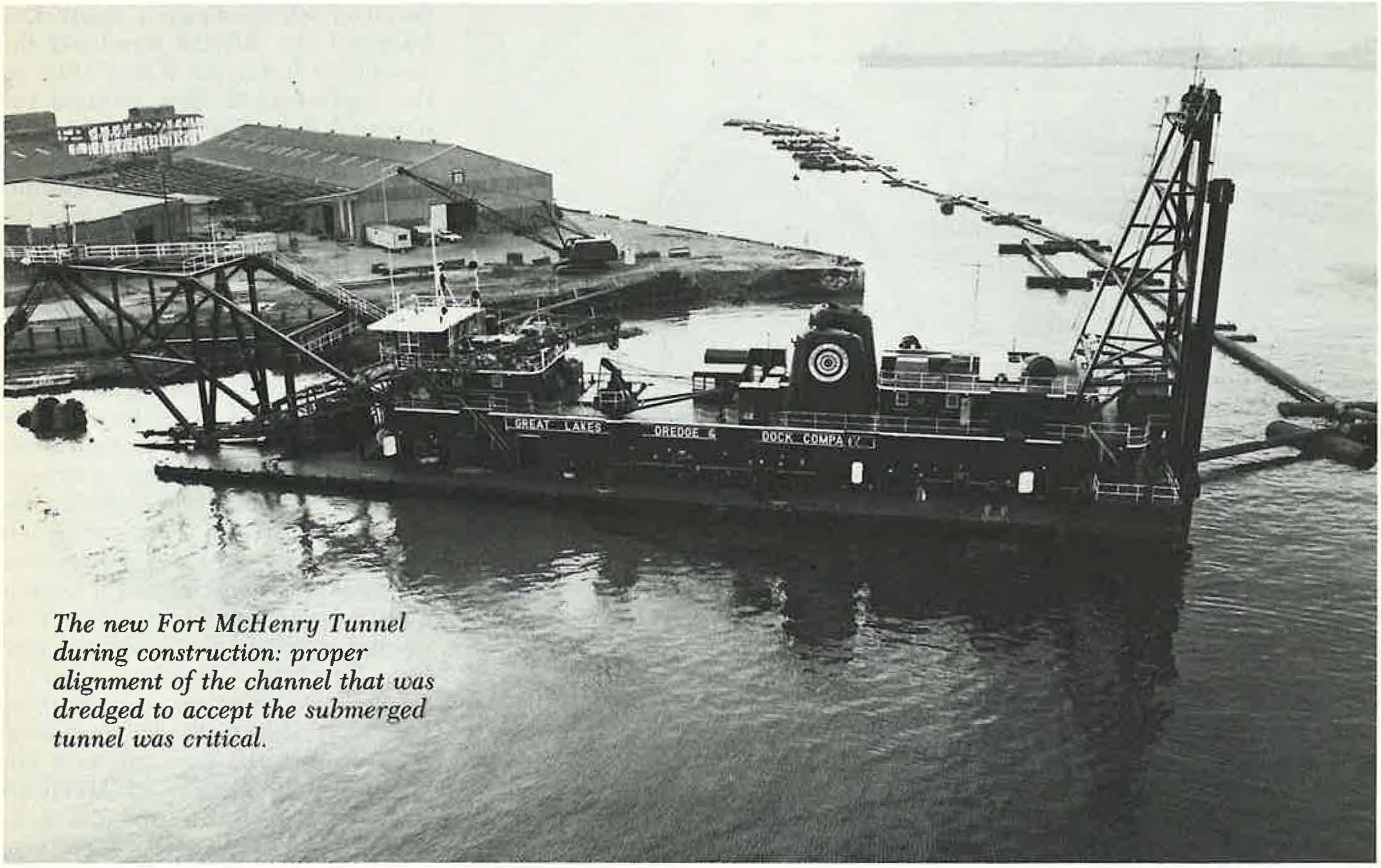
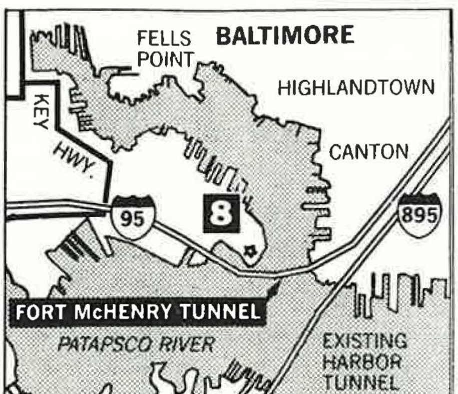


The new Fort McHenry Tunnel during construction: proper alignment of the channel that was dredged to accept the submerged tunnel was critical.

