From Horse Cavalry to Moon Rocket..Pt 1

The story of one of the 20th Century's Great Rocket Pioneers: Konrad Dannenberg (1912 – 2009)

Konrad Dannenberg, or Konnie as he is known to his friends, is as sharp as a tack, even though when I met him for this interview he had just celebrated his 95th birthday.

Perhaps *because* he had just celebrated it!

I visited the renowned von Braun team member at his elegant home in the Huntsville suburbs. Meeting Dannenberg in this comfortable suburban American utopia belies the fact that this man was a key player in some of the greatest stories and adventures of the 20th century.

He was born in the year 1912 in Prussian Saxony Germany, but grew up and later studied in Hannover. In 1928 the famed Austrian rocket engineer Max Valier (Pronounced Waleer) made a visit and gave a speech in Hanover. At the time Valier (who was working with the lesser known Willie Ley) was demonstrating how rockets could be utilized on cars, planes and bikes. (Maybe an earlier version of Tim Pickens). At the lecture, which Dannenberg attended, Valier proposed that a trip to Mars could be undertaken using rocket propulsion. This caught Dannenberg's attention and lead to a lifelong pursuit and interest in propulsion technologies.

At the University of Hannover Konrad studied mechanical engineering, but specialized in auto design and construction as well as in diesel fuel injection systems, a very useful discipline when later he would be called on to design rocket engines. He joined a rocket club which included Albert Pullenberg as a member, a friendship that would lead to great changes in Dannenberg's life.

In 1939 he was drafted into the Wehrmacht and served in the mounted cavalry during Hitler's invasion and subsequent occupation of France. It's possible to imagine that given Konrad's expertise in diesel engines, the cavalry unit he should be posted to would have been an armored one such as the Panzer Korps, but when I say mounted cavalry, I mean of the four legged kind. Yes horses were still used during WWII. The Diesel engineer was literally pulling horses around by the nose.

Konrad had maintained a written friendship with Pullenberg during the opening year of the war, this relationship proved to be fortuitous when Pullenberg went to work for General Dornberger who had been tasked with rocket development in the top secret advanced weapons programs that the Nazi high command had deemed necessary for the war effort. Pullenberg mentioned the young diesel engineers capabilities to the general and said that his skills could be very useful.

Strings were pulled, as they so often are in the armed forces and Konrad was transferred to Peenemunde on the Baltic coast. It hadn't been a difficult transfer as the commanding officer in the cavalry unit that Konrad served in stated that he was the only member of his unit that couldn't ride a horse. "You can have him" was the curt reply.

So in 1940 Konrad the engineer found himself in the midst of one of the wars most secret places, developing technologies that would lead to the first landing of men on the moon less than 30 years later.

Peenemünde

Initially most liquid fueled rocket engines designed in Germany during WWII were to be powered ostensibly by Gasoline and Liquid Oxygen (LOX), but the war had meant that supplies of gasoline were extremely limited and therefore design was pushed towards use of Ethyl Alcohol + LOX engines. In one respect this was a helpful move because alcohol burns at a cooler temperature than gasoline and heat transfer was a great difficulty to early designers of high performance rocket engines. However as any good rocket designer will tell you, higher temperatures usually translate into higher exhaust velocities and therefore higher thrust numbers, so there were always trade-offs in the ultimate design of the V2 rocket.

Konrad arrived after the basic design of the V2 (A4) engine had been decided, but the engineering problems were only just beginning. Konrad’s expertise in diesel ignition meant that his talents were much in demand. Diesel engines need a powerful pump, a high ignition pressure and temperature as well as a fine disbursement of the fuel into the ignition chamber. All of these were similar types of problems that faced the rocket engine team.

The original engines were being developed to produce a 25 ton thrust. The reason for this size was down to a calculation that General Dornberger himself had produced. Dornberger knew that the rockets couldn’t be launched from deep within Germany if they were to hit London. The rockets and their launchers would need to be located close to the north European coast in order to hit the main target, which was of course in Great Britain just across the English Channel. This meant that the whole rocket and launch platform had to be mobile and would need to fit in tunnels and under bridges on the roads and railroads. The railroad access dictated the maximum size that the rocket could be. This size required an engine with a 25 ton thrust.

Nothing on this scale had ever been attempted before and the challenge brought with it many technical engineering problems that needed to be solved, not the least of which was actually igniting the engine.

In smaller liquid fueled rockets, the fuel and oxidizer would normally be fed into the combustion chamber by applying pressure into the propellant tanks. (Plus a little help from gravity) This was all that was needed to ensure that the right amount of fuel and oxidizer was fed into the combustion chamber. But when an engine has to provide 25 tons of thrust, then large quantities of propellants need to be forced into the combustion chamber by turbo pumps. (Remember the more mass you can throw out of the combustion chamber, the more thrust you achieve) One of the first problems encountered in this kind of turbo fed system is that too much fuel would be pumped into the combustion chamber before proper ignition had occurred. This invariably lead to an over pressure explosion in the combustion chamber which destroyed the engine. The answer to this was to stage the ignition sequence.

