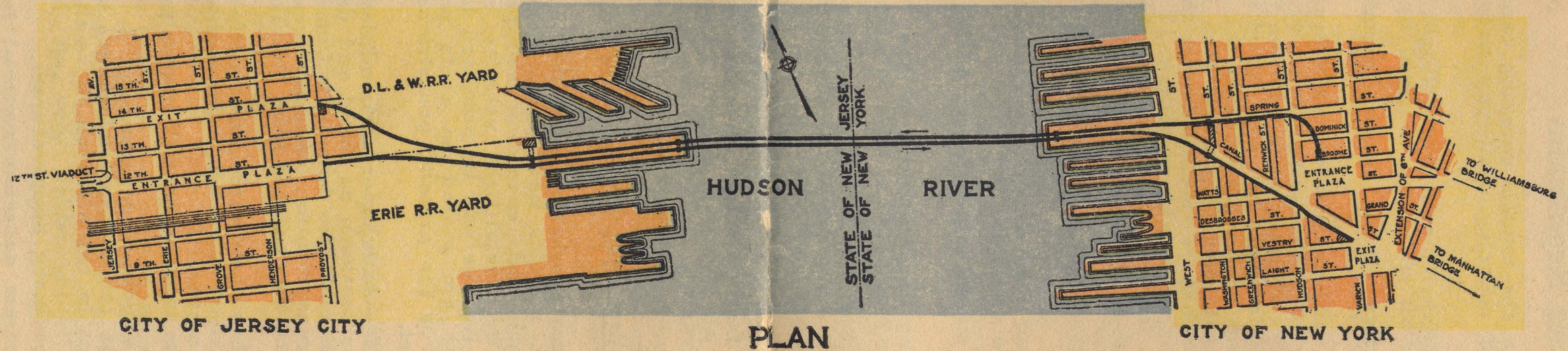
TRAFFIC REGULATIONS

DESCRIPTION OF TUNNEL

Rates and Regulations subject to change without notice

Office of the Superintendent—Administration Building,
Canal and Varick Streets, New York City

THE HOLLAND TUNNEL



constantly in reserve. The four ventilation buildings house these fans and the electric motors which drive them, together with all the necessary auxiliary apparatus and equipment.

The fresh air in the tunnel is led by side ports from below the roadway where it travels longitudinally, to an "expansion chamber" which extends on either side a little above the curb. A continuous slit allows the air to escape into the tunnel from this expansion chamber whence it passes through the exhaust ports in the ceiling, so that there is no movement of air lengthwise in the tunnel roadway portion; gases from automobiles are thus diluted before exhaustion.

The installed horsepower for the fan equipment amounts to about 6000 horsepower, of which about 4000 horsepower will be required to ventilate the tunnel at maximum capacity.

The method of ventilating The Holland Tunnel and the design of the ventilating equipment were based upon an exhaustive series of original tests and investigations carried on from December, 1919, to October, 1922.

The problem was unprecedented and data lacking, therefore, in November, 1919, the New York and New Jersey Bridge and Tunnel Commissions, through their Chief Engineer, sought and obtained the hearty co-operation of the United States Bureau of Mines in undertaking this investigational and experimental work. The Bureau agreed to furnish technical directors and facilities of several of their stations, while the Tunnel Commissions agreed to furnish funds for securing technical assistants, labor, etc.

Later the University of Illinois became a third party to the agreement and factors for power determination were obtained by experiments made from February, 1921, until October, 1922, at the Engineering Experiment Station, on model air ducts of concrete and sheet metal.

The investigations covered four main subdivisions: Nature and quantity of gases emitted by motor vehicles under usual road operation conditions; the physiological effects of the gases, particularly carbon monoxide; tests both as to the method of admitting and exhausting the air and the determination of the value of the friction of air flowing in concrete conduits, whence the power necessary, in any given case, could be accurately calculated. The physiological tests were made at Yale University and confirmed in the Bureau's "experimental mine" near Pittsburgh where the method of ventilation was also confirmed after tests.

These results have since been successfully applied, notably in the design and ultimate construction of the Liberty Tunnel of Pittsburgh, Pennsylvania, and in the building of the Estuary Tunnel of Oakland, California.

POWER SUPPLY—The electric current for operating the ventilation equipment and lighting of the tunnel is obtained from both sides of the Hudson River.

On each side current is available from three independent cables any one of which can be fed from either of two generating sources, making a total of four independent generating sources served by six independent cables. Each cable is of sufficient capacity to carry the full tunnel load, thereby providing adequate insurance against power failure.

