The History of the Twentieth Century
Episode 451
"Wonder Weapon"
Transcript

[music: Fanfare]

The Americans had their atomic bomb project, but the Germans were working on secret weapons, too. Hitler kept promising they'd turn the tide of the war.

Welcome to *The History of the Twentieth Century.*

[music: Opening War Theme]

Episode 451. Wonder Weapon.

Gunpowder, as I'm sure you already know, was invented in China. This happened so long ago that the where and who and how and when of it is unclear. It may have happened as early as the year 200 or so; certainly no later than the year 1000. Early gunpowder didn't explode, although it burned just fine, and one of the earliest uses of gunpowder was military: on fire arrows, which carried gunpowder to a target, where it would start a fire.

Over time, the formula for gunpowder was perfected, by which I mean this improved gunpowder not only burned, it exploded, making gunpowder history's first explosive. This gunpowder could be used in firecrackers and fireworks. It could also be used in guns, hence the name. First cannons, then smaller versions of cannons that could be carried by one person, then firearms. The word "gun" can refer to any or all of these weapons.

By the 13th century, the Chinese were using fireworks launched into the air on a rocket, propelled by gunpowder. Soon after, rockets propelled by gunpowder began to appear as a weapon of war.

In the decades that followed, gunpowder technology spread to India, the Muslim world, and Europe. The Mongols hired or forced Chinese gunpowder technicians to travel with their armies to assist in the use of gunpowder weapons. The first European to mention gunpowder in his writings was the great medieval polymath Roger Bacon in 1267.

Early rockets were cylinders made of lightweight materials, like paperboard. Burning gunpowder produced hot gases that blew out through a nozzle and propelled the rocket forward. Paperboard couldn't take much in the way of pressure, so these rockets were pretty small.

In 16th century India, they began to use iron rockets, which could be made much larger and more powerful. They also could survive getting wet, which ruined paper rockets. Even so, these rockets still had problems. They had an annoying tendency not to fly in the direction you wanted, because of inconsistencies in the gunpowder, so long wooden poles, as long as 15 feet, were attached to the rocket, which helped keep it on a straight course.

In the 18th century, the Indian Kingdom of Mysore used such rockets as weapons against the British. The British beat them anyway, but the British also took an interest in rocketry. By the early 19th century, the British had 32-pound rockets, which they used to good effect during the Napoleonic wars. Please note, for example, the phrase "the rockets' red glare," describing the 1814 Battle of Baltimore in the poem by Francis Scott Key that became the national anthem of the United States.

Back in episode 330, I explored the origins of science fiction, and in that discussion I included Jules Verne and H.G. Wells. How could I not? In 1865, Jules Verne published *From the Earth to the Moon*. Verne was by no means the first to tell a story about humans traveling to the moon—the oldest known story of this type dates back to the Roman Empire—but he was the first to tell one that includes serious consideration as to how such a feat could be accomplished. In earlier stories, trips to the moon were essentially fantasy. It was done by magic.

Verne had a practical idea for getting to the moon: build a giant cannon and use it to launch a projectile with enough force to send it to the moon and large enough to carry passengers. Interestingly, Verne imagined it would be Americans attempting this. It appears from the story that Verne thought about this carefully and calculated reasonable numbers for this project. He dealt with the part in which the cannon would launch the projectile at such a high acceleration that the passengers would be turned into jelly by ignoring it. See, that's how you write science fiction.

This Jules Verne novel inspired H.G. Wells to take a crack at a moon story himself; the result was 1901's *The First Men in the Moon*. Because this is an H.G. Wells story, it includes adventure, considers first contact between humans and intelligent extra-terrestrial life, and a hefty dose of social commentary. Wells gets his characters to the moon by hypothesizing the existence of a material that can block gravity in the same way a window shade blocks sunlight. See, that's how you write science fiction. His protagonists built a spherical spacecraft covered with shutters made of this material, and maneuvered it by opening and closing some of the shutters as needed.

By the way, Verne disapproved of the use of a made-up material in Wells' novel.

In the Russian Empire at this time, there was an intellectual movement known as cosmism, which drew from science, philosophy, and Eastern Orthodoxy to form a vision of the destiny of the human race. This vision involved advanced science and technology, space travel, immortality, and interaction with extraterrestrial civilizations.

