

*Dr. Robert H. Goddard — 100th
Anniversary October 5, 1882 - 1982*



NASA

National Aeronautics and
Space Administration

Goddard Space Flight Center
Greenbelt, Maryland

REMEMBERING ROBERT GODDARD

Today, on the 100th anniversary of his birth, Robert Goddard is accorded an honored place in the history of the space age. It is a place richly earned by the man rightfully called the Wilbur and Orville Wright of space travel, the father of modern rocketry.

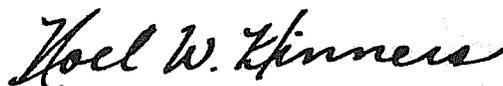
As a measure of the esteem in which Dr. Goddard has come to be held, NASA named its first new facility after Robert Goddard when it was built in 1961. That facility is the Goddard Space Flight Center in Greenbelt, Maryland, and today it is the development home of most of America's civil unmanned satellites.

We who work at the Goddard Space Flight Center are proud to preserve Robert Goddard's name and even prouder to continue his legacy. His life was an inspiring example of the truth that if we set ourselves a goal, there are no boundaries to what can be achieved.

Robert Goddard's goal was set 17 years after he was born in Worcester, Massachusetts, in 1882. He was trimming branches high up in a tree when he had a fantastic thought. As an avid reader of the science fiction of his day--H.G. Wells, Jules Verne--he had often dreamed of travelling to Mars. Suddenly, he decided he would build a vehicle to go there. Goddard called this moment of conviction his second "birthday," and noted its anniversary for years afterward in his diary. The rest of his life is simply the story of his efforts to build a rocket that could go to the planets.

Needless to say, Robert Goddard was unable to build the rocket he envisioned before he died in 1945. But he came remarkably close. His most powerful rockets travelled faster than the speed of sound and reached an altitude of almost 2 miles. Even now, rocket designers find themselves frequently referring to concepts and patents he originated.

Who can say how the space age may have evolved when, 100 years from today, our descendents celebrate the bi-centennial of Robert Goddard's birth? If we hold true to his example, we can be assured the future will be remarkable.



Noel W. Hinners
Director

In retrospect

The father of modern rocket propulsion is the American, Dr. Robert Hutchings Goddard. Along with Ziolkovsky of Russia and Oberth of Germany, Goddard envisioned the exploration of space. A physicist of great insight, Goddard also had a unique genius for invention.

By 1926, Goddard had constructed and tested successfully the first rocket using liquid fuel. Indeed, the flight of Goddard's rocket on March 16, 1926, at Auburn, Massachusetts, was a feat as epochal in history as that of the Wright brothers at Kitty Hawk. Yet, it was one of Goddard's "firsts" in the now booming significance of rocket propulsion in the fields of military missilery and the scientific exploration of space.

Primitive in its day as the achievement of the Wrights', Goddard's rocket successes made little impression upon government officials. Only through the modest subsidies of the Smithsonian Institution and the Daniel Guggenheim Foundation, as well as the leaves of absence granted him by Worcester Polytechnic Institute of Clark University, was Goddard able to sustain his lifetime of devoted research and testing. He worked for the U.S. Navy in both World Wars. Eighteen years after his successful demonstration at Auburn, Goddard's pioneering achievements came to life in the German V-2 ballistic missile.