TUNNEL LIGHTING—The lights in the tunnels' sidewalls are normally placed about 20 feet apart along the tunnel. At the portals and for a short distance within, this spacing is reduced in order to provide greater illumination at these points to counteract the sudden transition from daylight into the artificial lighting of the tunnel. The two main sources of power serve alternate lights, so that the failure of one source of power will leave half of the lights still illuminating the roadway.

SUPERVISORY CONTROL—In addition to a subsidiary control board in each of the four ventilation buildings, from which all equipment in that building can be operated, there is a central supervisory control board located in the top floor of the New York Administration Building from which board all equipment in the entire tunnel project can likewise be operated by the Chief Operator.

MISCELLANEOUS TUNNEL DATA—The principal data concerning The Holland Tunnel are to be found below.

Five shields were employed in driving the tunnels, two starting from the bottom of the New York land shafts and working their way, one for each tube, westward, through the streets and under the bulkhead wall of Manhattan out into the rock reef at the pierhead line and through the river shaft previously sunk into the rock; two from the bottom of the New Jersey land shafts working eastward through the New Jersey river shafts and across the river, meeting the westbound shields and joining with them in the rock. A fifth shield used in driving the south tunnel west, under the Erie Railroad yard, was rebuilt to drive the north tunnel west 30 feet, 4 inches in diameter, which is the largest shield-driven tunnel ever built.

Emergency exits, leading from one tunnel to the adjacent tunnel as well as to the surface at the shafts, are designated by signs.

The tile lining of the tunnel was carefully specified as to its quality and the requirements were unusually strict. These were fixed after extended experimentation to produce a tile that would withstand the temperature and atmospheric changes to be encountered in the tunnel, throughout the changing seasons.

Along the tunnel walls at convenient intervals occur various niches to accommodate fire fighting apparatus, hose for flushing and fire purposes, valves easily accessible, connected with the six-inch water main traversing each tunnel, sand bins, and telephone and relay niches. These are enclosed by bronze doors.

The distances from the entrance portals of each tunnel are designated by mosaic tile bands at the ¼ mile points and the state line is specially so marked.

TUNNEL DATA

TUNNEL LENGTHS

Total length of tunnel	9250 feet
Distance between portals	8463 feet
Distance between river shafts	3374 feet
Length of under-river portion	5480 feet

CAPACITY

Number of Roadways	2
Roadway widths	20 feet
Head room	13 feet, 6 inches
Estimated hourly capacity (in both directions)	3,800 vehicles
Estimated maximum daily traffic	46,000 vehicles
Estimated yearly traffic	15,000,000 vehicles
Maximum up-grade	3.8 per cent
Maximum down-grade	4.06 per cent

CONSTRUCTION DATA

Maximum depth, top of tunnel below mean high water 72 feet
Maximum depth of roadway below mean high water 93 feet
Quantities:

Tunnel Excavation	500,000 cu. yards
Cast-iron tunnel lining	115,000 tons
Tunnel concrete	130,000 cu. yards
Cost	\$48,400,000

VENTILATION

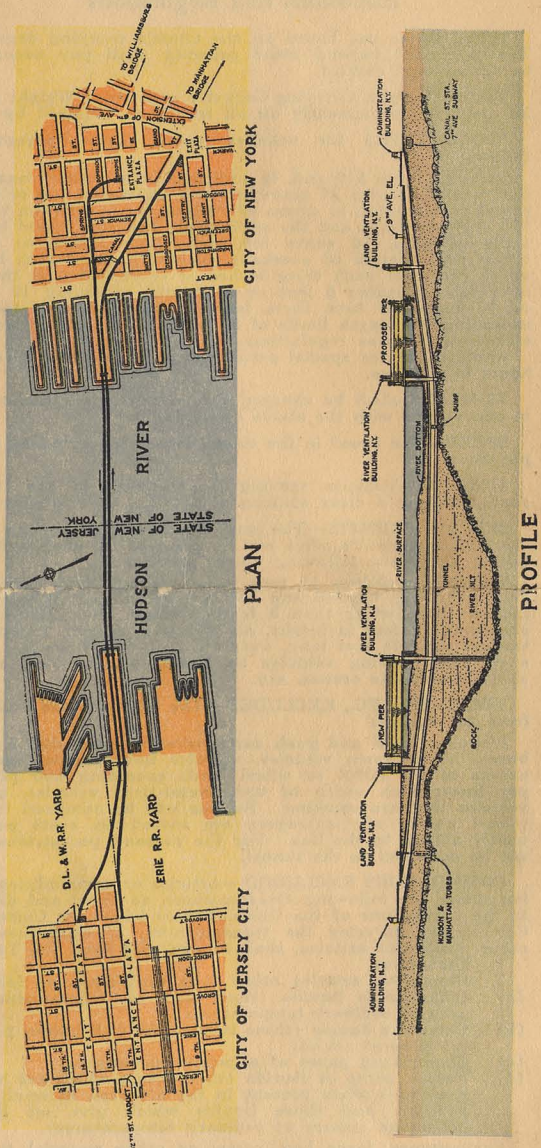
Method: Transverse distributed. Air will be discharged and removed continuously throughout the length of the tunnel—no longitudinal movement of air.

