TECHNOLOGY

Tunnels—Man-Made Thruways

Tunnels are carved under mountains, seas or cities. But tunneling techniques have not changed much since ancient times, William E. Small reports.

See Front Cover

➤ GIGANTIC TUNNELS are being blasted and carved out of rock and mud throughout the world to shrink the travel time from nation to nation and office to home.

Whether a mountain, a river, a leg of the sea or the teeming streams of city traffic that must be breached, engineers are designing a tunnel to solve the problem. But modern tunneling techniques are only modifications of those used in Greece and Rome centuries ago.

Mighty Mont Blanc, Western Europe's highest mountain, will have a hole through it seven miles long, to be completed this year. It will cut 125 miles from the driving distance from Paris to Rome.

The English Channel Tunnel, long a dream of tunnel engineers, is being discussed again to link the 20 miles from Dover, England, to Calais in France, speeding vacationists and their vehicles piggyback on a train at 90 miles an hour under the choppy channel waters.

A bridge-tunnel will soon span the Chesapeake Bay, linking Norfolk, Va., with the southern tip of the DelMarVa peninsula, allowing tourists to drive more than 17 miles across one of the world's greatest estuaries.

These and several other gigantic tubes and holes will be far longer than the present vehicular world record holder, the Mersey Tunnel which connects Liverpool and Birkenhead under the Mersey River in England. This giant tunnel stretches three miles under the water and is wide enough to pass four lanes of traffic.

Many Tunnels Planned

Of course, many more tunnels are in the planning or construction stage for passage of trains, the transport of water or sewage, the production of hydroelectric power or as atomic bomb shelters for ships, trains or populations.

This spring, workers celebrated the meeting of a Swiss team of miners and an Italian team boring under the Saint Bernard Pass in the Alps. Like the miners who celebrated the completion of the very first tunnel under the Euphrates River in 2180 B.C., or those who will celebrate the meeting of the French and Italians under Mont Blanc later this year, these workers cheered the accomplishment of man over nature.

But nature has long been building tunnels and caves, and animals have been tunneling for thousands if not millions of years. Man has lagged far behind since it is only slightly more than 100 years since the digging of tunnels became important.

Since that first transportation tunnel 4,000 years ago, engineers have learned much about tunnel construction and necessary safety. Powerful tools have been built to release many hands to other work. Still, those crude beginnings have been only modified or improved slightly.

The Mont Blanc Tunnel, considered one of the major highway engineering feats ever carried out in Europe, requires men to drill into the tough granite, blast away the rock and carry the debris out of the tunnel. A mechanical platform, called Jumbo and seen on the front cover, supports workmen and tools while drilling and blasting.

The Romans built their tunnels with slaves to drill into the rock. The rock was heated and then doused with cold water or vinegar to cause the rock to fracture The debris was then manually carried from the tunnel.

Difference in Technique

The main differences in the two techniques are in the power tools which replaced hand drills, dynamite for blasting, mechanical equipment instead of men to carry the debris, and the ventilation equipment now employed for the safety of the men.

Still the Mont Blanc Tunnel will be an accomplishment hard to achieve by methods used in ancient times.

The French miners will, in all likelihood, meet the Italian segment of the tunnel with only a few inches off. This, after each team has bored 3.7 miles from opposite sides of the mountain. No deaths are expected from lack of ventilation because of modern techniques.

This tunnel will be 23 feet wide with 26-inch roadsides. Trucks 14 feet high can rumble through. Up to 400 vehicles will pass 13 miles through the mountain and customs in less than an hour. Not even the greatest of Roman builders could have anticipated this.

There are actually three types of tunnels being built today. The first, and perhaps best known, is the true tunnel, dug nearly horizontal through rocks or earth, similar to the Mont Blanc Tunnel.

The second type of tunnel is simply a big ditch, in which a long tube is laid and covered, similar to many of the subway systems and sewer tunnels in present use. It is commonly called the "cut-and-cover" type.

The final tunnel type is the trench. This is a cut-and-cover tunnel under water. This type is becoming more popular with engineers, since materials can now be fabricated on land, floated on the water to be sunk in place.

The new multimillion bridge-tunnel snaking slowly across the Chesapeake Bay is a prime example of this trench type tunnel.

Two artificial islands, three bridges and two tunnels will be built across the Bay in a link 17.5 miles long. The tunnels are built and assembled on shore. They are floated over the trenches like huge ships, weighted with concrete and moved into place by skin-divers with the complete highway bed inside.

The Chesapeake project is reportedly the biggest challenge ever presented to United States construction men, since the tunnel-bridge is mostly in open ocean, as opposed to other structures which are in protected areas.

Another "true tunnel," competing in prominence with the Mont Blanc Tunnel, will be built high in the Rocky Mountains. Known officially as Straight Creek Tunnel, its length will be only 9,000 feet, but it will be the longest tunnel ever attempted at altitudes above 11,000 feet.

Complications with lack of oxygen and severe cold make it a great engineering feat, according to Mark V. Watrous, chief engineer of the Department of Highways in Denver, Colo.

Although the basic techniques of tunnel construction have not changed since the times of the ancient Greeks and Romans, at least three new innovations have been discovered which make the process and engineering better, more accurate and simpler.

The first was patented by Sir Marc Isambard Brunel in 1818. This was a compartmented shield, driven by powerful jacks, which pushed workmen right to the front of the tunnel and permitted digging and drilling without danger of cave-ins.