Russian thinkers attracted to cosmism were also influenced by the works of Verne and Wells. One of these figures was Konstantin Eduardovich Tsiolkovsky. I talked about him in episode 48, which was about the development of the airplane. In that episode, I noted the coincidence that the year 1903, when the Wright Brothers flew the first heavier-than-air aircraft, was also the year the Tsiolkovsky published his most important work, titled *The Exploration of Outer Space by Means of Rocket Devices*. This was the first serious effort to describe a realistic means of escaping Earth’s gravity and traveling through space.

Tsiolkovsky identified rockets as a real-world technology capable of lifting a payload into Earth orbit and beyond and set out the formula by which one could calculate the necessary mass of fuel required to accelerate a given mass of payload to a given velocity. This equation is today known as the Tsiolkovsky rocket equation. Tsiolkovsky was not the first person to derive this equation; several others had before him. It’s child’s play, really. (That’s assuming your child can solve differential equations.) But Tsiolkovsky was the first to apply the equation to a serious calculation of what would be required to launch a rocket into space, and so he gets his name on it. He envisioned a multistage rocket powered by liquid hydrogen and liquid oxygen.

By the way, Tsiolkovsky was also the first person to envision a hovercraft and a space elevator.

Tsiolkovsky supported the Bolshevik Revolution, and afterward the new Soviet Union honored him and his work, though he was surprised and disappointed that his work got little attention from anyone outside his home country, but it did get quite a lot of attention inside his home country.

Konstantin Tsiolkovsky died in 1935, at the age of 78, but research and development into rocketry continued in the Soviet Union. In 1938, work began on what became the Katyusha multiple rocket launcher, which the Red Army put to good use during the war, and which I talked about in episode 377.

Robert Goddard was born in 1882 in Worcester, Massachusetts. He displayed an interest in science by the age of five. His family encouraged him. Goddard read *The War of the Worlds* at the age of 16, when it was first published, and began to think seriously about the prospects of a device that could make possible travel from Earth to Mars.

Goddard earned a B.S. in physics from Worcester Polytechnic in 1908, then an M.A. from Clark University in 1910 and a Ph.D. in 1911. By that time, Goddard had arrived at the conclusion that rockets offered the best hope for interplanetary travel.

In 1914, Goddard took a position as an instructor and researcher at Clark University, where he began to experiment in rocketry. This was a subject not considered serious research by many in the academic community at the time, let alone by the general public, and the shy and introverted Goddard had to deal with more than his share of ridicule and mockery. But in 1914, he filed patents describing a multi-stage rocket and a liquid fuel rocket. He pioneered liquid-fueled rockets, as well as the use of a combustion chamber in the back of the rocket. Igniting the fuel in a purpose-built combustion chamber greatly enhanced the efficiency of rockets as well as eliminating the requirement that the entire rocket needed to be built of materials strong enough to contain the combustion. Goddard also worked out that the use of the right type of nozzle behind the combustion chamber could greatly increase the velocity at which the rocket's exhaust gases escaped, up to a speed several times that of sound. He independently worked out Tsiokovsky's rocket equation and realized that the combination of greater efficiency and a much higher exhaust velocity meant that launching a payload into space was indeed feasible.

After the United States entered the First World War, Goddard tried to interest the US government and military in the wartime potential of rockets. He devised a tube-fired rocket that could be launched by one or two soldiers, a forerunner of the bazooka, and demonstrated it to the Army. Unfortunately for Goddard, but fortunately for the rest of the world, the Armistice was signed just a few days later.

In 1919, Goddard published a groundbreaking paper titled *A Method of Reaching Extreme Altitudes*, in which he described the results of his research, funded by the Smithsonian Institution, and discussed how a rocket could be used to launch a payload into space. It was the most important publication on rocketry since Tsiolkovsky's 1903 paper.

In 1920, *The New York Times* published an article dismissive of Goddard's work. The following day, the paper saw fit to publish an editorial which included these words:

That Professor Goddard, with his 'chair' in Clark College and the countenancing of the Smithsonian Institution, does not know the relation of action to reaction, and of the need to have something better than a vacuum against which to react – to say that would be absurd. Of course he only seems to lack the knowledge ladled out daily in high schools.