Ventilation provides for changing air 42 times per hour.

Total amount of fresh air to be supplied to the tunnel per minute—3,761,000 cu. ft.

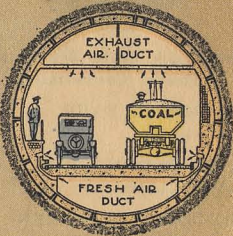
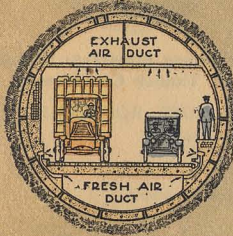
Carbon monoxide to be limited to 4 parts in 10,000 parts of air.

THE HOLLAND TUNNEL



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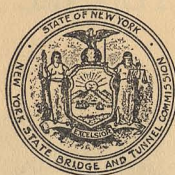
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Office of the Superintendent—Administration Building,
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New York State Bridge & Tunnel Commission and New Jersey Interstate Bridge & Tunnel Commission



New York State Bridge and Tunnel Commission

GEORGE R. DYER,
Chairman
E. W. BLOOMINGDALE,
Vice-Chairman
McDOUGALL HAWKES
A. J. SHAMBERG
ALBERT GOLDMAN,
Commissioner of Plant and
Structures of New York
City
FREDERICK S. GREENE,
Superintendent of Public
Works
PAUL WINDELS,
Counsel
MORRIS M. FROHLICH,
Secretary

OLE SINGSTAD
Chief Engineer and Acting Superintendent

TOLLS

The following toll rates shall apply to and be collected for
vehicles, as designated:

Vehicle Type	Group No.	Rate
Motorcycle	I	\$0.25
Passenger Automobile, with a capacity up to 7 passengers, ambulance or hearse...	II	0.50
Bus (Up to and including 29 passenger seating capacity)	III	1.00
Truck (Up to 2 tons)**	IV	0.50
2 Ton+to 5 Ton Truck	V	0.75
5 Ton+to 10 Ton Truck	VI	1.00
Trucks exceeding 10 Tons capacity and not exceeding 15 Tons Gross Weight nor exceeding 12 Tons Axle Load	VII	2.00
Vehicles admitted by Special Permit, only	VIII	Special*
For Bus exceeding 29 passenger seating capacity—apply for rates.		

Tolls, Speed, Spacing, Special Permits, Exclusions and Regulations

**Toll Rates are based on the truck's carrying capacity.
Trucks loaded beyond rated capacity shall pay according
to actual load carried.

Vehicle Weight, Carrying Capacity and Gross Weight must
be displayed prominently on all trucks as required by law.

*TOLL RATES for vehicles under special permit as
follows:

Survey charge \$10 and, in addition, for permit if issued a
flat rate of \$2 plus 25 cents for each additional ton or frac-
tional part thereof, in excess of 15 tons; or in addition to the
\$10 survey charge and the appropriate toll rate, listed in the
table of tolls, 10 cents for each three inches or frac-
tional part thereof of overhang exceeding the 9 inch limit;
or 10 cents for each three inches or fractional part thereof
of width exceeding 8 feet or of height exceeding 12 feet;
or 10 cents for each three feet or fractional part thereof
exceeding the length limits of 30 feet and 46 feet prescribed
elsewhere in these regulations.

Applications for special permits must be made at least 24
hours in advance.

TRAILERS shall be charged for as separate vehicles and
in accordance with the above schedule.

SPEED—The speed in the tunnel is not to exceed 30 miles
per hour.

SPACING—Vehicles moving or standing in the tunnel
shall maintain a clear spacing of not less than 75 feet.

SPECIAL PERMITS—The obtaining of special permits from
the superintendent's office will be required to admit vehicles
falling under the following classifications:

Vehicles exceeding 15 tons gross weight, those having a
side overhang beyond the rim of the wheel exceeding 9
inches, those wider than 8 feet or longer than 30 feet, or
exceeding 12 feet in height, all inclusive of load, four-wheel
trailers over 46 feet long, over all, including draw bar, and
such slow moving vehicles as floats, steamrollers, steam
shovels, movable cranes, etc.