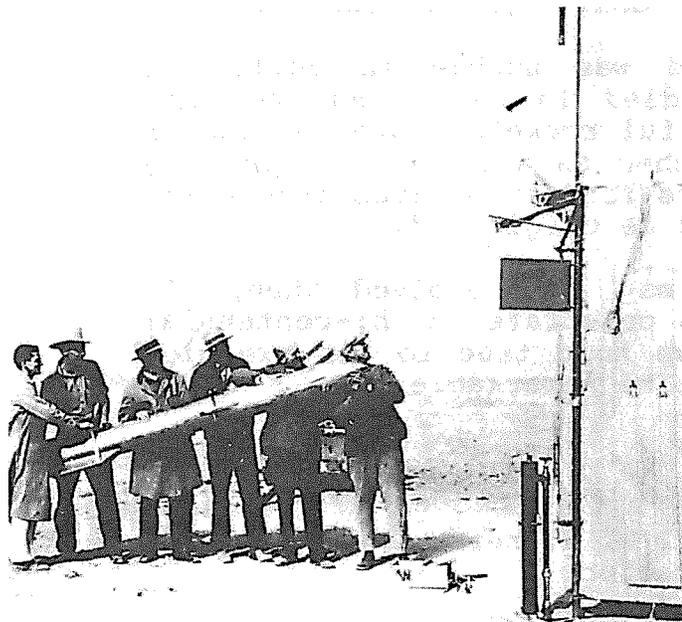
Goddard first obtained public notice in 1907 in a cloud of smoke from a powder rocket fired in the basement of the physics building at Worcester Polytechnic Institute. School officials took an immediate interest in the work of student Goddard. They, to their credit, did not expel him. He thus began his lifetime of dedicated work.



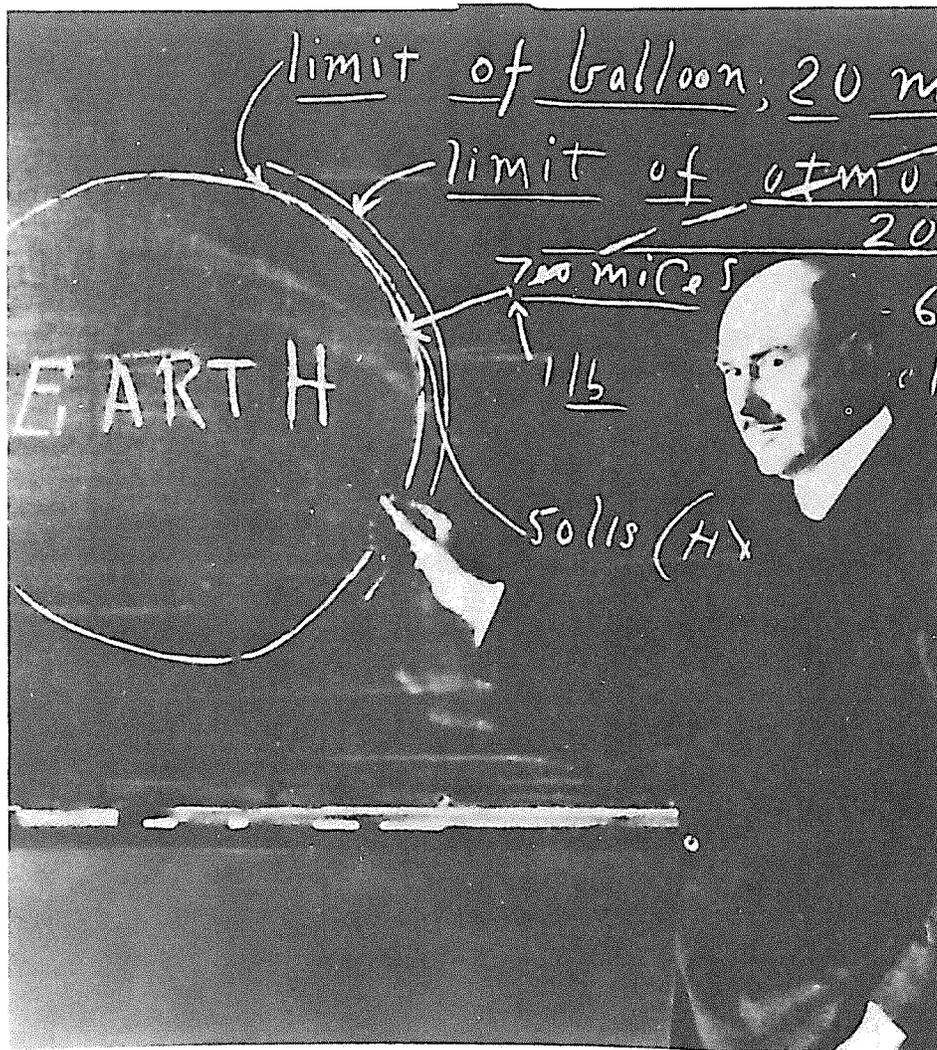
Dr. Robert H. Goddard making adjustments at the upper end of the rocket combustion chamber.