FORT McHENRY TUNNEL OPENS IN BALTIMORE

JOHN BERTAK

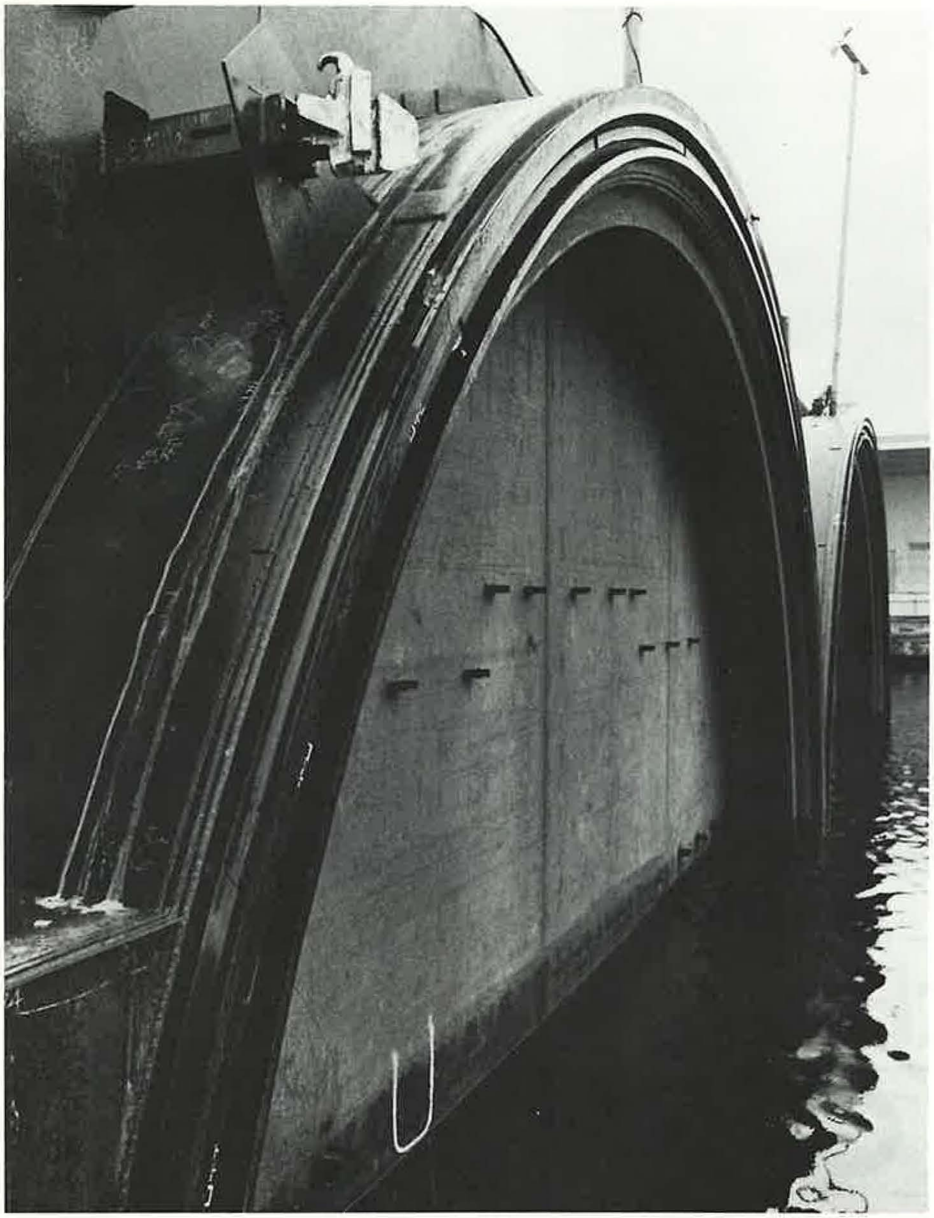


Locations of the newly completed Fort McHenry Tunnel and the 25-year-old Harbor Tunnel crossing Baltimore's Inner Harbor in Maryland.

