

## Engineering the Berlin Tunnel

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**The tunnel was 1,476 feet in length and consumed 125 tons of steel liner plate and 1,000 cubic yards of grout . . . This was not a small operation!**

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Fifty years ago, the CIA embarked on a project to intercept Soviet and East German messages transmitted via underground cable. Intelligence was collected to determine the best place to hit the target, and then concrete planning for a new collection site was begun.

Early in 1951 when I was working in the Engineering Division of the Office of Communications, I received a message from some people in the office of the Deputy Director of Plans—specifically the chief of Foreign Intelligence/Staff D (FI/D), and a member of his team—requesting a meeting.<sup>1</sup> The meeting was short. The only question they asked was whether a tunnel could be dug in secret. My reply was that one could dig a tunnel anywhere, but to build one in secret would depend on its size, take more time, and cost more money. After the meeting, I was transferred to FI/D. Thus began planning for the construction of the Berlin Tunnel.

**We started building the tunnel in August 1954 and completed it in February 1955. It was 1,476 feet in length; 3,100 tons of soil were removed; 125 tons of steel liner plate and 1,000**

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<sup>1</sup> Staff D was a SIGINT component.

cubic yards of grout were consumed. This was not a small operation!

Debate has swirled around the net intelligence value of the operation.<sup>2</sup> But the completion of this demanding project—accomplished in secret and under exacting conditions—is a tribute to the resourcefulness and expertise of an outstanding team of professionals.

### Learning as We Went

Prior to this project, my tunnel experience was limited to several night-shift visits to the Brooklyn-Battery Tunnel as a student civil engineer. Constructed in 1948 and somewhat unique, the tunnel extended from Battery Park in lower Manhattan to South Brooklyn. It was designed for two 18-foot bores, which were mostly blasted and drilled in solid rock. The East River crossing presented a problem, however.

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<sup>2</sup> Accounts of the tunnel project covering its conception and execution, its compromise by British spy George Blake, and Moscow's delay in closing it down include: David C. Martin, *Wilderness of Mirrors* (New York: Harper & Row, 1980); Peter Grose, *Gentleman Spy: The Life of Allen Dulles* (New York: Houghton Mifflin Company, 1994); David E. Murphy, Sergei A. Kondrashev, and George Bailey, *Battleground Berlin: CIA vs. KGB in the Cold War* (New Haven, CT: Yale University Press, 1997); and David Stafford, *Spies Beneath Berlin* (Woodstock, NY: The Overlook Press, 2003).

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**Soil from the tunnel would fill more than 20 living rooms in an average American home!**

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At the confluence of the East River and the Hudson River, there was a deep submarine canyon, a leftover from the extensive land erosion caused by the violent runoff of melt waters from the retreating Continental Glacier. The canyon was filled with the muck and detritus of eons of erosion. This fact required that a pressurized shield, solely for the prevention of blowouts on the East River crossing, had to be moved the entire length of the tunnel. The concept of such a shield surfaced in design discussions for the Berlin Tunnel project. The Brooklyn-Battery Tunnel demonstrated the magnitude of the job of marshaling the experienced personnel, materials, and equipment for the huge task of constructing a tunnel and disposing of the excavated soil. Work on the 18-foot bore tunnel could not have been done in silence. These matters were a warning, because silence would be a top priority in constructing the Berlin Tunnel in secret.

### Design Decisions

Once the Berlin project received a green light, design specifications had to be determined; men and materials assembled; and questions of site selection, training, and transportation answered. The big question that loomed was how to dispose of the tons of soil that would be excavated! Rough calculations

showed that the amount of soil expected to be brought out from the tunnel and vertical shaft would fill to the brim more than 20 living rooms in an average American home! Security and silence dictated that not one cubic foot of soil be removed from the site. A warehouse, with a basement for the storage of the excavated soil and a first floor reserved for recorders and signal equipment, was the solution.

My task began with an inspection of existing tunnels in the Washington, DC, area, which included utility bores, pedestrian walkways, storm drains, and railroad maintenance tunnels. From this research, I concluded that our tunnel should be 6 feet in diameter with a structure of steel-flanged corrugated liner plates—the 6-foot diameter would provide a comfortable working room at the tunnel face. Next came research at the Library of Congress to check the available literature dealing with earth pressures on tunnels. I already had two textbooks and found three relevant papers published by the American Society of Civil Engineers. Together, these provided the procedures I needed to start the mathemati-

cal analysis of the tunnel structure.