In 1914, Goddard received two U.S. patents. One was for a rocket using liquid fuel. The other was for a two- or three-step rocket using solid fuel. At his own expense, he began to make systematic studies about propulsion provided by various types of gunpowder. His classic document was a study which he wrote in 1916 requesting funds of the Smithsonian Institution so that he could continue his research. This was later published along with his subsequent researches and Navy work in a Smithsonian Miscellaneous Publication No. 2540 (January 1920). It was entitled "A Method of Reaching Extreme Altitudes." In this treatise, he detailed his search for methods of raising weather recording instruments higher than sounding balloons. In this search, as he related, he developed the mathematical theories of rocket propulsion.

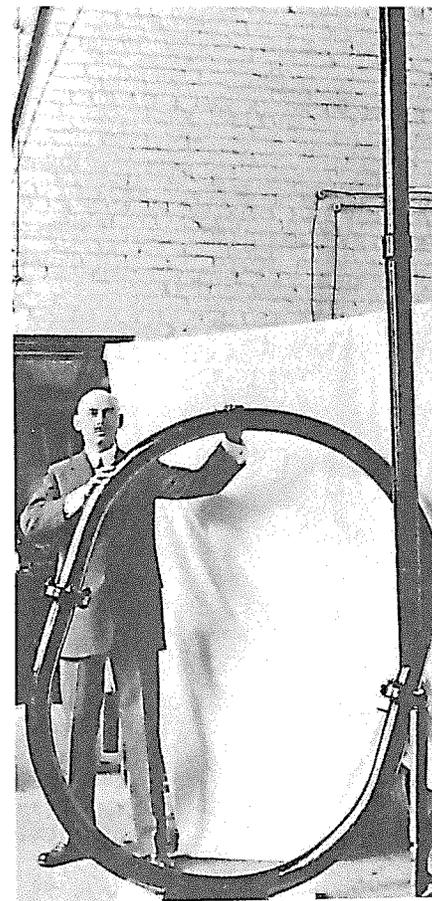
Towards the end of his 1920 report, Goddard discussed the possibility of a rocket reaching the moon and exploding a load of flash powder there to mark its arrival. The bulk of his scientific report to the Smithsonian was a dry explanation of how he used the \$5000 grant in his research. Yet the press picked up Goddard's scientific proposal about a rocket flight to the moon and erected a journalistic controversy concerning the feasibility of such a thing. Much ridicule came Goddard's way. And, he reached firm convictions about the virtues of the press corps which he held for the rest of his life. Yet several score of the 1750 copies of the 1920 Smithsonian report reached Europe. The German Rocket Society was formed in 1927, while the German army began its rocket program in 1931.



Dr. Goddard (second from right) and assistants placing the rocket used in the October 27, 1931 test in the tower.



Dr. Goddard at blackboard, Clark University, 1924.



Dr. Goddard with a circular vacuum tube used to prove rocket efficiency greater in a vacuum than in air.

Goddard's greatest engineering contributions were made during his work in the 1920's and 1930's (see list of historic firsts). He received a total of \$10,000 from the Smithsonian by 1927, and through the personal efforts of Charles A. Lindbergh he subsequently received financial support from the Daniel and Florence Guggenheim Foundation. Short of funds between grants, the Smithsonian later came through with another grant. Progress on all of his work was published in "Liquid Propellant Rocket Development," which was published by the Smithsonian in 1936. What modest subsidy supported the nascent efforts of Dr. Goddard which created a multi-billion dollar industry and brought forth the enormous potentialities of long-range missiles, earth satellites, and space flight?