The Fort McHenry Tunnel, which carries Interstate 95 under the Patapsco River that is Baltimore's harbor, opened in Maryland in November, completing one of the final links of the East Coast Interstate network. The first eight-lane submerged tunnel in the United States, this 1.7-mile project is a marriage of time-tested construction methods and state-of-the-art technology.

Not only is the tunnel the longest eight-lane Interstate tunnel ever built, it is also the world's widest immersed tube tunnel designed especially for vehicular traffic. A length of 8,800 feet from grade point to grade point and 7,200 feet from portal to portal, it closes Maryland's last gap in I-95, the East Coast's most important Interstate route, unplugging traffic bottlenecks on the Interstate as it passes through Baltimore and relieving congestion in the four-lane Baltimore Harbor Tunnel that was built in the 1950s.

John Bertak is Director of Public Affairs for the Maryland Department of Transportation. (all photographs by Richard I. Lippenholtz)



Close-up of a double-tube module before submersion. Modules were fabricated at Port Deposit, Maryland, and floated to the project site.

Controversy, Creativity, and Competence

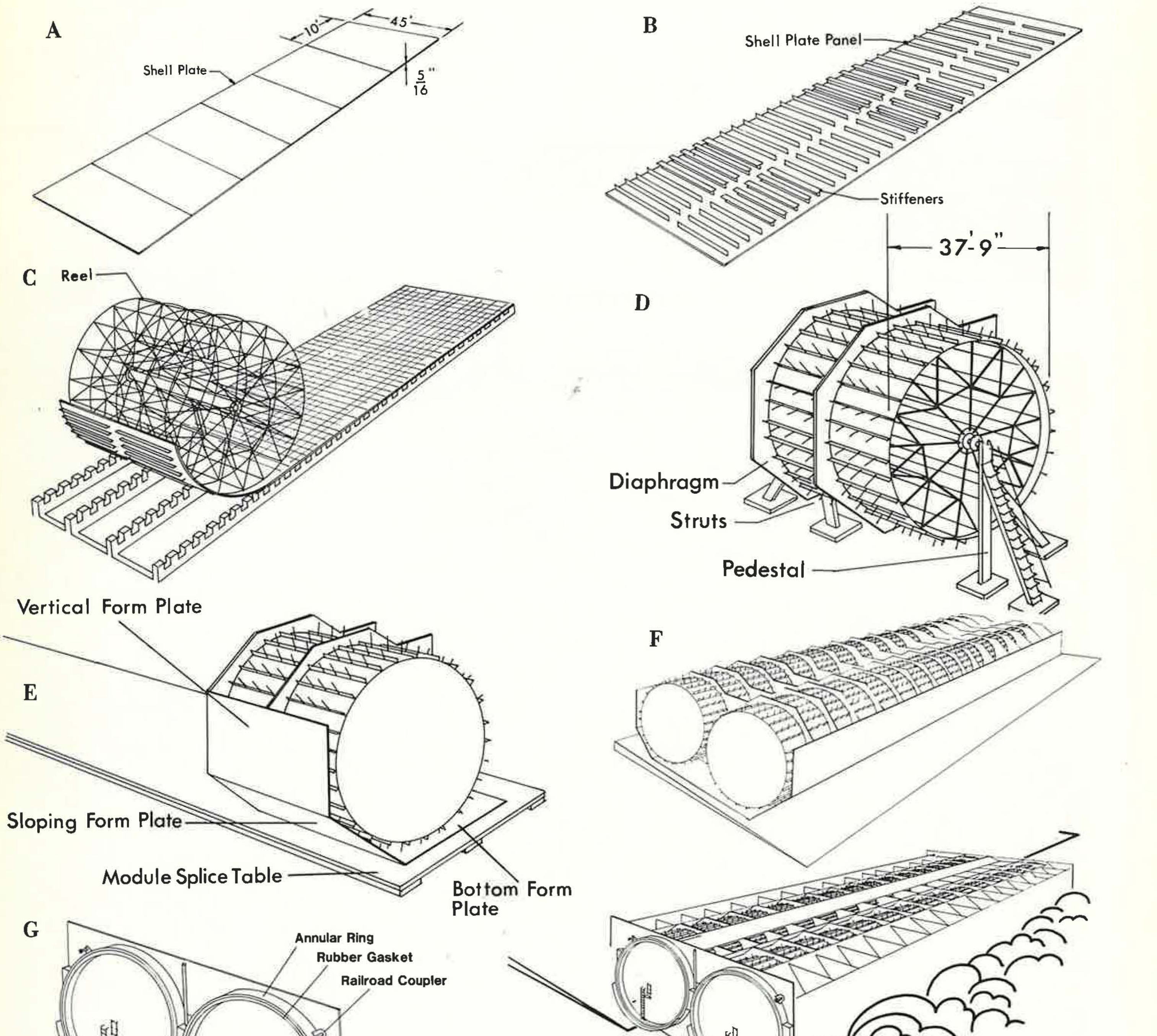
The story of the construction of the Fort McHenry Tunnel has been one of controversy, of creativity, and of competence. One of the first chapters in the story took place in front of the White House in Washington some 10 years ago with a demonstration by a group of Baltimoreans who were afraid that they were going to lose something very special—the grand presence of Fort McHenry and its colorful history. Fort McHenry is the Baltimore harbor garrison where Francis Scott Key watched the British bombard the Americans during the War of 1812. As the battle raged, Key penned the immortal lines that became the U.S. National Anthem.