In the spring of 1953, I flew to Frankfurt, Germany, to meet with a senior case officer at the CIA station. The officer told me that the tunnel site had not yet been selected. He also advised me that Lt. Col. Leslie M. Gross had been selected as the tunnel's resident engineer. He expressed regret that I had not been selected. I told him not to worry.<sup>3</sup>

The next subject we discussed was a meeting with the British in London. We would attend this meeting with Bill Harvey, chief of our Berlin base. At the beginning of the meeting, I started to discuss some notes I had on the unfinished mathematical analysis of the tunnel structure. Clearly the attendees were not interested in mathematics. The discussion turned to the matter of the form of the tunnel design. The British proposed using heavy concrete blocks, which were common in the London Underground. I countered with the idea of using steel liner plates, which would be lighter and easier to use in the tunnel and at the tunnel face. This proposal was accepted.

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<sup>3</sup> *Time* magazine of 7 May 1956 reported that some Army people saw "friends whom they knew to be engineers appearing in Berlin wearing the insignia of the Signal Corps."

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**The ‘circuit method’ of computing earth pressures on tunnels required solving six simultaneous equations.**

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The next subject was a question of using a shield. I did not offer an opinion because it was a topic that I felt should be discussed with Les Gross. Bill Harvey got the impression that I did not know the difference between a shield and a coat-of-arms. When we returned to Frankfurt, it was suggested that I make a drawing of a shield. Normally, a shield—such as the one used on the Brooklyn-Battery Tunnel—would not be used in a tunnel as small as 6 feet. Other methods, such as poling, would be used to prevent a collapse of the tunnel roof. However, I drew an engineering plan for a 6-foot shield, and Bill Harvey later used the drawing in his request for final approval of the tunnel.<sup>4</sup>

I had my first meeting with headquarters. A short conference resulted in an agreement that a shield should be used. A shield would have the added

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<sup>4</sup> A shield is made of a steel tube slightly larger than the tunnel bore. Hydraulic jacks are fitted inside the outer rim opposite the cutting edge. The shield, supported by an external framework, is assembled in a shaft at the beginning of a tunnel. The shield then makes its first shove forward, and the face is dug out until 12 or more inches of soil have been removed. The jacks are retracted and liner plates are installed in the space uncovered when the soil is removed. The flanges of the liner plates are bolted to a reinforced concrete wall and then bolted to each other, completing the first ring of the structure of the tunnel. The shield is then moved forward for construction of the second ring.

advantage of keeping the alignment of the tunnel on course. We selected a prime contractor for the liner plates and shield, negotiated a classified contract, and work commenced.

**Assembling Men and Materials**

Working out of an office in one of the World War II temporary buildings along the Reflecting Pool near the Lincoln Memorial, Les started the process of recruiting his team. He selected Corps of Engineers officers and non-commissioned officers. He also began to look into a site out West where the liner plates and shield could be assembled for training for the up-coming real thing.

Les left the structural analysis to me. Ordinarily, earth pressure on a tunnel is figured at four points: the overhead, both sides, and the invert. This technique did not seem adequate. I spent nearly a week at the Library of Congress searching for a better way of analyzing earth pressures. I found two technical papers that offered a better approach. The papers discussed the “circuit method”

of computing earth pressures on tunnels. It was a sort of circumferential calculus. The downside was that the circuit method of calculation required solving six simultaneous equations! Perhaps this sophisticated method was a bit of overkill; however, the design assumptions called for precise planning. The tunnel not only needed to be able to withstand a dead load of 10 or more feet of soil overburden, but also had to bear a potential surcharge load—to wit, Soviet or East German 60-ton tanks riding down Schoenefelder Chausee or maneuvering around the open field above the tunnel.

While Les narrowed the search for a site to test the installation of the shield and liner plates to New Mexico, I flew back to London for a meeting with Bill Harvey. We traveled with one of Bill’s British colleagues to a location to view the operation of the vertical shield needed to gain access to the Soviet communications cables. The vertical shield was demonstrated by the British sappers who would operate it at the site. This was a process that required extreme patience and skill. During the motor trip, I suggested that as a cover for the tunnel site, we should build one or two communications stations that would exchange false traffic. This idea was met by icy stares.