Goddard's work largely anticipated in technical detail the later German V-2 missiles, including gyroscopic control, steering by means of vanes in the jet stream of the rocket motor, gimbal-steering, power-driven fuel pumps and other devices. His rocket flight in 1929 carried the first scientific payload, a barometer, and a camera. Goddard developed and demonstrated the basic idea of the "bazooka" two days before the Armistice in 1918 at the Aberdeen Proving Ground. His launching platform was a music rack. Dr. Clarence N. Hickman, a young Ph.D. from Clark

University, worked with Goddard in 1918, and provided continuity to the research that produced the World War II bazooka. In World War II, Goddard again offered his services and was assigned by the U.S. Navy to the development of practical jet assisted takeoff (JATO) and liquid propellant rocket motors capable of variable thrust. In both areas he was successful. He died on August 10, 1945, four days after the first atomic bomb was dropped on Japan.

Goddard was the first scientist who not only realized the potentialities of missiles and space flight but also contributed directly in bringing them to practical realization. This rare talent in both creative science and practical engineering places Goddard well above the opposite-numbers among the European rocket pioneers. The dedicated labors of this modest man went largely unrecognized in the United States until the dawn of what is now called the "space age." High honors and wide acclaim, belated but richly deserved, now come to the name of Robert H. Goddard.

On September 16, 1959, the 86th Congress authorized the issuance of a gold medal in the honor of Professor Robert H. Goddard.

In memory of the brilliant scientist, a major space science laboratory, NASA's Goddard Space Flight Center, Greenbelt, Maryland, was established on May 1, 1959.

GODDARD'S HISTORIC FIRSTS

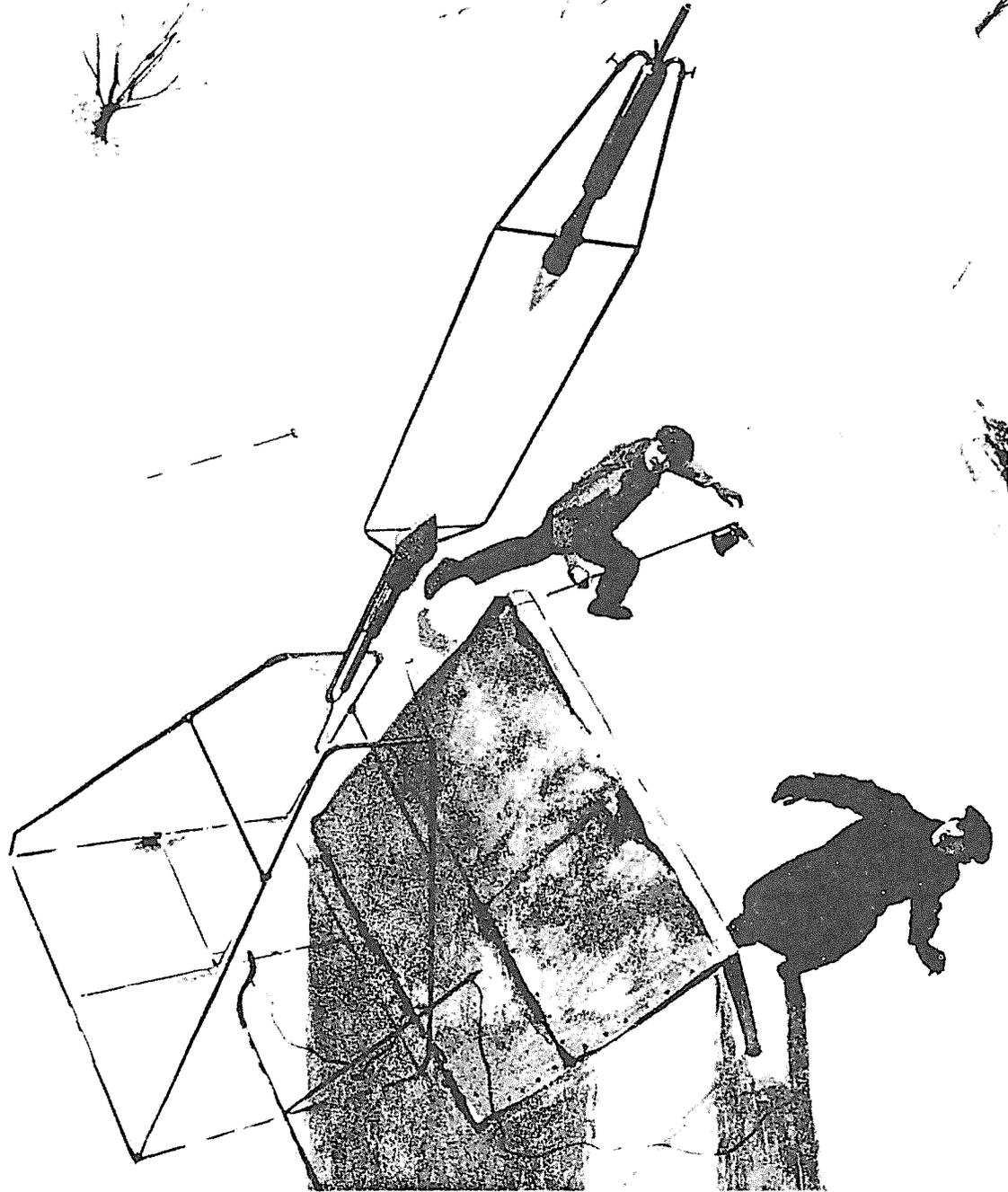
Robert H. Goddard's basic contribution to missile and space flight is a lengthy list. As such, it is an eloquent testimonial to his lifetime of work in establishing and demonstrating the fundamental principles of rocket propulsion.