VEHICLES, ETC., EXCLUDED—The following are excluded
from the tunnel:

Bicycles, hand and push carts, wheelbarrows, double-deck
buses, horse-drawn vehicles, vehicles having axle loads in
excess of 12 TONS or wheel loads exceeding 800 pounds
per linear inch width of tire, metal-tired vehicles, motor
vehicles that are smoking. No bus will be admitted to the
tunnel unless all passengers are seated on seats perman-
ently affixed to the bus. For the present, pedestrians will
not be admitted to the tunnel.

COMMODITIES EXCLUDED—Articles or commodities fall-
ing under the following classifications, as listed and defined
in the regulations of the United States Interstate Commerce
Commission covering the transportation of explosives and
other dangerous articles, shall be excluded from the Tunnel.

- Explosives.
- Dangerous articles other than explosives, as follows:
 - Inflammable liquids (these give off inflammable vapors at ordinary temperatures).
 - Corrosive liquids (these include the well known power-
ful mineral acids).
 - Compressed gases of a poisonous nature.
 - Poison gases or liquids (those gases which are highly
poisonous when present in the air even in small pro-
portions and those liquids which give off highly
poisonous vapors at ordinary temperatures).

Furthermore, loose hay, straw or other material in like
condition which is ordinarily combustible will not be
admitted; nor reserve gasoline exceeding 1 gallon.

REGULATIONS FOR DRIVERS AND OWNERS OF VEHICLES

(1) No operator who is physically incapable of operat-
ing his vehicle will be permitted to enter the tunnel.

(2) No vehicle which is so loaded or constructed as to
seriously retard traffic or injure persons or damage property
will be permitted to enter the tunnel. (Baled hay, or straw
or other inflammable material must be covered with tar-
paulin.) In special cases however admission may be ob-
tained through special permit by the superintendent.

(3) No tire changes may be made in the tunnel.

(4) Smoking in the tunnel is prohibited.

(5) No vehicle may leave its line except as so directed
by a policeman.

Drivers' attention is called to signs posted at New York
City exit at Canal Street; also to City police regulation of
traffic at this point.

(6) The use of cut-outs, horns, sirens, whistles and any
other noise making device in the tunnel is prohibited.

(7) All vehicle head lights must be extinguished upon
entering the tunnel.

(8) SIGNAL LIGHTS—GREEN SIGNAL LIGHT indicates
that traffic lanes are clear and that traffic may pro-
ceed. RED SIGNAL LIGHT indicates that traffic must halt.
Engines will not be permitted to race at a halt. "STOP
ENGINE" SIGNAL indicates that ALL ENGINES MUST BE
STOPPED AT ONCE and shall remain so until the green
light is again displayed for resumption of travel. YELLOW
SIGNAL LIGHTS indicate that all traffic shall move in right
hand lane only.

(9) Breakdown Vehicles, etc.

(a) Gasoline will be supplied to a car running out of
gasoline in the tunnel at \$1.00 per gallon. This will be
payable to the officer upon delivering the gasoline.

(b) Cars breaking down in the tunnel and requiring
the use of the tunnel emergency towing equipment will be
towed out into the exit plaza. The charge for such services,
double the regular toll rate, is payable to the sergeant in
charge of emergency truck.

(10) Any person who through gross carelessness, reck-
lessness or without due regard for the safety of persons or
property, violates the traffic rules of the Commissions or
endangers the safety of persons or property, shall be re-
ported by the Department of Police to the Superintendent.
Thereafter a notice shall be served upon such violator that
at a specified time and place a hearing will be held, at
which he is invited to attend and show cause why he should
not be barred from using the tunnel for a period to be
designated by the Commissions. Such hearing shall be
held before the Superintendent or a member of his staff
designated by him, and a report of his findings and rec-
ommendations shall be transmitted to the Commissions.

THE HOLLAND TUNNEL

AUTHORITY—In 1919, the New York State Bridge and
Tunnel Commission and the New Jersey Interstate Bridge
and Tunnel Commission were authorized by the legislatures
of their respective states to co-operate and enter into a con-
tract with each other for the joint construction, operation,
repair and maintenance of a tunnel between Manhattan, in
the vicinity of Canal Street, and a point in Jersey City.

CLIFFORD M. HOLLAND, FIRST CHIEF ENGINEER—
These Commissions unanimously appointed Clifford M. Hol-
land, of Brooklyn, New York, their Chief Engineer. Mr.
Holland assumed his office on July 1, 1919, and carried on
the work of planning and constructing the tunnel up to the
time of his death, October 27, 1924. Mr. Holland was suc-
ceeded as Chief Engineer by Mr. Milton H. Freeman, the
Engineer of Construction. He also died less than five months
after Mr. Holland's death, and was succeeded by the present
Chief Engineer, who up to that time had been the Engineer

of Designs. It was in Mr. Holland's honor that the tunnel
has been named "THE HOLLAND TUNNEL."