**Site Preparation**

Drawing on the clandestine sources of the Berlin base, Bill Harvey decided to locate the operation in a rural area of the American Sector southwest of Berlin known as Altglienicke. The target cables—two estimated to be in good shape, and a third, in poor shape—ran in a ditch on the west side of Schoenefelder Chaussee in the Soviet Sector. The aiming point for the tunnel was about 300 yards north of a graveyard.

Tunnels are usually kept on line and grade by surveys conducted in the tunnel and on the ground above it by transits and calibrated steel tapes. A surface survey, however, was obviously inappropriate for a secret tunnel. Having no lasers, we had to use other methods.

Drawing on the best technical resources of the time, several photographic over-flights were ordered. One flight used glass plates for maximum accuracy. The glass plates were sent to the Agency's fledgling air photoanalysis unit. They conducted air-photogrammetry studies to determine distance and elevation. The engineering and geologic analysis of the other photographs showed the site to be underlain by well-drained deposits of sandy loam. There was a possibility of encountering some "perched water tables"—where a layer of impervious clay traps a small

quantity of water—but this was not considered a problem.

We also used a newly developed electronic distance measuring system (EDMS). An agent faked a flat tire on the side of the road by the aiming point. While working on the tire, he placed a small device on the hood of the car. The device received and transmitted data in the EDMS system. Thus, air photogrammetry and electronic measurement fixed the coordinates of the target cables.

Next, under the supervision of a Berlin-based Corps of Engineers unit, the requisite "warehouse" was constructed on the site, using mostly local contractors and available materials. Keeping the plans secret was a constant challenge. *Time* magazine reported that a civilian engineer had quit the construction project in disgust because the blueprints seemed crazy. "Why build a cellar big enough to drive through with a dump truck?" he asked.<sup>5</sup> Good point. Warehouses were usually built on reinforced concrete slabs poured on well-drained, compacted sub-bases. A warehouse with a basement normally would require columns and beams, which were not incorporated into our plans. Our intention was to use the basement for the storage of the excavated soil, so columns and

<sup>5</sup> *Time*, 7 May 1956.



beams ultimately would not be necessary. The civilian engineer who quit was not the only one to raise an eyebrow. The Army Chief of Engineers finally resolved the design controversy. Calling it an "experiment," he ordered the warehouse built as planned, with a basement and no columns and beams.

**From Training to Action**

The two British sappers who would play a key role in the tunnel construction were invited to the New Mexico test site to observe the operation of the shield in conjunction with the liner plates. The time had come to demobilize the test site and ship all of the equipment to Berlin. The last step was to pack up all of the unit's files—consisting of requisitions,

receipts, and disbursements—for shipment to CIA headquarters, where they were locked in a safe.

All along, Les had planned to send the equipment to a US Army Quartermaster Corps boxing facility near Richmond, Virginia, for final packing for shipment to Berlin. Now he discovered that the boxing plant was due for closure and he quickly had to negotiate a 30-day hold. At Richmond, the metal parts were sprayed with a rubberized compound to eliminate clanking as they were taken into the tunnel and assembled. We wanted to avoid any kind of cowbell chorus deep in the tunnel. The shield, liner plates, conveyor belts, and a small, battery-powered forklift were shipped to Hamburg, Germany. From Hamburg, this

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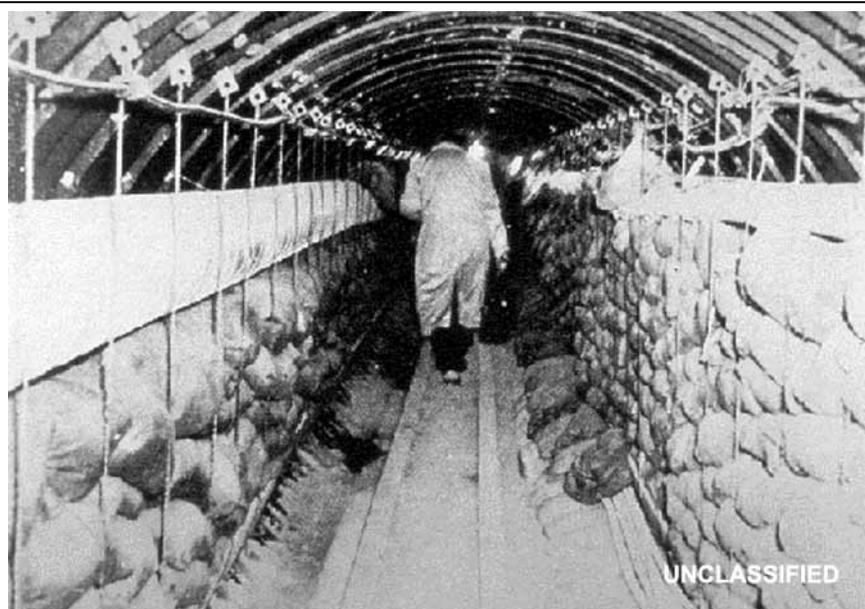
most secret cargo was transported to West Berlin on an ordinary goods train—no armed guards or security arrangements of any kind. The cargo arrived in West Berlin without incident.