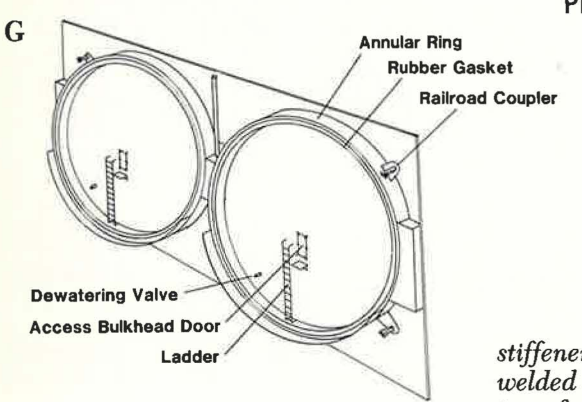
With construction of I-95 rushing north from one end and south from the other, historic Fort McHenry was caught in the middle. Also caught in this impending collision was the community of Locust Point, a bastion of old Baltimore. Even though no serious thought was given to usurping any part of Fort McHenry for construction of the I-95 link, at the center of the controversy was a plan to erect an enormous bridge almost directly over the fort and over Locust Point. The controversy continued for 5 years and, as expressed by a Baltimore city official, it became embarrassing for the city to see its citizens protecting a national monument from the plans of the city administration. The situation was resolved eventually when the bridge project was sunk beneath the Patapsco River and converted into the Fort McHenry Tunnel—at about twice the cost of the bridge originally planned.

$825-Million Project

The Federal Highway Administration (FHWA) approved the $825 million project, and it earned the reputation of being the most expensive single project on the entire National Interstate and Defense Highway System of the United States. In fact, however, several other tunnels have been costlier to build. But the tunnel was built under the largest single contract ever awarded for highway construction in the United States; that $425 million contract went to Wiley Manufacturing Co., Inc., for fabrication and placement of the giant steel and concrete tube sections, which are the primary elements of the tunnel.