CONSTRUCTION CONTRACTS—Ground was broken for
the first contract, the New York land shafts, on October 12,
1920, since which date there have been twenty-two construc-
tion and equipment contracts let and brought to completion
by the Commissions. Half of the expense of construction
and maintenance is borne by each State. The embellishment
of the entrances and exits, including the lining of the pres-
ent concrete walls with granite masonry, will be cared for
by two contracts still to be let, preparation of which is now
in progress. The tolls collected will finance the operation
and maintenance of the Tunnel and in time repay the two
States for their expenditures. The total cost of the Tunnel
will be forty-eight million, four hundred thousand dollars.

WORK UNDER COMPRESSED AIR—The driving of the
tunnels by means of shields underneath the bed of the Hud-
son River and the sinking of the seven shafts and thirty
caissons for building foundations were accomplished by
means of compressed air which balanced the pressures on
the outside of these structures and held the river water out,
which otherwise would have seeped down through the river
mud or silt and penetrated the working chambers of the
shaft caissons and the tunnel headings. While the greater
part of the under-river tubes were driven through silt, a
stretch of nearly 1000 feet near the New York pierhead line
was driven through ledge rock. It is in this rock that the
pump chamber and sump for collecting any water that might
flow in the tunnel roadway, are located, at the lowest point.
Four of the principal contracts covered this part of the
construction, which proceeded almost continuously from
June 27, 1921, to the date of the discontinuance of the use
of compressed air, May 8, 1926. The maximum pressure
required was for the New Jersey river shafts and was 47½
pounds per square inch above atmosphere.

During this five year period 756,565 decompressions took
place, of men coming out of the compressed air work, and
the care taken in spending the full times for decompressions
accounts for the low number of cases of "bends," or caisson
disease, which totalled but 528, or a percentage of less than
7/100 of one percent, no fatality having occurred which was
directly attributable to caisson disease.

THE TUNNEL—The cover page shows the two tubes com-
prising The Holland Tunnel while its location and statistics
are shown respectively on the plan and profile plate, and in
the table at the end of this pamphlet.

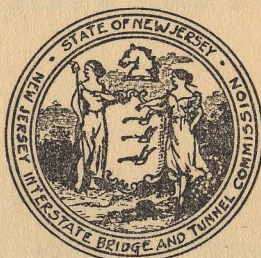
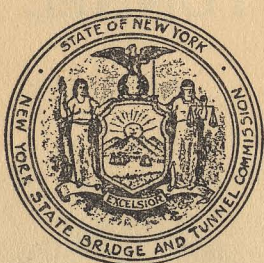
The north tube is to accommodate west-bound traffic, en-
tering the New York Entrance Plaza between Hudson and
Varick and Broome and Watts Streets, in New York, while
the south tube serves east bound traffic, entering at Twelfth
and Provost Streets, Jersey City. The exit in each City is
located some distance from the entrance, being at Canal
and Varick Streets, alongside the Administration Building
in New York, and at Fourteenth and Provost Streets, Jersey
City, next to the New Jersey Administration Building. This
separation of exit from entrance is to prevent undue traffic
congestion in the city streets, in the immediate vicinity of
the tunnel. Each tube is built of cast-iron segments bolted
together, forming a ring of 29 feet, 6 inch outside diameter.
This is lined on the inside with concrete, forming the road-
way supports, sidewalk and sides.

ROADWAY—The roadway in each tube, accommodating
two lines of traffic, is of granite block, with granite curbs.
It is estimated that an average of 1900 motor vehicles can
pass through each tube per hour.

VENTILATION—The air in the tunnel can be completely
changed in a little less than one and one-half minutes, or
42 times per hour.

The space below the roadway conducts fresh air from the
blower fans in the nearest ventilation building, and the simi-
lar space above the ceiling leads the vitiated air away
whence it is exhausted by exhaust fans in the same building.
There are 84 of these blower and exhaust fans provided,
with an allowance of one-third of their number being held

New York State Bridge & Tunnel Commission and New Jersey Interstate Bridge & Tunnel Commission



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Chief Engineer and Acting Superintendent

TOLLS

The following toll rates shall apply to and be collected for vehicles, as designated:

<i>Vehicle Type</i>	<i>Group No.</i>	<i>Rate</i>
Motorcycle	I	\$0.25
Passenger Automobile, with a capacity up to 7 passengers, ambulance or hearse...	II	0.50
Bus (Up to and including 29 passenger seating capacity)	III	1.00
Truck (Up to 2 tons)**	IV	0.50
2 Ton+to 5 Ton Truck	V	0.75
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Trucks exceeding 10 Tons capacity and not exceeding 15 Tons Gross Weight nor exceeding 12 Tons Axle Load	VII	2.00
Vehicles admitted by Special Permit, only	VIII	Special*
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****Toll Rates** are based on the truck's carrying capacity. Trucks loaded beyond rated capacity shall pay according to actual load carried.