Lord Cochrane, another Englishman, found that compressed air would increase the pressure inside the tunnel and prevent water and mud from oozing in. It was, however, 50 years before the idea was coupled with the shield.

Holland Made Important Advance

An American engineer, Clifford M. Holland, made the third important advance in tunnel engineering in the 1920's while working on the first long underwater tunnel for motor vehicles in the U.S. He solved the serious ventilation problem presented by auto exhaust in the tunnel under the Hudson River between New York City and Jersey City, N. J.

Although Holland did not live to see its completion, this famous Holland Tunnel was named in his honor.

New York's Brooklyn-Battery Tunnel is the United States' longest underwater auto tunnel, third longest in the world. The world's longest underwater twin-tube tunnel of the trench type is the Baltimore Harbor Tunnel in Maryland, with 7,650 feet from entrance to exit.

The Simplon Tunnel is the longest railroad tunnel in the world, stretching more than 12 miles under Mt. Leone from Brig, Switzerland, to Iselle, Italy. The U.S. alone has approximately 1,400 railroad tunnels totaling more than 300 miles in length.

But tunnels for trains or trucks or cars are by no means the longest nor the most important. There are tunnels the world over for other purposes as vital to our society as transportation tunnels.

Beginning with the first civilization, man has had to construct tunnels to carry water to the populations. In New York State, for example, there are two tunnels sunk deeper than the height of the Empire State building and snaking 105 miles to relieve the thirst of the nation's largest city.

Chicago, Denver, Los Angeles and San Francisco are only a few of the cities in this country dependent on tunnels for water.

Sewage tunnels channel waste waters from most of the cities in the nation to be disposed in plants and rivers. Hydroelectric power is also produced in tunnels which are part of several large dams.

Sweden has pioneered in tunneling underground hangars for military planes and underground bases for ships to steam into as protection against atomic bombs. In Stockholm there is also a 1,000-foot-long tunnel garage for 600 cars which can be converted to a shelter for 6,000 persons in the event of war.

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PHYSICS

Plasma Eater for Studies

➤ A "PLASMA EATER" is being used for studies essential to developing ways of controlling H-bomb reactions for peaceful purposes, the American Physical Society was told in Washington, D. C.

The plasma eater may also contribute to research programs on burning coal to make electricity from roaring plasma jets instead of spinning turbines, two scientists from Oak Ridge National Laboratory, Oak Ridge, Tenn., reported. The device could also help in the development of space ship power using plasma jets.

The device measures the rate of flow of a plasma, and consumes the plasma as it does so, hence its name. The plasma eater is simply a stack of spaced metal plates, resembling an open Venetian blind, placed across the plasma flow, Drs. I. Alexeff and R. V. Neidigh told the meeting.

A plasma, sometimes called the fourth state of matter, is a collection of neutral particles, charged particles and free electrons that as a whole is electrically neutral. Ordinary matter—water, rocks, potato peelings, etc.—becomes plasma when it is heated to temperatures of many thousands of degrees. Lightning bolts and fluorescent lights are common examples of plasmas.

Normally a plasma would merely flow between the plates of the "plasma eater." However, if alternate plates are connected to a sufficiently high voltage, the plasma is electrically pulled apart. The electrons are attracted to the postive plates, and the positively charged ions to the negatively charged plates, thus destroying both.

The reason for doing this is to find out about plasma flow. By measuring the electrons being collected, the amount of plasma entering the plasma eater each second can be found. When the plasma source is turned off, the plasma density can be calculated. Also, the time required for the plasma to flow into the plasma eater indicates the velocity of flow.

Such knowledge is essential to the development of controlled nuclear fusion in which a confined plasma duplicates the power source of the sun.

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Weight of Electron

➤ IF YOU KNEW your own weight as accurately as the weight of an electron has been measured, you would know your weight within one-thirtieth of an ounce.

The weight of the electron is .910904 with 26 zeroes between the decimal point and the first nine. Dr. E. Richard Cohen of Atomics International, a division of North American Aviation, Inc., Canoga Park, Calif., said the electron's weight had been measured with an accuracy of approximately one part in 100,000. He reported his findings to the American Physical Society meeting in Washington, D. C.

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Measure Speed of Light

➤ DR. R. D. CUTKOSKY of the National Bureau of Standards told the meeting of the American Physical Society in Washington, D. C., that the speed of light would soon be measured again in darkness. Other measurements made so far, he said, indicate that the value now accepted for the speed of light is quite accurate.

This value is in close agreement with one computed from measuring the unit of resistance, the ohm. The value of the ohm has been determined both directly and indirectly and results of both methods agree, Dr. Cutkosky said. The National Bureau of Standards' unit of resistance is 1.0000023 ohms, with an estimated 50% error of two parts in a million.

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Cesium for Clocks

➤ IF THE MOTIONS of cesium atoms were used as the frequency element in a clock, the clock would be so uniform that it probably would not lose or gain more than one second in 16,000 years, when compared with another clock just like it. This was reported to the meeting of the American Physical Society in Washington, D. C., by Dr. R. C. Mockler of the National Bureau of Standards.

He noted that British Nobelist P. A. M. Dirac had suggested many years ago that perhaps gravity is weakening. The attraction between the sun and earth or between the earth and a satellite may decrease by a very tiny amount as time goes by. Dr. R. H. Dicke, Princeton University, has considered this possibility in some detail, and has suggested that this weakening of gravity could be measured.

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