In other words, they were saying that a rocket would not work in the vacuum of space because the rocket exhaust would have nothing to push against. This was a frequent criticism of Goddard's work and was based on a misunderstanding of Newton's Third Law of Motion. A rocket does not need anything to push against. It is the hot gas escaping from the back of the rocket that propels the rocket forward, even in vacuum, a fact Goddard kept trying to explain to the skeptics.

Goddard launched the first liquid-fueled rocket in 1926. Between then and the US entry into the war, Goddard continued his work. Along the way, his rockets evolved into the look we associate with rockets: a smooth case with a point at the top and four tail fins. But he had difficulty with funding, especially after the Great Depression began.

Goddard’s case is the reverse of Tsiolkovsky’s. Tsiolkovsky was ignored by most everyone except in this home country, where there was great interest. Goddard’s work was largely ignored in his home country, but sparked interest abroad, especially in the Soviet Union and Germany. Intelligence agencies in both countries carefully monitored his work.

The Soviet Union already had its own researchers studying the potential of rockets, though they were happy to examine Goddard’s work and compare it to their own, which helped reassure them they were on the right track. As for Germany, there was great interest in Goddard’s work in that country as soon as the First World War was over. In 1923, Goddard predicted that rocket research in various countries would “become something in the nature of a race.” Nailed it.

The German military took an early interest in rockets. Remember that back in the Twenties, the German military was doing everything it could to evade and subvert the restrictions placed on it by the Treaty of Versailles. The Treaty placed limits on artillery, but had nothing to say about rockets, so the military investigated the use of rockets as a substitute.

On the civilian side, in 1927 a group of Germans interested in rocketry formed the Verein für Raumschiffahrt, or VfR. The name translates roughly as Space Travel Association. Among the first members was Hermann Julius Oberth, who was the German Robert Goddard.

Oberth was born in 1894, an ethnic German in Transylvania, which was then part of Hungary. He grew up speaking German, Hungarian, and Romanian. In 1905, at the age of 11, young Hermann discovered Jules Verne’s *From the Earth to the Moon*, and that was that. He built his first model rocket three years later, at the age of 14. At the age of 18, he moved to Munich in Germany to study medicine, but his studies were interrupted by the war. He served in the German Army on the Eastern Front.

In 1915, the Army assigned him to a medical unit in Transylvania. There he had enough free time to resume his work on rockets. In 1917, he tried to interest the German military in his design of a rocket with a range approaching 300 kilometers.

He married during the war, and afterward returned to Munich, now to study physics. He went to graduate school at the University of Göttingen, but the University refused to consider his doctoral dissertation because the topic was rocketry, and Oberth refused to consider changing his dissertation topic. This deadlock broke the following year when the University of Cluj in Romania invited him to bring his dissertation there. He did, and they awarded him a Ph.D. in 1923.

During the interwar period, Oberth continued to work on rockets, although he supported himself and his family by teaching math at a high school in Transylvania, now in Romania, from 1924 to 1938.

Oberth was one of the first members of the VfR in 1927, where he became mentor and inspiration to the association. In 1929, he published an expanded version of his dissertation under the title *Wege zur Raumschiffahrt*, or *Paths to Space Travel*, in which he predicted that human beings would be riding rockets into outer space within a few decades. Oberth lived long enough to travel to the Kennedy Space Center in 1969 to witness the confirmation of his prediction first-hand at the launch of Apollo 11, and again in 1985, a launch of the US Space Shuttle *Challenger* on a mission on behalf of the German Federal Republic that included two German astronauts. Oberth died in 1989, at the age of 95.

One of Oberth's assistants later said of him, "A place of honor should be reserved in the history of science and technology for his ground-breaking contributions in the field of astronautics."

The name of that assistant was Wernher von Braun.

[music: Holst, *The Planets*.]

Wernher Magnus Maxilimian Freiherr von Braun was born on March 23, 1912, in the town of Wirsitz, which then lay in the German Empire, but today is within the borders of Poland. His father was a civil servant and politician, a member of the German National People's Party, which you'll recall from our episodes on the Weimar era, was a right-wing monarchist party that allied for a time with the NSDAP before the Nazis turned on them. There's a lesson to be learned there, folks.

