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Goddard Launches the First Liquid Fuel Propelled Rocket

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GODDARD LAUNCHES THE FIRST LIQUID FUEL PROPELLED ROCKET

Categories of event: Space and aviation
Time: March 16, 1926
Locale: Auburn, Massachusetts

Using liquid oxygen and gasoline as fuels, Goddard pioneered the first practical liquid fuel rocket, setting the stage for future developments in modern rocketry

Principal personage:

ROBERT H. GODDARD (1882-1945), a physics professor who is considered a pioneer in modern astronautics and was the first to develop a liquid fuel rocket motor

Summary of Event

Just as the conquest of the air had its twentieth century origins with the rather inauspicious trials in 1903 of the Wright brothers at Kittyhawk, North Carolina, so too the seemingly insurmountable obstacle of space flight had its humble beginnings with the initial test of Robert H. Goddard's liquid-fueled rocket in an Auburn, Massachusetts, cabbage patch on March 16, 1926. On that clear and cold day, with snow still on the ground, Goddard successfully launched a 3-meter-long rocket using liquid oxygen and gasoline as propellants; the projectile's flight lasted only two and one-half seconds, during which it rose a mere 12 meters and landed approximately 56 meters away from its fabricated pipe launching frame.

Although successful, the rocket's design was unwieldy and inefficient. Initially, Goddard had maintained that greater stability would be achieved by placing the motor and nozzles ahead of the fuel tanks, layout analogous to a horse and buggy. Subsequently, this arrangement was changed when it became obvious that the motor needed to be positioned at the rear of the rocket's body. Although Goddard had been working on various pumps for several years to control the flow of the reactants to the combustion chamber, neither pumps nor an electrical system were incorporated in the first liquid-fueled rocket prototype. By turning a valve and placing an alcohol stove beneath the motor, Clark University machinist Henry Sacks ignited the propellants before dashing for safety, while Goddard and colleague Percy Roope, standing behind an iron barrier, cautiously watched the experiment.

Yet, despite the improvised apparatus and rustic scene, this pivotal episode in the history of technology changed the future course of history. Not only did it firmly establish Goddard as the leading rocket theoretician and experimentalist between World Wars I and II, but also the success of a liquid-fueled rocket laid the groundwork for enhanced financial support from both the Smithsonian Institution and the Guggenheim Foundation.

Astute observers aware of Goddard's accomplishment now recognized that the liquid fuel rocket had enormous potential for the investigation of high-altitude phenomena, for possible travel in space, and as a weapon in modern warfare. While Goddard shunned publicity and continued to refine his designs for the next fifteen years, innovating in areas of guidance systems, motors, flight controls, and instrumentation, other workers in the United States, Russia, and Germany quickly followed in Goddard's footsteps. This activity was clearly reflected and demonstrated in Nazi Germany, for the V-2 rocket contained many of Goddard's designs and ideas.

Goddard's achievement of March, 1926, was not the result of amateurish dilettantism, but rather the culmination of a lifelong interest in rockets and the possibilities of space travel that was grounded in theoretical and experimental science. Growing up in New England, Goddard first speculated about rockets and space travel at age seventeen. Undoubtedly stimulated by reading H. G. Wells's *The War of the Worlds* (1898) and Garrett P. Serviss' *Edison's Conquest of Mars* (1898), he submitted a manuscript outlining his ideas on the possibilities of traveling through a near vacuum in 1907 to several scientific journals. Undeterred by the essay's subsequent rejection, Goddard began to formulate ideas concerning the use of liquid fuels in 1909, and after completing his Ph.D. in physics at Clark University and a postdoctoral fellowship at Princeton University, he began to pursue experimental work. Convinced that Sir Isaac Newton's third law was the basis of motion in space, he demonstrated that a gun recoiled in a vacuum when fired. At first, Goddard worked with solid fuel rocket designs. During World War I, he pursued investigations at the Mount Wilson Observatory in California, where he evaluated both black powder and smokeless powder as propellants. His practical efforts led to the development of the bazooka—a weapon that was used extensively during World War II—as well as bombardment and antiaircraft rockets. Nevertheless, these inventions were never used in the battlefield during World War I, as American involvement in the conflict ended in November, 1918. Goddard's extensive World War I weapons development experience convinced him that high nozzle velocities of combustible reactants were central to the design of a successful interplanetary rocket and, therefore, that solid materials were intrinsically limited in this crucial chemical characteristic when compared to the enormous potential of combustible liquids.

After World War I, Goddard returned to Clark University and formulated a coherent research program. By 1920, he had concluded that a liquid-fuel rocket motor, with its inherently smooth thrust, had the potential and was perhaps the most effective means of reaching the upper atmosphere and ultimately the reaches of space. In part, the development of his idea required further theorizing, yet experimental studies were also necessary. Central to Goddard's success was an uncanny ability to combine or hybridize knowledge from chemistry, physics, and the engineering sciences, with the express purpose of designing a workable rocket design. As no other contemporary, he had the ability to combine theory with practice.

Clearly, the most efficient fuel from a thermodynamic standpoint was hydrogen; acting as an oxidizer, oxygen possessed distinct advantages. Although difficulties in handling hydrogen forced Goddard to consider such alternatives as propane, ether, kerosene, and gasoline, he remained wedded to the notion of using liquid oxygen, even though it was hard to obtain locally and was extremely dangerous, since it boiled at −148 degrees Celsius and exploded upon contact with oils, greases, and flames. Within a short time, Goddard found a source for liquid oxygen at a local plant, and he pursued a number of static tests at the laboratory bench to measure the thrust produced by the expansion of reactant fuels during combustion. Self-contained pressure pumps also needed to be constructed; for several years prior to the momentous March, 1926, test flight, Goddard and assistant Nils Riffolt were occupied with this difficult problem. Pump design became so vexing, and external pressures to demonstrate the potential of his work to the Smithsonian Institution and other patrons so great, that at the end of 1925, Goddard, despite the inefficiency of this arrangement, resorted to the use of inert gas back pressure to feed the reactants.

