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# The Holland Vehicular Tunnel

## A Great Engineering Achievement

By EDWARD M. SEVCIK '30

The Holland Tunnel is a notable achievement, not only because it fills a great economic need and is the finest structure of its kind ever built, but also because its design and construction represent a distinct advance in engineering progress. This vehicular tunnel is the first highway between Manhattan Island and New Jersey. Its great size and peculiar location constantly presented new problems. No one before had ever attempted to build tubes nearly two miles long under a river, allow poisonous gases to be freely discharged in them and make them perfectly safe for the transit of thousands of people every hour.

### Roadway

The tunnel consists of two tubes. The north tube accommodates westbound traffic while the south tube takes care of the eastbound traffic. The roadway in each tube is normally twenty feet wide between curbs and is paved with granite block. The vertical clearance between the roadway and the ceiling is 13 feet 6 inches. It is estimated that 1,900 vehicles per hour can pass through each tube.

### Ventilation

The air in the entire tunnel can be completely changed in a little less than one and one-half minutes, or about 42 times per hour. There are 84 blower and exhaust fans provided with their electric motors to drive them. The horsepower of this fan equipment is 6,000 horsepower. Two-thirds of the equipment, or 56 fans with about 4,000 horsepower, are all that are required to ventilate the tunnel at maximum capacity so that one-third of the ventilating equipment is held constantly in reserve for any emergency that may arise.

The space below the tunnel roadway conducts fresh air from the blower fans in the nearest ventilation building, and a similar space above the ceiling leads the vitiated air away, whence it is exhausted by exhaust fans in the same building. The air travels in these lower and upper air ducts lengthwise of the tunnel. The fresh air, however, is led from below the roadway by side ports to an expansion chamber, which extends along the tunnel on either side a little above the curb.

A continuous slit allows the air to escape into the tunnel from this expansion chamber on each side and dilutes the gases from those vehicles, whence it is straightway exhausted up through the ports in the ceiling. This arrangement prevents any movement of air along the tunnel roadway. The advantage of the transverse over a longitudinal operation in the traveled way is obvious, both from the standpoint of fire hazard—for vehicles going through the tunnel are no more immune from fire than they are in the streets—and from the standpoint of quick ventilation. This advantage was clearly demonstrated by the

deliberate burning of automobiles in the tunnel roadway. The dense smoke as it formed passed upward and out through the ceiling ports and did not extend more than 30 or 40 feet along the tunnel on either side. In the event of an automobile catching fire all traffic in front of it could immediately pass out of the tunnel, while that halted behind it would be unaffected.

"What is the absolute minimum amount of the gases discharged by automobiles that can be tolerated in the atmosphere of the tunnel?"

There was no authoritative answer to this vital question. A correct answer had to be had and the tunnel engineers took steps to find out. With the co-operation of the United States Bureau of Mines, Yale University, and the University of Illinois, a series of studies were made on the composition of automobile exhausts and the effects of the gases on human beings of all states of health and it was found that anyone could breathe for an hour, without injury, air containing four parts in 10,000 of the most poisonous exhaust gas (carbon monoxide). This figure has taken its place with the other significant data of engineering.

### Lighting

It is no easy matter to properly light a tunnel. In order to insure safe driving there must be no sudden transition to darkness on entering the tunnel or glare on leaving it; the eye of the driver must not be subjected to a succession of bright lights when in transit; sharp, confusing shadows must be absent; and there must be a general appearance of attractive lightness throughout.

Aided by engineers of the Westinghouse Lamp Company, who built an accurate model to investigate various methods of illumination, the tunnel engineers have utilized a system that is probably the nearest thing to daylight so far achieved in so large a space. It is said that the automobile driver no more realizes that the tunnel is lighted than that a sunlit road is lighted.

### Power Supply

The electric power supply of the tunnel is well nigh infallible. Every other lamp is supplied by current from New Jersey, and the remaining lamps are supplied by power from New York. Furthermore, both the New York and New Jersey power is supplied from three separate cables and two independent sources.

The high standards the engineers set for themselves were apparent in even the smallest details. Thus, a special device was designed in order to insure that the tension of the nut on each bolt in the cast iron lining should be precisely the value set by the engineers.

### Drainage

A six-inch water main extends throughout each tunnel, supplying water for flushing and fire-fighting purposes at intervals of 120 feet along

each side of the tunnel. To carry this water off, or any seepage that may occur, a complete drainage system has been installed. A gutter runs continuously behind the granite curb on the low side of the roadway in each tunnel and water can enter through openings spaced about 17 feet apart. This gutter will enclose and prevent explosion from any gasoline that might become ignited in the gutter. This gutter leads from the entrances and exits to the main sump, which is at the low point of each tunnel.

#### Fire Protection

To combat fires that may occur in the tunnel the following equipment is provided:

- (1) Water, with 100 feet of two and one-half inch hose every 120 feet of tunnel.
- (2) Five gallon, foam type, extinguishers every 120 feet of tunnel.
- (3) Sand in bins for fighting gasoline fires; bins every 240 feet.
- (4) Two emergency trucks, one at each tunnel exit. These trucks carry not only fire-fighting apparatus, but also first aid and wrecking equipment.

#### Work Under Compressed Air

The driving of tunnels by means of shields underneath the bed of the Hudson River and the sinking of the seven shafts and caissons for building foundations were accomplished by means of compressed air, which balanced the pressure on the outside of these structures and held out the river water, which otherwise would have seeped down through the river mud or silt and penetrated the working chambers of the shaft caissons and tunnel headings. While the greater number of the under-river tubes were driven through silt, a stretch of nearly 1,000 feet was driven through ledge rock. The maximum pressure required was 47 pounds per square inch above atmospheric pressure.

During the five-year construction period, 756,565 decompressions of men coming out of the compressed air work took place. Only 528 cases of "bends," or caisson disease, were recorded; no fatality having occurred which was directly attributable to caisson disease.

Six shields were employed in driving the tunnels. The north tube, on the New Jersey side, for about 800 feet is of larger diameter, 30 feet 4 inches, in order to provide greater spaces for ventilation ducts in this longer upgrade portion where it is anticipated the motor vehicle exhaust will be greater. This is the largest diameter shield driven tunnel ever built.

#### Traffic Signals

Along each side of the roadway at regular intervals are traffic signal lights. The signal light "Stop Engine" will be flashed when all automobile engines must be stopped. No engine will be permitted to race at a halt. A corps of over 200 police supervises the tunnel.

The Holland Tunnel takes its name from that of the first chief engineer, Clifford M. Holland, of Brooklyn, N. Y. He died before the tunnel was completed, and Milton H. Freeman succeeded him. He also died before the task was finished, and Ole Singstad was appointed to finish the job.

(Continued on Page 24)

## HOLLAND TUNNEL

(Continued from Page 8)

**Tunnel Data**

Total length of tunnel.....	9250 feet
Length of under-river portion.....	5480 feet
Number of roadways.....	2
Roadway widths.....	20 feet
Head room.....	13 feet 6 inches
Hourly capacity (both directions) .....	3,800 vehicles
Estimated maximum daily traffic .....	46,000 vehicles
Estimated yearly traffic.....	15,000,000 vehicles
Maximum depth of roadway below mean high water .....	93 feet
Tunnel excavation.....	500,000 subic yards
cast iron tunnel lining.....	115,000 tons
Tunnel concrete.....	130,000 cubic yards
Cost .....	\$48,000,000

Ventilation method is transverse distribution. No longitudinal movement of air in tunnel. Fresh air supplied per minute amounts to 3,761,000 cubic feet.

Carbon dioxide limited to four parts in 10,000.

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