ISSUE 44

APOGEE

PEAK OF FLIGHT

NEWSLETTER

75 Years Ago this Week

By Peter Alway

On October 19, 1899, a seventeen year old devotee of science fiction climbed a cherry tree in his family's orchard. As he set to trim its branches, he was overcome by a powerful fantasy: a great whirligig of a machine that would one day transport him to Mars. This dream would possess Robert H. Goddard for the rest of his life.

As he progressed through his education in physics, Goddard realized that clever spinning perpetual motion machines would get him nowhere. By the time he started teaching at Clark University, in Massachusetts, Goddard recognized that rockets were the only way into space. He resolved to apply physics to the problem of the space rocket.

His contributions included the application of the de Laval nozzle (borrowed from the steam turbine) to the rocket, which allowed him to create the most efficient rockets of the time, using available solid propellants (this innovation is used today in all chemical rockets save the cheapest fireworks).

He also demonstrated that rockets were not only capable of propulsion in the vacuum of space, but that they even performed better in a vacuum (this demonstration of Newton's Third Law earned him the derision of the New York Times for making claims contrary to the basic science every child learned in school).

At the end of World War I, Goddard demonstrated his rockets to the US Army, in the form of a weapon that would eventually become the Bazooka. But the Army showed little interest.

Goddard published his work to date in the 1920 Smithsonian monograph "A Method of Reaching Extreme Altitudes." Meant as a proposal for atmospheric sounding rockets, it brought Goddard into the headlines with a calculation showing the possibility of a rocket carrying a load of flash powder to the Moon. Overnight, Goddard was transformed from an obscure physics professor to a celebrity mad scientist.

Goddard felt a solid fueled rocket could reach space if if three improvements were made. First, he replaced the crude nozzles of existing fireworks with deLaval nozzles. He then replaced the ancient Chinese gunpowder with a solid grain of "double base" propellant made of nitroglycerine and nitrocellulose, also known as "smokeless powder." These two changes alone increased exhaust velocity by a factor of six.

But the explosive propellant could only be contained by a heavy, thick-walled combustion chamber. A chamber big enough to hold a space rocket's entire fuel supply would be so heavy as to make space travel impossible.

Goddard concluded that by firing chunks of propellant into the rocket's combustion chamber machine-gun style, he could build a lightweight rocket. Goddard managed to fly such a rocket, but mechanical problems led him to drop the idea in 1921.

Goddard, like Tsiolkovsky concluded that space travel would require liquid propellant rockets. Unlike the Russian, he took action.

With funding from the Smithsonian Institution, Goddard, tested gasoline/liquid oxygen rocket engines, re-designed, and re-tested. Finally, on March 16 1926, Goddard lugged a liquid propellant rocket to his Aunt Effie's cabbage patch, his wife, Esther Goddard, bringing still and movie cameras.

Goddard's rocket was a simple affair. At the top was a combustion chamber equipped with a de Laval nozzle. Liquid oxygen (LOX) and gasoline flowed up from tanks at the base of the rocket through two asbestos-wrapped steel tubes. An asbestos-wrapped cone shielded the LOX tank from the engine's flame.

Goddard's machinist, Henry Sachs, lit a torch and held it to a pyrotechnic igniter protruding from the top of the combustion chamber. Once smoke poured from the chamber, he lit an alcohol burner under the oxygen tank. The pressure of the boiling liquid oxygen would force both oxygen and gasoline up into the combustion chamber.

A small smokeless flame issued from the nozzle, but the

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rocket remained motionless. Esther's movie camera ran down. Then, as Robert put it, the rocket decided "I think I'll get the hell out of here." It reached an altitude of 41 feet (12.3 m), and crashed into the snow 184 feet (55 m) away. Modern rocketry was born.

Goddard made three more flights in Auburn, Massachusetts, but in 1929, when the roar and crash of the fourth rocket was reported as a plane crash, the state fire marshal ended the tests. The news reports that stopped the flights were not entirely bad - They came to the attention of aviation hero Charles Lindbergh, who had crossed the Atlantic Ocean solo just two years earlier. With his access to the rich and famous, Lindbergh persuaded the Guggenheim family to fund Goddard's work.

Goddard moved out to Roswell, New Mexico to continue the tests. The Roswell rockets, built with the engines and stabilizing fins at the rear, would probe problems of propulsion, guidance, control, and recovery.

Goddard launched several gyroscope stabilized rockets. Typically, Goddard mounted a 4" (10 cm)-diameter gyroscope on gimbals in the rocket. They gyroscope maintained its orientation, so if the rocket deviated from vertical, it would close electrical contacts on the gimbals. Current through these contacts would trigger small electromagnets which would open pneumatic valves. Gas pressure in bellows would then move rods that forces small vanes into the rocket exhaust as needed to right the rocket. Some rockets also carried air vanes, either attached to the blast vanes or actuated separately.

Goddard's "Movable Casing Rocket," featured gimballed engine that swiveled up to 2.5x without loss of thrust. The whole tail section moved with the engine, adding fin deflection to the control mechanism. Most modern liquid-propelled rockets feature gimballed engines, but goddard dropped the idea as too complex.

Most of Goddard's rockets forced propellants into the engines with gas pressure. This system required a large, heavy, high-pressure tank that limited altitude. Goddard's projects culminated in a pump-fed rocket. Small turbines powered centrifugal pumps that supplied gasoline and oxygen to the engine. This design was remarkable in that it incorporated every element of a modern liquid-propelled rocket. Unfortunately, WW II interrupted his work before he perfected the design. One of his pump-fed rockets stands in the National Air and Space Museum, alongside a replica of his first liquid-propelled rocket.

Goddard spent the war working on Jet Assisted Take-Off (JATO) for Navy aircraft, but when his rocket set a plane on fire, this work stopped. In August of 1945, after a lifetime of frail health, Robert Goddard died.

Goddard left over 200 patents, many filed by Esther after Robert's death. By the time of his death, Goddard had invented nearly every component of a functional space launch booster. But so had Wernher von Braun's V-2 group in Germany. Frank Malina and his JPL group would fly their independently created Wac Corporal sounding rocket within a month. Because of his secrecy, Goddard forced others to independently repeat much of his invention and discovery. His real impact on rocket development is debatable. But it's not debatable that 75 years ago, Robert Hutchings Goddard was the first to launch a liquid-fueled rocket.

Author Information:

Peter Alway
Saturn Press
PO Box 3709
Ann Arbor, MI 48106-3709
http://members.aol.com/satrnpress/saturn.htm

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