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Survey charge \$10 and, in addition, for permit if issued a flat rate of \$2 plus 25 cents for each additional ton or fractional part thereof, in excess of 15 tons; or in addition to the \$10 survey charge and the appropriate toll rate, listed in the table of tolls, 10 cents for each three inches or fractional part thereof of overhang exceeding the 9 inch limit; or 10 cents for each three inches or fractional part thereof of width exceeding 8 feet or of height exceeding 12 feet; or 10 cents for each three feet or fractional part thereof exceeding the length limits of 30 feet and 46 feet prescribed elsewhere in these regulations.

Applications for special permits must be made at least 24 hours in advance.

TRAILERS shall be charged for as separate vehicles and in accordance with the above schedule.

SPEED—The speed in the tunnel is not to exceed 30 miles per hour.

SPACING—Vehicles moving or standing in the tunnel shall maintain a clear spacing of not less than 75 feet.

SPECIAL PERMITS—The obtaining of special permits from the superintendent's office will be required to admit vehicles falling under the following classifications:

Vehicles exceeding 15 tons gross weight, those having a side overhang beyond the rim of the wheel exceeding 9 inches, those wider than 8 feet or longer than 30 feet, or exceeding 12 feet in height, all inclusive of load, four-wheel trailers over 46 feet long, over all, including draw bar, and such slow moving vehicles as floats, steamrollers, steam shovels, movable cranes, etc.

VEHICLES, ETC., EXCLUDED—The following are excluded from the tunnel:

Bicycles, hand and push carts, wheelbarrows, double-deck buses, horse-drawn vehicles, vehicles having axle loads in excess of 12 TONS or wheel loads exceeding 800 pounds per linear inch width of tire, metal-tired vehicles, motor vehicles that are smoking. No bus will be admitted to the tunnel unless all passengers are seated on seats permanently affixed to the bus. For the present, pedestrians will not be admitted to the tunnel.

COMMODITIES EXCLUDED—Articles or commodities falling under the following classifications, as listed and defined in the regulations of the United States Interstate Commerce Commission covering the transportation of explosives and other dangerous articles, shall be excluded from the Tunnel.

1. Explosives.
2. Dangerous articles other than explosives, as follows:
 - (a) Inflammable liquids (these give off inflammable vapors at ordinary temperatures).
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(3) No tire changes may be made in the tunnel.

(4) Smoking in the tunnel is prohibited.

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Drivers' attention is called to signs posted at New York City exit at Canal Street; also to City police regulation of traffic at this point.

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(7) All vehicle head lights must be extinguished upon entering the tunnel.

(8) **SIGNAL LIGHTS**—**GREEN SIGNAL LIGHT** indicates that traffic lanes are clear and that traffic may proceed. **RED SIGNAL LIGHT** indicates that traffic must halt. Engines will not be permitted to race at a halt. **"STOP ENGINE"** **SIGNAL** indicates that **ALL ENGINES MUST BE STOPPED AT ONCE** and shall remain so until the green light is again displayed for resumption of travel. **YELLOW SIGNAL LIGHTS** indicate that all traffic shall move in right hand lane only.

(9) **Brokendown Vehicles, etc.**

(a) Gasoline will be supplied to a car running out of gasoline in the tunnel at \$1.00 per gallon. This will be payable to the officer upon delivering the gasoline.

(b) Cars breaking down in the tunnel and requiring the use of the tunnel emergency towing equipment will be towed out into the exit plaza. The charge for such services, double the regular toll rate, is payable to the sergeant in charge of emergency truck.

(10) Any person who through gross carelessness, recklessness or without due regard for the safety of persons or property, violates the traffic rules of the Commissions or endangers the safety of persons or property, shall be reported by the Department of Police to the Superintendent. Thereafter a notice shall be served upon such violator that at a specified time and place a hearing will be held, at which he is invited to attend and show cause why he should not be barred from using the tunnel for a period to be designated by the Commissions. Such hearing shall be held before the Superintendent or a member of his staff designated by him, and a report of his findings and recommendations shall be transmitted to the Commissions.