- First explored mathematically the practicality of using rocket propulsion to reach high altitudes and to shoot to the moon (1912)
- First proved, by actual static test, that a rocket will work in a vacuum, that it needs no air to push against
- First developed and shot a liquid fuel rocket, March 16, 1926
- First shot a scientific payload (barometer and camera) in a rocket flight (1929, Auburn, Mass.)
- First shot a liquid-fuel rocket faster than the speed of sound (1935, near Roswell, New Mexico)
- First used vanes in the rocket motor blast for guidance (1932, New Mexico)
- First developed gyro control apparatus for rocket flight (1932, New Mexico)
- First received U.S. patent on idea of multi-stage rockets (1914)
- First developed pumps suitable for rocket fuels
- First launched successfully a rocket with a motor pivoted in gimbals under the influence of a gyro mechanism (1937)

BIOGRAPHICAL DATA

- Born:** Worcester, Massachusetts, October 5, 1882
- Died:** August 10, 1945
- Education:** B.S. Degree, Worcester Polytechnic Institute, 1908; M.A., Clark University, 1910; Ph.D., Clark University, 1911
- Academic Career:** Instructor of Physics, Worcester Polytechnic Institute, 1910-1911; student at Princeton University, 1914-1915; Assistant Professor, 1915-1919; full Professor at Clark after 1919