The elder von Braun in fact served for a few months as Germany's Minister of Agriculture under the Papen and Schleicher governments, but lost the position in January 1933 when Adolf Hitler became chancellor.

The von Braun family moved to Berlin during the First World War. Young Wernher learned the piano and the cello at an early age and had ambitions of becoming a composer. He even took lessons in composition from the German composer Paul Hindemith. Remind me to talk about him some day. In 1924, his parents gave him a telescope, which kindled in him a keen interest in astronomy. A couple of years later, when he was still a teenager, Wernher discovered Hermann Oberth's writings on rocketry. He decided then he wanted to be a rocket engineer and began intensive study of mathematics and physics, two fields he'd previously shown little interest in.

In the late Twenties, some of Oberth's students collaborated with the Opel car company in Germany to design, build, and test rocket-propelled cars. This work inspired 16-year-old Wernher to experiment on his own. He built a model car, attached to it a firework rocket, and launched it down a Berlin sidewalk. From this experiment he learned that rocket tests can attract the attention of the police and trigger paternal disciplinary action.

He joined the VfR in 1930, got his physics degree in 1932, and his doctorate in physics in 1934. By that time, von Braun's interest in rockets had already attracted the attention of the German military, which hired him to do classified research into rocketry. His first rocket design, in 1933, was named the A1. The letter A stood for *Aggregat*, the German word for aggregate. The A1 weighed 150 kilograms and stood 1.5 meters tall. It was powered by tanks of ethanol and liquid oxygen, and it was not a success, though the lessons learned were incorporated into 1934's A2, which was the same size as the A1, but with an improved design. Two A2 rockets were built; they were dubbed Max and Moritz, after the classic German tale of two exceptionally naughty boys. These two rockets reached altitudes in excess of two kilometers.

The German Army was sufficiently pleased to fund the A3. Development began in 1935, and along the way, the A3 project was moved from the outskirts of Berlin to the Army Research Center at Peenemünde, on the coast of the Baltic Sea. The A3 was much larger than its predecessors, about five times greater in weight, though like them it was fueled by ethanol and liquid oxygen and included a system of gyroscopes to keep the rocket on course. The test A3s did not stay on course and often suffered from engine failure. Ultimately, the A3 was abandoned, although the Army commander-in-chief, Werner von Fritsch, was persuaded of the potential military value of rockets and supported continuing the program.

By this time, von Braun was already at work on designing the A4, a much larger rocket intended for use as a weapon, but the failure of the A3 forced him to shelve that project until the problems with the A3 could be resolved. In late 1937, as the rocket research project grew in size and importance, von Braun was told by his superiors he needed to join the Nazi Party if he wanted to continue to be a part of it. He chose to join the Party rather than give up rocket research in November 1937. There is no evidence that von Braun's involvement with the Party went beyond paying Party dues and wearing the Party lapel pin.

In 1938, work next began on the A5, a small-scale test rocket with a redesigned engine. Adolf Hitler was invited to witness test firings of the A5 in 1939, but was not impressed, dismissing rockets as nothing more than very expensive artillery shells. Also in 1939, Robert Goddard cut off communications with German rocket researchers. Previously, Goddard had exchanged correspondence with German rocket researchers in which they discussed some of the technical issues in the German program, but Goddard ended the relationship after Germany occupied Bohemia and Moravia.

In 1940, an officer of the SS arrived at von Braun's office in Peenemünde and informed him he was there at the request of SS leader Heinrich Himmler himself to ask von Braun to join the SS. Von Braun replied that he was too busy with his rocket work. The SS officer told him it would require none of his time and Himmler urgently wished for von Braun to accept his invitation.

Von Braun asked for time to think it over, and was granted it. He consulted with his superiors in the Wehrmacht, who told him this was an Army versus SS thing. The SS very much wanted to have their "finger in the pie" of German rocket research, as they put it, and told von Braun that if he wanted to continue his work, he would be well advised to accept Himmler's invitation, which he did.

The engine problems were eventually solved, and by 1941, researchers at Peenemünde had the technology to build the A4. Prototypes were built and tests began. The first successful A4 launch took place on October 3, 1942. That rocket reached an altitude of 85 kilometers.