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of Designs. It was in Mr. Holland's honor that the tunnel has been named "THE HOLLAND TUNNEL."

CONSTRUCTION CONTRACTS—Ground was broken for the first contract, the New York land shafts, on October 12, 1920, since which date there have been twenty-two construction and equipment contracts let and brought to completion by the Commissions. Half of the expense of construction and maintenance is borne by each State. The embellishment of the entrances and exits, including the lining of the present concrete walls with granite masonry, will be cared for by two contracts still to be let, preparation of which is now in progress. The tolls collected will finance the operation and maintenance of the Tunnel and in time repay the two States for their expenditures. The total cost of the Tunnel will be forty-eight million, four hundred thousand dollars.

WORK UNDER COMPRESSED AIR—The driving of the tunnels by means of shields underneath the bed of the Hudson River and the sinking of the seven shafts and thirty caissons for building foundations were accomplished by means of compressed air which balanced the pressures on the outside of these structures and held the river water out, which otherwise would have seeped down through the river mud or silt and penetrated the working chambers of the shaft caissons and the tunnel headings. While the greater part of the under-river tubes were driven through silt, a stretch of nearly 1000 feet near the New York pierhead line was driven through ledge rock. It is in this rock that the pump chamber and sump for collecting any water that might flow in the tunnel roadway, are located, at the lowest point. Four of the principal contracts covered this part of the construction, which proceeded almost continuously from June 27, 1921, to the date of the discontinuance of the use of compressed air, May 8, 1926. The maximum pressure required was for the New Jersey river shafts and was 47½ pounds per square inch above atmosphere.

During this five year period 756,565 decompressions took place, of men coming out of the compressed air work, and the care taken in spending the full times for decompressions accounts for the low number of cases of "bends," or caisson disease, which totalled but 528, or a percentage of less than 7/100 of one percent, no fatality having occurred which was directly attributable to caisson disease.

THE TUNNEL—The cover page shows the two tubes comprising The Holland Tunnel while its location and statistics are shown respectively on the plan and profile plate, and in the table at the end of this pamphlet.

The north tube is to accommodate west-bound traffic, entering the New York Entrance Plaza between Hudson and Varick and Broome and Watts Streets, in New York, while the south tube serves east bound traffic, entering at Twelfth and Provost Streets, Jersey City. The exit in each City is located some distance from the entrance, being at Canal and Varick Streets, alongside the Administration Building in New York, and at Fourteenth and Provost Streets, Jersey City, next to the New Jersey Administration Building. This separation of exit from entrance is to prevent undue traffic congestion in the city streets, in the immediate vicinity of the tunnel. Each tube is built of cast-iron segments bolted together, forming a ring of 29 feet, 6 inch outside diameter. This is lined on the inside with concrete, forming the roadway supports, sidewalk and sides.

ROADWAY—The roadway in each tube, accommodating two lines of traffic, is of granite block, with granite curbs. It is estimated that an average of 1900 motor vehicles can pass through each tube per hour.

VENTILATION—The air in the tunnel can be completely changed in a little less than one and one-half minutes, or 42 times per hour.

The space below the roadway conducts fresh air from the blower fans in the nearest ventilation building, and the similar space above the ceiling leads the vitiated air away whence it is exhausted by exhaust fans in the same building. There are 84 of these blower and exhaust fans provided, with an allowance of one-third of their number being held

constantly in reserve. The four ventilation buildings house these fans and the electric motors which drive them, together with all the necessary auxiliary apparatus and equipment.

The fresh air in the tunnel is led by side ports from below the roadway where it travels longitudinally, to an "expansion chamber" which extends on either side a little above the curb. A continuous slit allows the air to escape into the tunnel from this expansion chamber whence it passes through the exhaust ports in the ceiling, so that there is no movement of air lengthwise in the tunnel roadway portion; gases from automobiles are thus diluted before exhaustion.

The installed horsepower for the fan equipment amounts to about 6000 horsepower, of which about 4000 horsepower will be required to ventilate the tunnel at maximum capacity.

The method of ventilating The Holland Tunnel and the design of the ventilating equipment were based upon an exhaustive series of original tests and investigations carried on from December, 1919, to October, 1922.

The problem was unprecedented and data lacking, therefore, in November, 1919, the New York and New Jersey Bridge and Tunnel Commissions, through their Chief Engineer, sought and obtained the hearty co-operation of the United States Bureau of Mines in undertaking this investigational and experimental work. The Bureau agreed to furnish technical directors and facilities of several of their stations, while the Tunnel Commissions agreed to furnish funds for securing technical assistants, labor, etc.