Goddard's efforts between 1920 and 1925 involved "string and sealing wax" equipment and little financial assistance. Riffolt provided valuable technical expertise in the design of various pumps and motors, and Goddard's wife Esther assisted in numerous ways, including photographing various trials. Clark University had granted Goddard research funds at a critical juncture in 1923; but by 1925, internal funding was in short supply, and requests for money from the Smithsonian Institution were typically denied. Given the circumstances, Goddard was determined to test his ideas in early 1926, and his unqualified success in Auburn, Massachusetts, not only changed his career but also set the stage for an intense phase of experimental rocketry both in the United States and in Europe.

Impact of Event

Described as secretive and a loner, Goddard avoided attention despite the newsworthiness of the 1926 event. Always content to work within the scientific community's "invisible college" rather than act as a self-serving promoter, Goddard refused to cash in on his work by cultivating broader constituencies. Further small-scale tests incorporating technical refinements continued during the next three years. On July 17, 1929, Goddard launched a rocket with an instrument payload that included an aneroid barometer, thermometer, and recording camera. The noisy crash of this missile, uproar on the part of local officials concerning public safety, and Goddard's own pronouncements about the possibilities of such a liquid-fueled rocket striking the moon made *The New York Times*, thereby generating considerable public reaction. Aviation hero Charles A. Lindbergh learned of Goddard's work, and Lindbergh's considerable influence enabled Goddard to receive grants from both the Carnegie Institution and the Guggenheim Foundation.

By mid-1930, Goddard and a small group of assistants had organized a more sophisticated, full-time research program at a site near Roswell, New Mexico. Drawing on his newfound financial resources, Goddard made significant advances in almost every aspect of astronautics between 1930 and 1941. His work culminated with the 1941 launching of a rocket to an altitude of 2,700 meters. Gyrocontrol improvements, including linking a gyroscope to small movable vanes located directly in the exhaust blast, greatly enhanced flight stability. Further advances in the design of clustered engines, gimbal mounted tail sections, and turbine-driven propellant pumps were also worked out at this time.

Concurrently, interest in rocketry intensified both in the United States and abroad. By the late 1920's and early 1930's, members of the American Rocket Society and the German Society for Space Travel sustained a technical momentum that Goddard had initiated in the period before World War I. With the onset of World War II, investigations in rocket technology became high priorities within emerging American and German military-industrial complexes.

Germany's success with its V-2 rocket was a direct consequence of Goddard's scientific and technical achievements, and the V-2 program seemingly called into question Goddard's ability to organize a large-scale effort and fully exploit his ideas. Goddard's ideas were not brought to complete fruition in the United States during his lifetime. Nevertheless, Goddard remains as modern rocketry's foremost pioneer, a scientist who had vision, theoretical understanding, and the gift to translate these ideas into a viable technology.

Bibliography

Goddard, Robert H. *The Papers of Robert H. Goddard*. Edited by Esther C. Goddard. 3 vols. New York: McGraw-Hill, 1970. A most important resource for any serious student of Goddard and the history of rocketry, these edited papers contain summaries of Goddard's diary entries, reprints of noteworthy technical papers, and relevant correspondence among important members within the scientific community. As primary source material, this collection provides the reader with an intimate glimpse into the world of the distinguished Clark University professor and scientist, clearly and chronologically outlining the evolution of Goddard's ideas and techniques.

Hacker, Barton C. "Robert H. Goddard and the Origins of Space Flight." In *Technology in America: A History of Individuals and Ideas*, edited by Carroll W. Pursell, Jr. Cambridge, Mass.: MIT Press, 1981. In this brief essay, Hacker not only traces Goddard's career but also characterizes the institutional context surrounding his achievements. Despite popular notions concerning Goddard as a solitary, persevering scientific figure, the Smithsonian Institution, the Guggenheim Foundation, and the military played crucial roles in Goddard's ultimate success.

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Pendray, G. Edward. "Pioneer Rocket Development in the United States." In *The History of Rocket Technology: Essays on Research, Development, and Utility*, edited by Eugene M. Emme. Detroit: Wayne State University Press, 1964. Written by a pioneer in the development of rockets in America and an individual intimately knowledgeable of Goddard's scientific and technical work, this essay briefly and succinctly sketches Goddard's major accomplishments in astronautics.

Von Braun, Wernher, and Frederick I. Ordway III. *Space Travel: A History*. 4th ed. New York: Harper & Row, 1985. Perhaps the best single-volume history on human's conquest of space, von Braun and Ordway thoroughly discuss the scientific and technical contributions of Konstantin Tsiolkovsky, Hermann Oberth, and Goddard in a chapter entitled "The Pioneers of Space Travel." Containing a large number of remarkable photographs and an excellent bibliography, the book concisely summarizes Goddard's work both in Massachusetts and New Mexico by using an extensive chronological timeline that describes Goddard's static and in-flight investigations.

Williams, Beryl, and Samuel Epstein. *The Rocket Pioneers: On the Road to Space*. New York: Julian Messner, 1958. This easy-to-read historical study includes chapters on Sir William Congreve, Konstantin Tsiolkovsky, Herman Oberth, and Goddard. Well researched and written, the authors clearly describe Goddard's key technological innovations within the context of his lengthy scientific career.

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Cross-References

Tsiolkovsky Proposes That Liquid Oxygen Be Used for Space Travel (1903), p. 189; The Germans Use the V-1 Flying Bomb and the V-2 Goes into Production (1944), p. 1235.