Von Braun and the military leadership at Peenemünde were convinced that they had reached the threshold of a whole new technological era. Their enthusiasm rubbed off on Adolf Hitler, who in December 1942 set aside his doubts and signed off on the A4 program. Provisions were made for large-scale production of the A4 and work began on selecting and developing a launch site on the Channel Coast, from which location the A4 would be capable of reaching London. It was hoped that the rocket would be ready to use by late 1943. Soon after, work began on a launch site close to England on the Channel coast of France, to maximize the range of the A4 over Britain.

In May 1943, a military committee reviewed the work on both the A4 rocket, and the Kirschkern; that was the codename for what would later be dubbed the V-1 or the "buzz bomb." The committee agreed that both weapons were nearly ready for deployment and produced a recommendation to the *Führer* that large-scale production of both weapons begin.

On July 7, 1943, von Braun traveled to the Wolf's Lair, where he showed Hitler a film of that successful A4 test last October. This time, Hitler responded with enthusiasm, ordering that the A4 project at Peenemünde be given the highest priority. He also said he regretted his earlier dismissal of the project and suggested that if Germany had had these rockets in 1939, the war would already be over.

The following month, the RAF bombed the Peenemünde site, after British intelligence was alerted to the German rocket program. I mentioned this raid in episode 400. Peenemünde was back in operation six weeks later. Buildings and facilities damaged in the bombing raid were used as camouflage to create the impression that the site had been abandoned.

Both the Kirschkern and the A4 were manufactured in underground facilities using slave labor. It was hoped that A4 rocket production could be increased to 2,000 per month, although Germany never managed more than about a third of that total. The A4 program also required expansion of facilities to produce liquid oxygen and ethanol for fuel. At its peak, the A4 program was consuming a third of Germany's entire production of ethanol.

Development of the A4 took longer than von Braun had predicted. One result of this was to make Nazi leaders sound a little foolish when their public predictions that German vengeance weapons would soon be unleashed on Britain didn't pan out.

By early 1944, Werhner von Braun was under surveillance by the SD, the intelligence agency operated by the SS. In February 1944, SS chief Heinrich Himmler summoned von Braun to a meeting, at which he suggested to von Braun that SS commander Hans Kammler, who was an engineer and who had arranged for the use of slave labor to build the A4s, be more closely involved in von Braun's rocket research. This had more to do with Himmler once again trying to get his finger in the pie. Von Braun told him that the remaining work on the A4 was merely to iron out a few technical problems and no such collaboration with Kammler would be necessary.

In March 1944, the Gestapo arrested von Braun after an SD informant overheard him express regret to some of his colleagues in the A4 program that their rocket work was being used for military purposes rather than for space exploration, especially since it appeared Germany was going to lose the war anyway. Himmler judged this sufficient reason to arrest him, though Himmler justified the arrest by making false accusations that von Braun was a Communist and that he had sabotaged the A4 program, which was the reason for the delays.

Von Braun was taken into custody and held in a Gestapo prison. He was not told what the accusations against him were. The leaders of the A4 program, including the Reichsminister for War Production Albert Speer, persuaded Hitler that von Braun was indispensible to the A4 program and that he should be released and reinstated.

In April 1944, as the Allies were ramping up their bombing raids in France, the British government requested attacks on the sites the Germans had constructed along the Channel coast of France for launching the Kirschkern and the A4 against England. In June, shortly after the Normandy invasion, the Germans began launching the Kirschkern missiles, now designated V-1, against targets in England. Allied bombings of the launch sites continued.

In the case of the A4, Allied bombing did enough damage to the newly constructed launch sites to persuade the Germans to launch A4s from mobile launchers. These mobile launchers proved sufficient to launch the rockets and to avoid Allied bombers.

German V-1 launches from France ended in early September when the Canadian Third Infantry Division reached the launch sites. Future V-1 attacks would be launched from German aircraft. In the autumn of 1944, American researchers reverse-engineered the V-1 from parts recovered from attacks on England. The United States began production of its own version of the V-1 and contemplated using it against Japan.

When the V-1 launches ended, it left some British military leaders scratching their heads. What happened to the other German secret weapon, the A4 rocket? It didn't take long to get an answer. Just days later, the Germans launched the first two rockets, now designated V-2, as in "second vengeance weapon," against Paris, which was by this time in Allied hands. Both rockets were a failure, but the following day, a V-2 successfully reached Paris, doing some minor damage, while two others struck London, killing three civilians.