Later the University of Illinois became a third party to the agreement and factors for power determination were obtained by experiments made from February, 1921, until October, 1922, at the Engineering Experiment Station, on model air ducts of concrete and sheet metal.

The investigations covered four main subdivisions: Nature and quantity of gases emitted by motor vehicles under usual road operation conditions; the physiological effects of the gases, particularly carbon monoxide; tests both as to the method of admitting and exhausting the air and the determination of the value of the friction of air flowing in concrete conduits, whence the power necessary, in any given case, could be accurately calculated. The physiological tests were made at Yale University and confirmed in the Bureau's "experimental mine" near Pittsburgh where the method of ventilation was also confirmed after tests.

These results have since been successfully applied, notably in the design and ultimate construction of the Liberty Tunnel of Pittsburgh, Pennsylvania, and in the building of the Estuary Tunnel of Oakland, California.

POWER SUPPLY—The electric current for operating the ventilation equipment and lighting of the tunnel is obtained from both sides of the Hudson River.

On each side current is available from three independent cables any one of which can be fed from either of two generating sources, making a total of four independent generating sources served by six independent cables. Each cable is of sufficient capacity to carry the full tunnel load, thereby providing adequate insurance against power failure.

TUNNEL LIGHTING—The lights in the tunnels' sidewalls are normally placed about 20 feet apart along the tunnel. At the portals and for a short distance within, this spacing is reduced in order to provide greater illumination at these points to counteract the sudden transition from daylight into the artificial lighting of the tunnel. The two main sources of power serve alternate lights, so that the failure of one source of power will leave half of the lights still illuminating the roadway.

SUPERVISORY CONTROL—In addition to a subsidiary control board in each of the four ventilation buildings, from which all equipment in that building can be operated, there is a central supervisory control board located in the top floor of the New York Administration Building from which board all equipment in the entire tunnel project can likewise be operated by the Chief Operator.

MISCELLANEOUS TUNNEL DATA—The principal data concerning The Holland Tunnel are to be found below.

Five shields were employed in driving the tunnels, two starting from the bottom of the New York land shafts and working their way, one for each tube, westward, through the streets and under the bulkhead wall of Manhattan out into the rock reef at the pierhead line and through the river shaft previously sunk into the rock; two from the bottom of the New Jersey land shafts working eastward through the New Jersey river shafts and across the river, meeting the westbound shields and joining with them in the rock. A fifth shield used in driving the south tunnel west, under the Erie Railroad yard, was rebuilt to drive the north tunnel west 30 feet, 4 inches in diameter, which is the largest shield-driven tunnel ever built.

Emergency exits, leading from one tunnel to the adjacent tunnel as well as to the surface at the shafts, are designated by signs.

The tile lining of the tunnel was carefully specified as to its quality and the requirements were unusually strict. These were fixed after extended experimentation to produce a tile that would withstand the temperature and atmospheric changes to be encountered in the tunnel, throughout the changing seasons.

Along the tunnel walls at convenient intervals occur various niches to accommodate fire fighting apparatus, hose for flushing and fire purposes, valves easily accessible, connected with the six-inch water main traversing each tunnel, sand bins, and telephone and relay niches. These are enclosed by bronze doors.

The distances from the entrance portals of each tunnel are designated by mosaic tile bands at the $\frac{1}{4}$ mile points and the state line is specially so marked.

TUNNEL DATA

TUNNEL LENGTHS

Total length of tunnel	9250 feet
Distance between portals	8463 feet
Distance between river shafts	3374 feet
Length of under-river portion	5480 feet

CAPACITY

Number of Roadways	2
Roadway widths	20 feet
Head room	13 feet, 6 inches
Estimated hourly capacity (in both directions)	3,800 vehicles
Estimated maximum daily traffic	46,000 vehicles
Estimated yearly traffic	15,000,000 vehicles
Maximum up-grade	3.8 per cent
Maximum down-grade	4.06 per cent

CONSTRUCTION DATA

Maximum depth, top of tunnel below mean high water 72 feet
Maximum depth of roadway below mean high water 93 feet
Quantities:

Tunnel Excavation	500,000 cu. yards
Cast-iron tunnel lining	115,000 tons
Tunnel concrete	130,000 cu. yards
Cost	\$48,400,000

VENTILATION

Method: Transverse distributed. Air will be discharged and removed continuously throughout the length of the tunnel—no longitudinal movement of air.

Ventilation provides for changing air 42 times per hour.

Total amount of fresh air to be supplied to the tunnel per minute—3,761,000 cu. ft.

Carbon monoxide to be limited to 4 parts in 10,000 parts of air.

THE HOLLAND TUNNEL

