

Air and Space this Week

Item of the Week

Robert Goddard and the First Liquid-Fuel Rocket

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Rockets using gunpowder or some other solid fuel had been known for many centuries before Robert Goddard came along. But solid fuel had some characteristics that made it unattractive when building really large rockets, say, big enough to go to the Moon or Mars. It was heavy, and once started, couldn't be turned off. Robert Goddard knew that liquid fuel, and oxygen in a liquid form, would give the necessary oomph.

Robert H. Goddard was fascinated as a boy by the accomplishments of the Wright Brothers and dreams of flying to Mars. He began experimenting with gunpowder rockets as a student at WPI (then a part of Clark University). He quickly realized that gunpowder was inadequate for making a rocket big and powerful enough to reach high into the atmosphere, let alone the Moon or Mars. He also realized, as did others at the time, that no fuel was powerful enough to lift all of its tankage as its fuel and oxidizer was expended, a "stepped rocket" would be needed.

Rockets design to work in Space, unlike airplanes, have to have both fuel AND oxygen. Goddard knew that any metal tank that could hold oxygen under high pressure would be much too heavy to lift. But what if oxygen in its very cold, liquid state could be used instead?

Goddard's initial research resulted in **two U.S. patents**; one for a liquid-fuel rocket and another for a multi-stage solid-fuel rocket. Goddard's work was self-funded, at first. Nobody seemed to be taking much of an interest in rocketry and his experiments. By 1915, he was considering walking away from rocketry. But he kept at it.

Goddard wrote to the Smithsonian Institution in September, 1916, providing a description of his work to date, and requesting funding so he could continue his research. The official handling the request was intrigued, and recommended it be funded to SI Secretary Charles D. Walcott, who agreed. The Secretary granted Goddard \$5000 from the Institution's Hodgkins Fund for Atmospheric Research (the possibility of rockets carrying meteorological instruments to high altitude was the motivation).

[Walcott was a big believer in funding smaller research projects that might otherwise have trouble attracting sponsors; he left a bequest that to this day provides seed money for research of this type. One grant recipient and I informally named a rock hill near Danby Dry Lake in the Mojave, "Wally's Knob," in recognition of his largesse. Will his honors ever cease?]

The results of the work supported by the Smithsonian published its Miscellaneous Publication Number 2540 in January, 1920, entitled, "A Method of Reaching Extreme Altitudes." Most of

the report was a straightforward recitation of how the grant money was spent, a plan to use rockets for high-altitude meteorological research, and Goddard's derivation of the mathematics of rocket propulsion. But in his closing remarks, Goddard speculated about sending a rocket to the Moon, proving its arrival with an explosion of flash powder when it hit. Goddard was always secretive about his research (as had been the Wrights), and asked the Smithsonian not make his report public.

Well, the press got wind of his remarks about sending a rocket to the Moon. Instead of excitement over the potential of Goddard's work, the press, including the *New York Times*, heaped tons of scorn and ridicule down upon him. He never forgave the media, and never trusted them at all, to the detriment of rocketry's development. But he kept at it.

Goddard's test rocket built on his liquid-fuel concept reflected his understanding of rocket stability. If he put the tankage atop the combustion chamber, the rocket would need fins for stability, but if he put the combustion chamber on top, and that tankage below, the rocket would be stable (as long as the rocket exhaust didn't ignite the fuel/oxidizer tanks!).

On **March 16**, 1926, Goddard tested his liquid-fueled rocket. You can see it in the images in the links below, but recognize that the rocket is the central part, surrounded by a non-flying frame to hold it upright before firing (the first "gantry!"). It worked, reaching an altitude of all of 41 feet before crashing back to Earth, damaged beyond repair. He salvaged what he could from the wreckage. He (likely) used the combustion chamber nozzle on one of his follow-up test rockets, two months later, now part of the collection of the National Air and Space Museum. The test launch site, in Auburn, MA, is now a National Historic Site.