The dig began in August 1954. A 10-foot-diameter vertical shaft, 10 feet deep, was excavated 15 feet inside the warehouse foundation. The shield was assembled in this shaft below the basement floor. The excavation of the tunnel

started with a sequence of push, dig, retract, assemble liner-plate ring, and repeat. An unanticipated messy problem developed about 10 feet beyond the tunnel portal when the shield passed under the leach field of the compound's sanitary system. The drainage problem was quickly solved with a pump. History does not record what was used to alleviate the odor!

The dig proceeded. A wooden-rail track was built to keep the forklift on course. About one-eighth of the spoil never left the tunnel. Sandbags were filled and stacked halfway up the sides of the finished tunnel. They were secured with steel cables and gave the tunnel cross section a T-square look. The benches formed by the sandbags were used to support and store air-conditioning ducts and power and message cables running back and forth between the equipment-room amplifiers and the Ampex recorders, which packed the first floor of the warehouse.

The operation of the shield resulted in an overcut of 2 1/2 inches. This provided space for the liner plates, but left a 1/2-inch void between the tunnel and the undisturbed earth above. This void had to be filled in order to prevent subsidence of the earth above the tunnel. About every fourth liner-plate ring had “grout plugs,” threaded cores that filled holes used for pumping grout into the void. The plugs were screwed



Tunnel interior with wooden rails for forklift and sandbag “benches” for utility lines and ventilation ducts.

out, grout under high pressure was pumped in, and then the plugs were replaced. The grout selected was called "Vollclay," a molecular composite of clay, minerals, and other ingredients. Once, a full boxcar of Vollclay disappeared between Chicago and Baltimore! It took five days for the Office of Logistics to find the shipment, but the grout reached Berlin without delaying the progress on the tunnel.

The British team of sappers started—and completed in the spring of 1955—the construction of the vertical shaft needed to gain access to the Soviet communications cables. This was the most delicate and tedious job in the entire process. The vertical shaft was carved out using a "window blind" shield: A slot was opened and about an inch of soil was

removed; then that slot was closed and the next one opened. This sequence was repeated until the target cables were reached, a process that required extreme patience and skill.

The tap of the first cable was completed in May 1955. A team of British specialists started the work of transferring the cable voice and signal circuits to the recording equipment. The full tapes were collected and sent to London and Washington.