Konrad was very much involved in the ignition testing of the A4 engine on its 1.4 ton test stand at Peenemünde. The method used to tackle the ignition problem was ingenious, but as in all subsequent rocket engine development, required copious testing on the stand. First the propellant tanks were pressurized, once the fuel valves were opened this allowed a low flow of propellants into the combustion chamber without the assistance of the turbo pumps; this was called the pre-stage. At this point the propellants entered the combustion chamber under relatively low pressure. To ignite the propellants a small wooden cross tipped with solid rocket fuel was inserted through the throat of the chamber. The solid fuel was electrically ignited as the fuel started to be sprayed into the combustion chamber. The cross would quickly spin up like a Catherine wheel firework and ignite the fuel spray. (You can see something similar under the main Space Shuttle engines when they first ignite, this spray of flame is to ensure that no gases coming out of the combustion chamber are not ignited, hence causing a possible explosion) Once the team saw a good flame coming out of the nozzle, they would turn on the turbo pumps electrically. Within a second the rocket would be running at its designated thrust and the burn became self sustaining. As you can tell, answers came in all shapes and sizes to the questions being asked by this very innovative high tech program.

Other substantial engineering problems had to be overcome, including heat transfer. Once the engineers had managed to get the engines to run for longer, they found out that even the fairly well cooled A4 engine could not cope with the combustion heat. Many developments had to be quickly worked in this area. The solution was to inject low pressure fuel into the wall of the combustion chamber and flow it around the expansion chamber in small vents. This basically solved the overheating problem. Some of these vents were simple expansion joints because the A4 had a fairly thick combustion chamber. Another problem was that the chamber became hot and the thick steel expanded. This issue needed serious attention. Problems with feed line expansion and contraction depending on LOX (cooling and contracting) and the fuel (heating and expanding) meant that much experimentation had to be done in this area. The engineers had tried expansion bellows but this was problematic under high pressure. That's why eventually they wrapped the fuel lines around the chamber. They had to run many tests and then had to deal with metal fatigue from the expansion/contraction issue. These problems took many months to address and to engineer solutions to the problems.
The rocket chamber was made of the best steel available at the time; not stainless because Nickel was in short supply, adding a little chromium made the best steel possible in the circumstances. (Beryllium was also not available during the war)
The upper injection chambers were initially made of aluminum to save weight but this meant having to invest in a heavy flange which weighed more than the weight saving, so they went back to steel injectors because welding aluminum to steel was a new technology back then. (In fact Aluminum to Iron welding was another technology developed at Peenemünde) Welding the whole combustion chamber of steel was more efficient. Much work was initiated on many different aluminum alloys to be able to handle the temperature and to be light and strong.

Shortly after Konrad arrived at Peenemünde, the air war over Great Britain had been lost to the RAF. It was because of this fact that Hitler had turned his attention and more resources towards the secret weapons development at Peenemünde and elsewhere, which he turned over to the army's control. Because the army now had control of the program more funds were made available and leaders such as Wernher von Braun understood that in order to create the A4, they had to dance to the Army's song. However, even with the Army's control of the project, funds were limited for obvious reasons, namely that Hitler was fighting a war on the Eastern front by this time. It wasn't until the night of August 17/18th 1943 that Hitler finally realized how important the long range rocket program was. On that night the RAF executed Operation Crossbow, which was the strategic bombing of the test facilities and housing at Peenemünde. Their primary objective was to kill as many personnel involved in the research and development of the V-weapons as possible by bombing the workers' quarters. The secondary objectives were to render the research facility useless and "*destroy as much of the V-weapons related work and documentation as possible"* On this night many workers and some scientists involved in the program were killed, including the Germans top chemist, Walter Thiel.

Thiel had been one of the top scientists at Kummersdorf just south of Berlin, where prior to the war, much of the work on liquid rockets had been developed. It was his initial contention that the fuel for the A4 should be a storable hypergolic (spontaneous combustion) as had been used in the Wasserfall, surface to air missile. *Thiel's design was based on Visol (vinyl isobutyl ether) and SV-Stoff, (Red fuming Nitric Acid) or Salpeter, (90% nitric acid, 10% sulfuric acid). This hypergolic mixture was forced into the combustion chamber by pressurizing the fuel tanks with nitrogen gas released from another tank.(Credit Wikipedia)* Thiel had initially tried to move the A4 towards stored propellants but von Braun and his idea for cryogenic (cooled) propellants had prevailed.

(It was at this point in the interview with Konrad that he commented on Jeff Sheerin's clever design to use high pressure fuel tanks instead of turbo pumps on the Canadian Arrow.)

Immediately after the bombing raid, Hitler froze the design of the A4 and moved production of the finished design to the Mittelwerks facility, built inside a mountain near Nordhausen in Germany. It had been argued that such a complex machine as the A4 could never be built by unskilled labour. But much to the credit of the slave labour being used at the Mittelwerks who worked under appalling and inhuman conditions and some of whom were brave enough to sabotage parts of the production process, this was not the case and soon thousands of V2's were rolling off the production lines. The finished product ran its combustion chamber at about 3000°C with an internal running pressure of approximately 30 atmospheres or about 450psi, an incredible engineering feat.

The V2 went on to become a much feared weapon in England and Northern Europe. It carried a one ton high explosive warhead, with a range of up to 500 miles. When it impacted its target it was traveling at supersonic speeds and was reentering the atmosphere from space. There was no defense, no warning, a large explosion was followed by the roar of the vehicle after it had arrived. It was indeed a terror weapon of the first degree. Thankfully it entered the war too late to be of any great significance to the wars outcome.

By Richard Godwin

To be continued Part two – America and the moon.