HOW IT WORKED



MARCH 16, 1926
THE FIRST LIQUID FUEL ROCKET

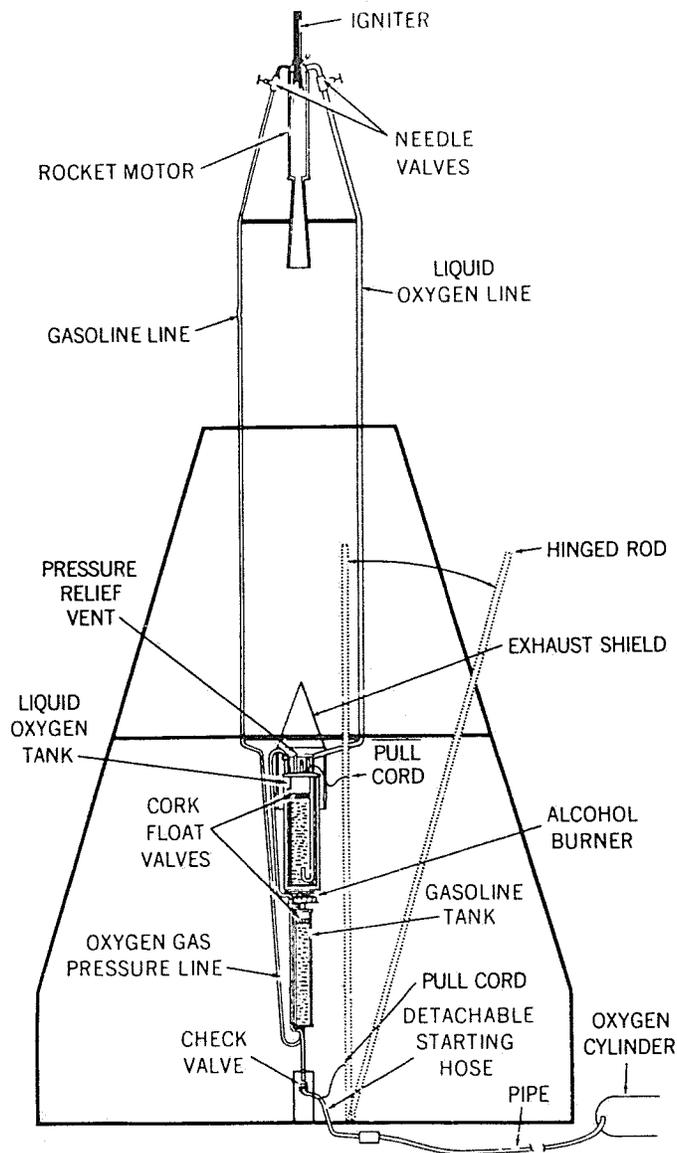


Figure 1
Dr. Goddard's 1926 Rocket

BACKGROUND

For hundreds of years man lived with the deficiencies of the solid, gunpowder-type rocket developed by the Chinese in the 13th century. So too, for a while, did Dr. Robert H. Goddard, the New England physics professor and American rocket pioneer.

As early as 1909, however, Goddard considered the idea of a liquid fuel rocket utilizing hydrogen and oxygen. In his studies he recognized that solid fuels produced a lower exhaust velocity than could be obtained by the use of liquid fuels.

After 17 years of theoretical and experimental work, Dr. Goddard finally achieved flight of a liquid-fueled rocket on March 16, 1926. The manner in which that rocket worked is described here.

TECHNICAL PROBLEMS

A liquid fuel requires a continuous source of oxidizer to be able to burn at a rate capable of producing the rocket thrust desired. A means for combining the fuel and the oxidizer at the proper rates in the combustion chamber had to be developed. The high pressures created by combustion required that the fuel and oxidizer be injected into the chamber under even higher pressure.

NOVEL USE OF LOX

After a number of design attempts, Dr. Goddard finally chose gasoline as the fuel and liquid oxygen (lox) as the oxidizer. Below -297°F . oxygen is a liquid at atmospheric pressures. At higher temperatures it vaporizes, and produces tremendous pressures in closed containers. Dr. Goddard used the pressure of this gas to push both liquids simultaneously from their tanks, through separate pipes, to the combustion chamber where they mixed and burned. To speed the vaporizing of the lox, he applied heat with an alcohol burner.

The photograph shows Dr. Goddard with this rocket. Figure 1 points out the rocket's main features.

MECHANICAL INGENUITY

There was a pipe connection for the pressurizing gas between the lox tank and the gasoline tank. Safety required that neither liquid should pass through this pipe and mix with the other before entering the combustion chamber. Figure 1 shows the cork floats Dr. Goddard used to minimize sloshing of liquid into the pipe, but still allow gas to flow. Once

the rocket left the ground, this gas pressure would be the only means for pumping fuel and oxidizer.

Before launch, however, it was necessary to pressurize the system from an oxygen cylinder located about 30 feet from the rocket. Heavy rubber tubing fed the oxygen into the rocket's pressure line. As the rocket began to rise, this hose had to be pulled free. The resulting opening was rigged with a flap check valve to slam shut and prevent loss of pressure.