The V-1, the buzz bomb, made a sound as it approached, which gave people on the ground some warning. The V-1 could be intercepted by a fighter plane or shot down by anti-aircraft guns. But the V-2 was an entirely different kind of weapon. When it fell from the sky on its final descent, it moved at Mach 3, that is, three times the speed of sound, which meant there was no warning whatsoever before the missile exploded. Countermeasures were impossible. No fighter plane, no antiaircraft gun, had any hope of disabling a V-2 before it reached its target.

The British government kept the attacks secret, blaming the mysterious explosions in London on gas mains. It was only in November, after the Germans publicly announced the V-2 attacks, that Winston Churchill reported to Parliament that Britain had been under German rocket attack for the past two months.

I've already told you that by 1944 the RAF had Typhoon fighter-bombers equipped with antitank rockets. These were small, unguided solid-fuel rockets, simple but effective. Germany was also experimenting with unguided air-to-air and ground to air rockets. The year 1944 also saw the deployment of the Me 163 Komet, or Comet, the world's first, and so far only, rocket-powered fighter plane. The Komet had remarkable capabilities. It could fly at speeds approaching the speed of sound, but it couldn't carry much fuel, only enough for a few minutes of powered flight. Allied fighter pilots soon realized the secret to downing a Comet was to wait until those few minutes were over, then attack the plane as it went into an unpowered descent for landing.

The Comet used hydrazine hydrate for fuel, which was expensive to manufacture and dangerous to handle, which limited its availability and limited the Comet's value to the German war effort.

The V-1 missile is generally regarded as a success. They were relatively cheap to build. Nearly 2,500 of them reached London, killing around 6,000 people and injuring 18,000. That works out to about 2.5 people killed and 7 wounded per missile.

The V-2, on the other hand, was much more expensive. Relative to the size of the German economy, the Germans spent as many resources developing the V-2 as the Americans did on the atomic bomb project. About 1,400 V-2s struck London, killing around 2,700 people and injuring 6,500. That works out to about 2 people killed and 4.6 wounded per missile, making the V-2 not even as effective as the much cheaper and simpler V-1.

An English analyst working for the RAF named Freeman Dyson remarked after the war that the RAF was grateful for the V-2. Each V-2 rocket cost as much as a fighter plane and yet they had a negligible effect on the war, while the Luftwaffe was in desperate need of fighters to counter Allied air supremacy over Europe.

Ultimately, the V-2 had little effect on the war, but its development would have a huge impact on the post-war world. But that is a story for another episode.

We'll have to stop there for today. I thank you for listening, and I'd like to thank Amy and Morgan for their kind donations, and thank you to Michael for becoming a patron of the podcast. Donors and patrons like Amy, Morgan, and Michael help cover the costs of making this show, which in turn keeps the podcast available free for everyone always, so my thanks to them and to all of you who have pitched in and helped out. If you'd like to become a patron or make a donation, you are most welcome; just visit the website, historyofthetwentiethcentury.com and click on the PayPal or Patreon buttons.

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And I hope you'll join me next week, here on *The History of the Twentieth Century*, as we take a look at African-American civilians in the United States, and how their lives were shaped by the war. The Double V, next week, here, on *The History of the Twentieth Century*.

Oh, and one more thing. V-1, V-2, you might be wondering if there were any more wonder weapons under consideration in Germany. There were. The V-3 was almost completed. The V-3 was a very long artillery gun, its barrel in a fixed position, typically running up a hillside, that used multiple charges along the length of the barrel to accelerate an artillery shell to a very high speed. The Germans hoped to develop this technology until it could launch shells from France that would land in England. Early testing was underway in spring of 1944, but the RAF bombed the guns in July and the Canadians overran the site in September, and that was the end of the V-3.

There was no weapon designated V-4 during the war, but after the war, commentators have applied the designation V-4 retroactively to several German secret projects, including atomic research, a long-range battlefield rocket known as Rheinbote, and the A9 rocket. The A9 was a bigger, more powerful version of the A4 or V-2, with two stages and a projected range of 5,000 kilometers, enough to reach the East Coast of North America. It was developed under the code name Projekt Amerika. Real subtle.

The war ended before the A9 project got very far.

[music: Closing War Theme]