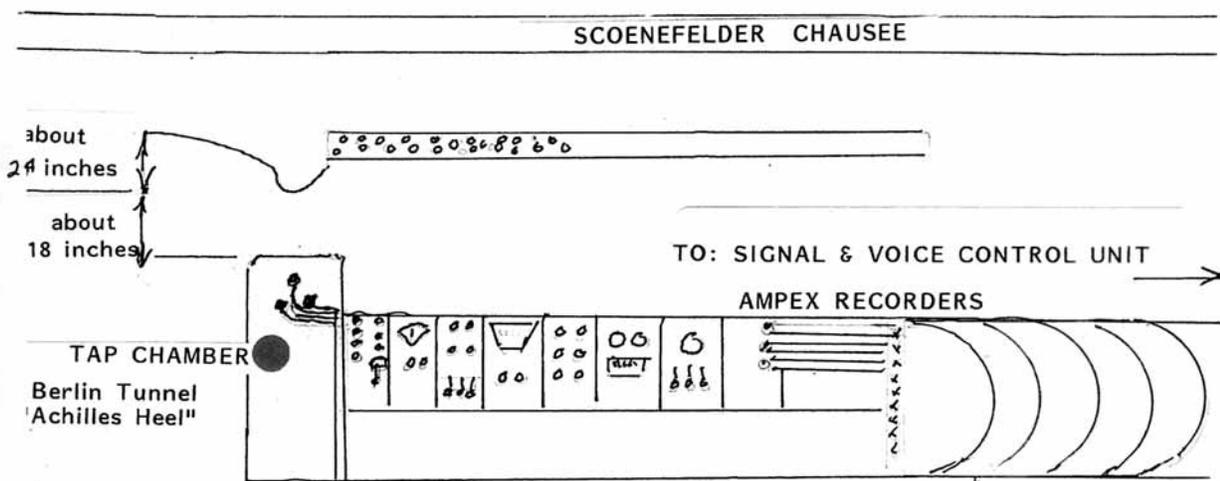
### Unexpected Development

On two occasions, I was invited to visit the tunnel site. I declined, suggesting that, without a good reason for such a visit, we might be turning the tunnel site into a tourist attraction. Then, a good reason surfaced.

The electronic equipment room, located under the roadway, was jammed with amplifiers, transformers, and tuners. All of these devices used vacuum tubes—"valves," under British nomenclature—that were high heat generators. The maximum expected heat load of these generators had been used to calculate the required level of air-conditioning. Something was wrong, however, because the temperature in the equipment room was rising.

This problem had to be solved before winter set in. Some cold morning, a frost-free black mark might appear on the roadway over the equipment room, perhaps extending into the field between the road and the warehouse, calling attention to something strange occurring below the surface. Emergency action was needed.

Author's sketch of tap chamber and amplifier room at end of tunnel. (U)



A chilled-water air-conditioning system was the only solution because there was no room for extra ducts on the sandbag benches. Such a system, including about 1500 feet of newly developed 3/4-inch plastic irrigation tubing, was shipped to the site. The tubing fitted nicely alongside the existing air ducts.

We still needed a way to monitor the temperature in and above the tunnel. With assistance from the Office of Logistics, we checked out a company in New Jersey named Wallace and Tiernan Products, Inc. Primarily a manufacturer of altimeters and surveying equipment, the company also made a remote temperature recording system consisting of sensors, a data-recording station, and connecting cables. We purchased the system and shipped it to Berlin.

As the Washington “expert,” I followed with an engineering drawing of the planned locations and elevations of the sensors that were to go into the earth above the tunnel. The first job was to install the sensors, since the plan called for statistical analysis to determine if observed differences in temperatures were random or significant. The grout plugs now had a second purpose. A number were removed and holes were drilled in each to accommodate a sensor and its cable. Eleven sensors were

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used: one in the tap chamber, four in the equipment room, three in the tunnel, and three at the tunnel portal. The tunnel portal sensors served as controls for comparative analysis. When the sensors were in place and the plugs restored and sealed, the connecting cables were run back to the entrance shaft.

The next step involved getting the cables up through the basement floor of the warehouse and connected to the recording station. This required pounding a hole through 16 inches of reinforced concrete with a star drill and hammer! It took three days before the cables were connected and operating.

The first readings showed that the temperatures in the ground above the tunnel were in general agreement with the readings from the sensors at the tunnel portal; however, temperatures in the ground over the equipment room were indeed elevated. Later, data sent to CIA headquarters showed that the temperatures

over the equipment room were dropping, almost certainly due to the supplemental cooling system.

Further monitoring of ground temperatures became irrelevant when the tunnel was discovered in late April 1956. A team of East German telephone workmen unearthed the tunnel while inspecting the cable system. That spring had been unusually wet and we had overheard numerous conversations about flooded cable vaults and the need to fix the problems and restore communications.

### Reflection

Over the years, the Berlin Tunnel project has been heatedly debated. Opinions have ranged widely—some favorable, some resentful of its success, some political, and many just plain wrong. Most of the controversy has centered on differing interpretations of net intelligence value of this costly, time-consuming, and technically challenging project. The simple truth, however, is that Leslie M. Gross and his Army Corps of Engineers staff, along with the British sappers, built the tunnel and tap chamber in SECRET!!

Hand salute, gentlemen, hand salute.

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