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VT Radio Fuse

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EARLY in the war it became apparent that surface ships of the fleet were going to get the tar knocked out of them by air attack unless some new and better defensive weapon could be cooked up. The fate of the *Arizona* and other battlewagons at Pearl Harbor, and of the British *Prince of Wales* and *Repulse*, sunk by Jap planes off Singapore, seemed like a fair sample of the destruction in store for the rest of our own and Allied warships.

VT

Existing antiaircraft weapons were good, but they were not good enough. For close-in defense, the Navy had 40-mm and 20-mm guns, but long-range defense depended on the 5-inch gun. This fired shells equipped with two types of fuses. The contact fuse exploded only on a direct hit—a good trick if you can do it—but Jap planes were damned elusive targets. The time fuse also had a basic drawback: You had to calculate distance from gun to target every time you fired, and a slight error in the fuse setting, or an unexpected maneuver of the plane, meant your shell would explode harmlessly in mid-air, too far from the target to cause any damage.

What was needed was a fuse that would automatically explode a shell as soon as it came close enough to the target to inflict damage. That meant an electronic device, small enough to fit into a shell and rugged enough to stand the terrific shock of propulsion from a gun. At the Navy's request, the Office of Scientific Research and Development had begun research on this project as early as August 1940. It was a tough job, conducted in the same absolute secrecy that characterized the atomic-bomb program.

On Jan. 5, 1943, the cruiser *Helena* knocked down a Jap plane. The crew of that aircraft never knew what hit them—but what hit them was a VT-fused projectile, the Navy's (and OSRD's) answer to the aircraft menace.

A VT ("variable time") fuse is a pint-sized, five-tubed radio, installed in the nose of a shell and capable of both sending and receiving. The radio device causes the projectile to explode if it passes anywhere within 70 feet of the target (or in other words, an area of 3,000 square feet). That means the gunner's target is enlarged 50 times and his average effectiveness increased 300 percent.

For a long time the Joint Chiefs of Staff restricted the use of the new fuse to ships firing over water, so that duds would not fall into enemy hands. The Navy would not allow VT to be used even over Pacific islands. The only indication that the Axis could have had about something new being added was the unprecedented accuracy of American gunfire at sea.

But late in 1943 Allied intelligence reports revealed that the Germans were preparing to launch robot bombs against England. By January 1944, VT fuses were being tested against mockups of the buzz bombs the Krauts were expected to use. When the V-1s were finally launched on June 12, 1944, Allied fighter planes formed the first line of defense, but VT-fused antiaircraft weapons were used when weather hampered the planes. Soon it was realized that the gunners could do better without interference from the fighters. Then all antiaircraft weapons were moved to the Channel coast, where fields of fire lay over ocean areas and bursts would not be dangerous to civilians. The result was a sensational increase in kills: from 24 percent (in the eighth week of the 80-day V-1 attack) to 79 percent (in the eleventh week). Out of 88 V-1s appearing over the English coast on the last big day of the buzz-bomb offensive, 68 were downed by VT-fused antiaircraft.

After D-Day, VT was used to protect the two artificial harbors set up off the Normandy beaches, as well as in the defense of the harbors at Cherbourg and, later on, Antwerp, which the Germans made determined efforts to destroy. But it was not until the Battle of the Bulge, in December 1944, that VT was used in land warfare—two months ahead of schedule. VT-fused shells exploded day and night, 10 to 60 feet in the air over German positions, spraying fragments over large areas and cutting down the protection of foxholes, bunkers and terrain. Kraut PWs described this new kind of fire as the most demoralizing and destructive they had ever faced. Gen. Patton called it "devastating," and the WD described the new fuse as "the most important innovation in artillery ammunition since the introduction of high-explosive shells" and "second in importance only to the atomic bomb."

The final VT victory came in the last months of the Pacific war, when the Navy used the fuse against the *kamikazes* with decisive effect. In the siege of Okinawa, the destroyers *Hadley* and *Evans* were attacked by 156 planes within an hour and a half. The *Hadley* knocked down 12 and the *Evans* accounted for 23, mostly with VT-fused 5-inch fire. Only one Jap plane taken on by the 5-inch gunners of the *Hadley* escaped undamaged. (One VT "hit" was usually enough to destroy a Jap plane, but German aircraft, more heavily armored, took two or three.)

Some of our fighter planes were also equipped with rockets fused by the VT principle. Carrying six rockets apiece, these fighters averaged one enemy plane downed for every two rockets fired within a range of 1,000 yards.

HERE's how the VT works: The shock of fire breaks a small glass vial, filled a liquid electrolyte, near the base of the fuse. Centrifugal force in the rotating projectile causes the liquid to flow toward the outside of a cylindrical cell, through a stack of thin, ring-shaped plates insulated from each other. Contact between the electrolyte and the plates instantly makes it an active wet battery, charging a firing condenser with electricity.

This electricity activates a radio vacuum tube, which sends out a continuous radio frequency signal at the speed of 186,000 miles per second. This signal will be reflected back by any target that gives a radio reflection, such as airplanes, ships or other metal objects, water or earth.

The reflected signal, received by an oscillator, interacts with the outgoing signal to create a "ripple pulse." When the projectile approaches within 70 feet of a reflecting object, the ripple pulse (amplified by audio tubes) becomes powerful enough to trigger a thyratron tube. This sets off a chain of reactions, all accomplished in a fraction of a second: Energy stored in the charged condenser is released, an electrical detonator exploded, an auxiliary ("booster") explosive charge set off, and finally the explosive filling in the projectile detonated.

Since the shell is designed to explode on making radio contact with its target, what prevents it from bursting in the muzzle itself as a result of the nearness of the gun or the ship or earth from which it was fired? The inventors took care of this danger by designing two safety switches, described below, which are not entirely released until the projectile has traveled about 400 yards at the approximate rate of 2,600 feet per second. Only then is the projectile ready to detonate.

The first of the safety devices is a flexible metal reed switch, placed in the circuit so as to keep the firing condenser discharged when the projectile is at rest. Upon firing, centrifugal force opens the switch and permits the firing condenser to charge.

The second safety device is a mercury unshorter switch, composed of two chambers: an inner one filled with mercury, which maintains an electrical short between firing condenser and case, and an outer chamber, empty prior to the shell's spinning. A porous diaphragm separates the two chambers. When the projectile starts spinning as it is fired, mercury seeps through the diaphragm into the outer chamber. This removes the short circuit and arms the projectile.

If the projectile misses its target, the reed spin switch gradually closes as the projectile's spin decreases; then, with the mercury in the outer chamber, it establishes the circuit that explodes the shell, thus preventing the projectiles from falling intact into enemy hands.