Creative financing for the project resulted from agreements between the city of Baltimore, the state of Maryland, and the FHWA. As with the majority of Interstate highway projects, the FHWA was prepared to cover 90 percent of the costs. However, in an unprecedented move, the FHWA also agreed to advance the city of Baltimore the 10 percent local share. "I think the people in Washington appreciated the importance of this project," Maryland Trans-





Tube fabrication. A, *The process begins with panels welded together to form the shell plate.* B, *Longitudinal stiffeners are added for strength.* C, *Shaping module begins by wrapping the welded steel plate around a specially designed reel.* D, *Reel and steel shell are transferred to a pedestal where other structural pieces are added.* E, *Reel is collapsed from inside module and module is transferred to a table where bottom, sloping, and vertical form plates are added.* F, *Sixteen modules (8 for each tube) are joined on shipway to form section of double-barreled tube.* G, *Dam plates are fabricated and attached to seal each end of tube.* H, *Keel concrete is placed to add strength and rigidity; the double-barreled tubes are side launched for 12-hour tow to outfitting pier near Fort McHenry.*

West portal of the Fort McHenry Tunnel during construction. Extensive dewatering of the excavation was necessary. Note the submerged tube modules at far end of excavation.

portation Secretary William K. Hellmann commented. A complex financial arrangement was also worked out between the city and the Maryland Transportation Authority, the agency that operates all state toll facilities in Maryland. After completion, the tunnel became a Transportation Authority toll facility, and the FHWA will be reimbursed for its advance with revenue from the tolls collected. The $1.00 toll is the same as that charged at the other two Baltimore harbor crossings.

The design for the tunnel was the task of the joint venture design and construction management team of Sverdrup/Parsons/Brinckerhoff (SPB). Assisting SPB were several subconsultant firms, including Delon Hampton & Associates; Whitman, Requardt and Associates; Rummel, Klepper & Kahl; RTKL Associates, Inc.; Purdum & Jeschke; The Leon Bridges Company; and Ecological Analysts, Inc. The entire project was the responsibility of the Interstate Division for Baltimore City (IDBC) of the Maryland Department of Transportation and the FHWA.

Dredge Disposal Site To Be Marine Terminal

In addition to providing a major benefit to motorists traveling on the main East Coast Interstate highway, the Fort McHenry Tunnel will provide a substantial direct benefit to the city of Baltimore and the state of Maryland. That benefit comes largely from the construction of a major marine terminal in the Port of Baltimore, built entirely from material dredged for the tunnel. In the summer of 1980, construction began on a dredge disposal site 1.5 miles southeast of the tunnel. The site will become the Canton-Seagirt Marine Terminal, a 146-acre container facility that will be the second largest port facility in Baltimore.

To construct the dredge disposal site, about 5,600 linear feet of cellular cofferdams was installed at the location with each cofferdam being 62 feet in diameter. The facility now holds the 3.5 million cubic yards of material dredged from the harbor bottom to make way for the tunnel tubes.

The importance of the Canton-Seagirt project was highlighted this year when Secretary Hellmann announced that completion of the port facility will be accelerated by 2 1/2 years in order to provide much-needed additional cargo-handling space for containers.

Ground Broken for Tunnel in 1980

Dredging of the massive trench in the bed of the Patapsco River began in 1980. Like an enormous vacuum cleaner, the 27-inch hydraulic dredge pulled material from the river bed. The material was transported in a fluid state by pipeline to the disposal site. The trench was 180 feet wide at the base and reached a maximum depth of 115 feet.

Preparation of the tube base required a screeding operation by which gravel is deposited into the dredged trench and carefully spread by a screed barge. The operation was continuously monitored by sounding the trench bottom and resulted in a 2-foot-thick bed that served as the leveling course and the foundation for the tunnel tubes.

While work was under way at the tunnel site, construction was begun 30 miles north of Baltimore on the giant tubes that form the main tunnel. Wiley Manufacturing constructed the tubes at a plant built in Port Deposit, Maryland, on the shores of the Susquehanna River. More than 800 employees worked around the clock on fabrication of the tubes.

Each of the 32 double-tube sections was constructed, sealed, and launched into the Susquehanna River and then floated by tug to the tunnel site.

The lowering of the tubes into the trench was a precision operation in which the lay barge was anchored and a temporary survey tower was mounted on the outboard end of the tube. The survey tower extended above the water line when the tube rested on its foundation and was used as a sighting target for accurate alignment of the tube during placement.