The combustion chamber was equipped with an igniter system containing match heads and black gunpowder to provide the starting fire for ignition of the lox and gasoline when they were forced into the combustion chamber (Figure 2).

THE LAUNCH

Only a few steps were necessary in the countdown and launch. First, an assistant using a blowtorch on a long pole reached up and heated the igniter casing until the enclosed match heads caught fire and ignited the black powder. He then closed the pressure relief vent on the lox tank (Fig. 3) and quickly lighted the alcohol-soaked cotton in the burner. Next, Dr. Goddard piped oxygen from the cylinder to the propellant tanks at 90 pounds per square inch pressure. This forced gasoline and lox to the combustion chamber, where the igniter was still burning. With a loud roar, the rocket motor fired. When the rocket motor's thrust exceeded the weight, it rose a few inches from the ground, tethered only by the hose. With a long rope, Dr. Goddard pulled a hinged rod that yanked the hose away, and the rocket was free to fly (Fig. 1). The swing of this rod also unseated a spring-loaded valve (Fig. 3), allowing lox to drip into the heated chamber surrounding the lox tank. Here the lox flashed into vapor, and the resulting gas pressure fed the liquids to the combustion chamber.

THE FLIGHT

After $2\frac{1}{2}$ seconds of flight, the fuel was expended, the roar ceased abruptly, and the rocket fell to earth 185 feet away. It had reached an estimated speed of 60 miles per hour and height of 41 feet.

This was the world's first liquid fuel rocket flight, an event considered comparable in its significance to the Wright Brothers' achievement of manned flight at Kitty Hawk.

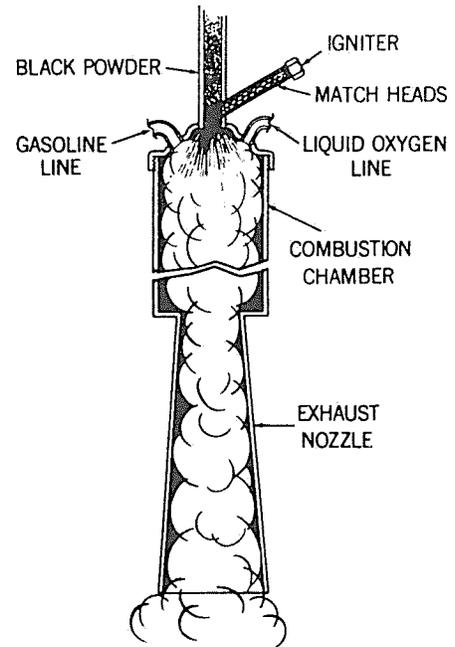


Figure 2
Igniter and Rocket Motor

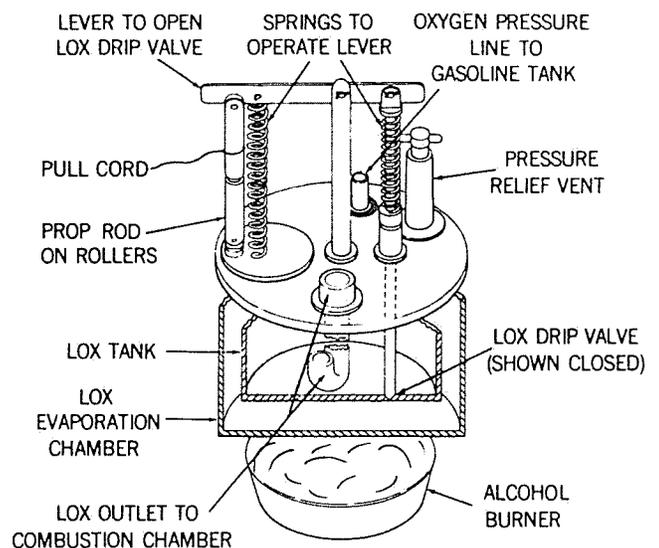


Figure 3
Liquid Oxygen Tank