Goddard kept launching rockets in Auburn, with the final one going up on July 17, 1929. It was an important milestone, the first time that a rocket carried a scientific payload, in this case, a barometer and a camera. The rocket involved was heavier and louder than those previous, and its noise sparked several comical emergency calls and a lot of negative local publicity.

Rocketry was getting serious interest from a number of quarters now. The Smithsonian gave him another grant, and additional funds from the Guggenheim Foundation, under the recommendation of Charles Lindbergh, also came through.

The media (and his neighbors) may have given Goddard a hard time, but the notion of rockets in Outer Space would become a staple of 1930's pulp fiction and moviedom (e.g. *Flash Gordon*, *Buck Rogers*, and the *King of the Rocket Men*). And at least some of the public was captivated by the idea of travel by rockets, and several important rocket societies were founded around this time.

The additional funding allowed Goddard to leave Massachusetts, at what would become the White Sands Proving Grounds, where he could launch to his heart's content, away from the press and annoyed neighbors. There he made a lot of progress in rocketry and its ancillary technologies. At first, the military and the public were not particularly interested. Too bad, because he was laying the groundwork for the new technology, but he wasn't the only one.

Valentine Tsiolkovsky in Russia, and Hermann Oberth in Germany, were also big believers in rocketry. Oberth was listened to, and he motivated a lot of technology advances in the buildup to WWII, and the leadership listened. Sad to say, any war is the catalyst for rapid technological advancement, and most of the advances in new-generation propulsion and rocketry were made by the Germans.

Goddard died on August 10, 1945. The technical successes of the Nazi rocket scientists, and the growing concerns of the post-WWII/Cold War era, made rocketry “cool again.” Goddard got a lot of belated recognition, since it was impossible to develop rocketry technology without acknowledging his accomplishments (he had 214 important patents related to rocketry either in-hand or in the pipeline when he died). He’s now known as the “Father of American Rocketry,” and he, Tsiolkovsky, and Oberth are recognized as the “Fathers of Rocketry.”

Congress struck a gold medal in Goddard’s honor on September 16, 1959, and NASA’s Goddard Space Flight Center was dedicated on March 16, 1961, 35 years to the day after that first liquid-fuel rocket flew. And when *Apollo 11* launched to the Moon in July, 1969, the *New York Times* (finally) published a formal retraction of their earlier stories ridiculing Goddard’s concept of using rockets to reach the Moon! While that gave the departed Goddard little comfort, we can find comfort in his famous response to a snotty reporter’s questions about rockets to the Moon, “Every vision is a joke until the first man accomplishes it, once realized it becomes commonplace.” Apart from needing to update “man” to “person,” that’s something to remember.

For more information, see:

http://pioneersofflight.si.edu/culture/rocket_societies

https://www.nasa.gov/centers/goddard/about/history/dr_goddard.html

https://airandspace.si.edu/collection-objects/goddard-may-1926-rocket/nasm_A19850176000

<https://airandspace.si.edu/stories/editorial/robert-goddard-and-first-liquid-propellant-rocket>

<https://apod.nasa.gov/apod/ap010316.html>

<https://www.nps.gov/articles/goddard-rocket-launching-site.htm>

<https://siarchives.si.edu/history/featured-topics/stories/robert-h-goddard-american-rocket-pioneer>

Konstantin Tsiolkovsky:

<https://www.nasa.gov/audience/foreducators/rocketry/home/konstantin-tsiolkovsky.html>

Hermann Oberth: <https://www.nasa.gov/audience/foreducators/rocketry/home/hermann-oberth.html>

Several biographies have been written about Goddard, including:

Clary, David A., 2004, *Rocket Man: Robert H. Goddard and the Birth of the Space Age*, ISBN-13: 978-0786887057

Streissguth, Thomas, 1995, *Rocket Man: The Story of Robert Goddard*, ASIN: B01FGL7W3A

West, Doug, 2017, *Dr. Robert H. Goddard – A Brief Biography*, ISBN-13: 978-1548246334

Fulton, Kristen, 2018, *When Sparks Fly: The True Story of Robert Goddard, the Father of US Rocketry*, (for younger readers), ISBN-13: 978-1481460989

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