Tubes were lowered to within a few feet of the previous section and connected by divers with railroad coupler-type connections. Hydraulic jacks drew the lowered tubes against the tubes already in place. The opening of the dewatering valves resulted in thousands of tons of water pressure and provided the final push to move the tubes into location. Plates were welded around the interior joints and the area behind the plate was filled with concrete for final water

Gravel barge and floating screed during construction process. Procedures for preparation of the gravel bed in the dredged harbor floor trench were critical; improper grade control would have prevented proper placement of tube modules.

tightness. After each pair of tubes was properly located and joined, backfill material was placed around and on top of the tubes to lock them into position and provide traction. Each of the tube sections has 1,688 tons of steel surrounded by 2,660 cubic yards of concrete.

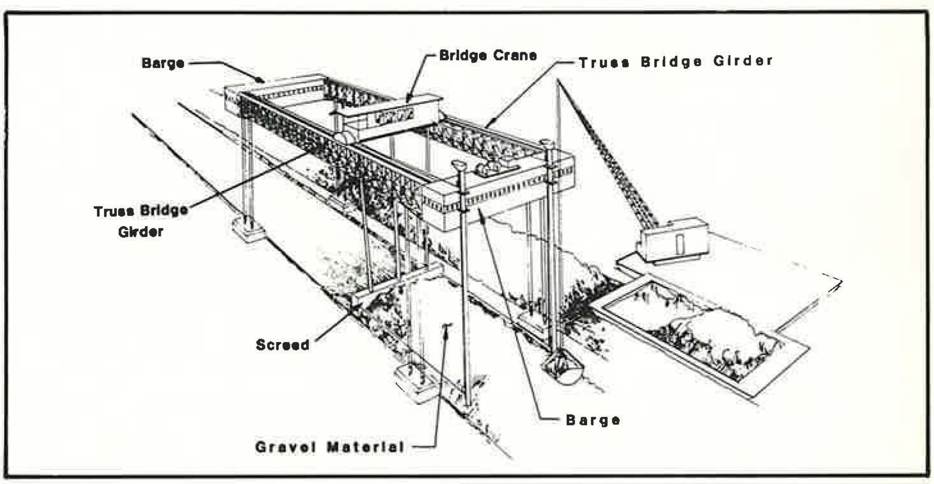
The 1.7-mile project includes approach roads and a ventilation building, which extend well below ground level on each end of the tunnel itself.

To allow for the subterranean construction phase of the ventilation buildings, the groundwater in the area was temporarily lowered by using a system of well points. Sheeting was driven before the excavation began and tiebacks were installed where necessary while the excavation continued to the required depth.

Massive "gravity slabs" of concrete were put in place to overcome the buoyant effect of groundwater that occurs when the temporary wells are removed.

Aesthetics was a major consideration in the design of the ventilation buildings at each end of the tunnel. The west ventilation building has a brick facing to ensure that it is aesthetically compatible with the historic area. A berm approximately 10 feet high was placed around the west building and landscaped with plantings of both deciduous and evergreen trees. In the summer, from Fort McHenry an observer will see only trees along the shoreline. In winter, the building will appear as a 15-foot brick wall behind a growth of evergreens.

Nearly 3,000 workers have been involved in the construction project during the past 5 years. The tunnel



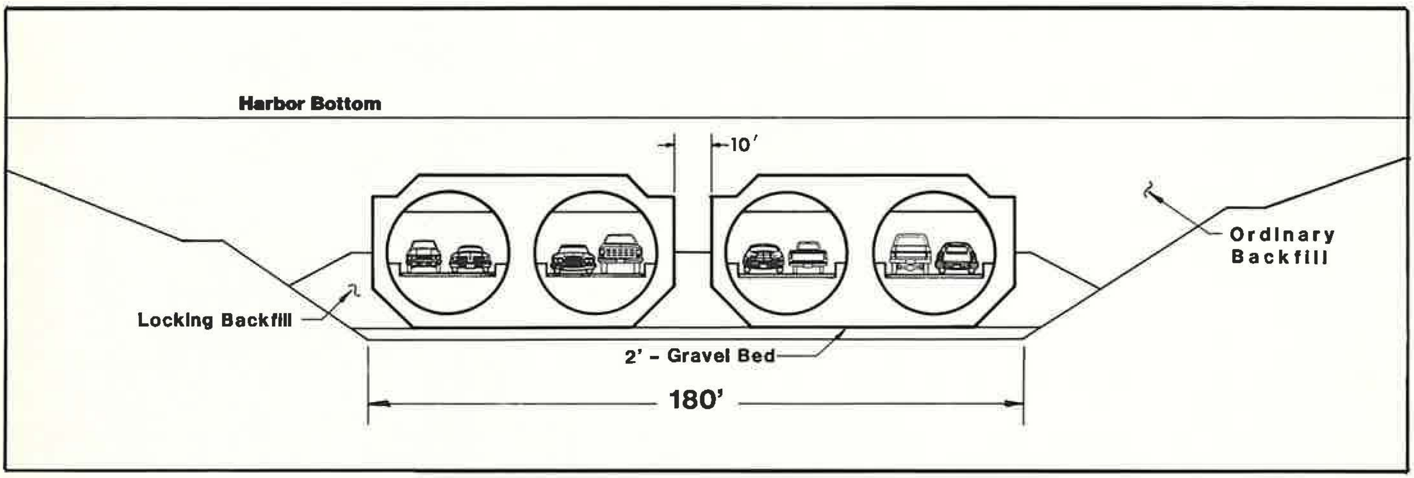
Screed barge: suspended from barge crane is the actual screed, a heavy plowlike beam that spreads and levels gravel material.

A total of 1,800,000 square feet of tiles lines the tunnel.

project totals include 100 million pounds of steel and 3 billion pounds of concrete along with 8 million white ceramic tiles that line the four tubes. Each of the tiles was placed by hand.

A significant aspect of the tunnel project is that it was completed on schedule and $75 million under budget, testimony to the competence of those responsible for the project. Project manager Kenneth Merrill of the IDBC attributes the cost reduction to a drop in inflation, lower fuel prices, and the 1980 recession that drove down construction costs. Others familiar with the project note that much of the savings resulted

Cross section of the eight-lane tunnel.



Clean lines of tunnel portal belie the complex design and construction. Aesthetic considerations demanded that this major traffic carrier be unobtrusive.

directly from sound management during all phases of construction.

High-Tech Tunnel Controls

Much of the high-tech aspect of the Fort McHenry Tunnel only became apparent after the tubes were in place and the interior work began. Sixty-four television cameras monitor traffic from all portions of the project, and the control room in the main administration building looks like a NASA installation. Twenty-four tollbooths stand at the plaza to house Transportation Authority collectors in climate-controlled comfort.

Computers monitor traffic flow through the tunnel and change messages on the facility's variable message boards as the situation demands. Air quality is also continuously monitored by computer and 48 giant ventilation fans are ready to replace the tunnel's air supply at the rate of 6,684,000 cubic feet per minute.

An AM-FM repeater antenna runs the length of the tunnel, reducing apprehension for drivers who usually lose radio signals in a tunnel. Prerecorded and live messages will also be broadcast to motorists when appropriate.

Estimated 80,000-100,000 Vehicles per Day To Use Facility

The Maryland Transportation Authority expects full operation of the tunnel to require a staff of 220 people, including toll, police, fire, maintenance, and administrative personnel. The new project will relieve the heavily traveled Harbor Tunnel and link industrial traffic from marine terminals in several Baltimore locations. Planners estimate that 80,000 to 100,000 vehicles per day will use the facility.

As with many public works projects, the official name of the tunnel is not the name by which it is popularly known. Several years ago, the state board responsible for naming facilities decided that the new tunnel should honor the general who commanded the garrison at Fort McHenry during the famous British attack of 1814. Thus the project is officially the General Samuel Smith Memorial Tunnel, although as noted by Maryland Transportation Secretary Hellmann (who also serves as Chairman of the Transportation Authority), road signs directing motorists to the project indicate "Fort McHenry Tunnel."

Master control room for monitoring tunnel operations. Sixty-four television cameras and other sophisticated monitoring devices provide real-time information to tunnel operators. Computers are used to coordinate traffic flow, operate variable-message signs, and meet air-quality requirements, as well as in other tunnel operations.