Early Rocketry and Rocket Propellant Part 2

America - Robert Hutchings Goddard
Theory becomes practice

Whilst the lonely theorists in Russia, Germany and France were producing their feats of theory a researcher in America was engaged in work which offered the prospect of practical success.

From an early age Robert Goddard had been fascinated by the upper atmosphere and the idea of investigating what was happening up there by sending sounding rockets up into the stratosphere and ionosphere.

What differentiated him from the theorists was the fact that as well at being adept at theory he also had great mechanical ability which he was able to turn to building experimental rockets in his own laboratory.

After gaining a doctorate whilst holding a research fellowship at Princeton University, he made extensive calculations and concluded that a rocket with a practicable fuel load could take a light load of instruments to great heights.

The first breakthrough came when he confirmed by practical experiment in a combustion chamber he had built that a rocket needs no air to push against it and would in fact develop more thrust when fired in an airless space, a vacuum.

At this point Goddard, by now an Assistant Professor, in 1916 wrote a report which was specifically directed to obtaining funding for an actual rocket. In it he set out his calculations, including demonstrating the determination of velocity, and therefore how high the rocket will go before its fuel is consumed, based on mass ratio and exhaust speed. For the highest altitudes, drawing on the practice in existing life saving rockets he advanced the idea of the step rocket with a second stage being set off as the first reached its peak velocity. At this juncture Goddard's interest was confined to carrying meteorological instruments to heights greater than those being achieved by current sounding balloons. He was deeply interested in space travel but this prospect was beyond his theory at that time.

His report went the rounds of various scientific foundations without success until it reached the Smithsonian Institution in Washington. Here fortune favoured him and the Institution agreed the sum he requested, to be paid in stages as the project progressed.

Goddard's first action was to research a better combustion chamber for a dry fuelled rocket. The alternative was liquid fuel but this was considered impracticable. In order to achieve a steady thrust he concluded that the fuel would be stored separately from the combustion chamber, to be fed in at a predetermined rate, easier said than done. By then it was 1917, America was entering the War and the US Government was funding military research, including a grant to Goddard for the study of rockets as weapons. He was enabled to transfer his workshop to the Mount Wilson Observatory at Pasadena, California. As assistants he took with him two graduate students, C.N. Hickman and H.S. Parker. Almost 30 years later this was to have momentous consequences for Hickman and American rocketry.

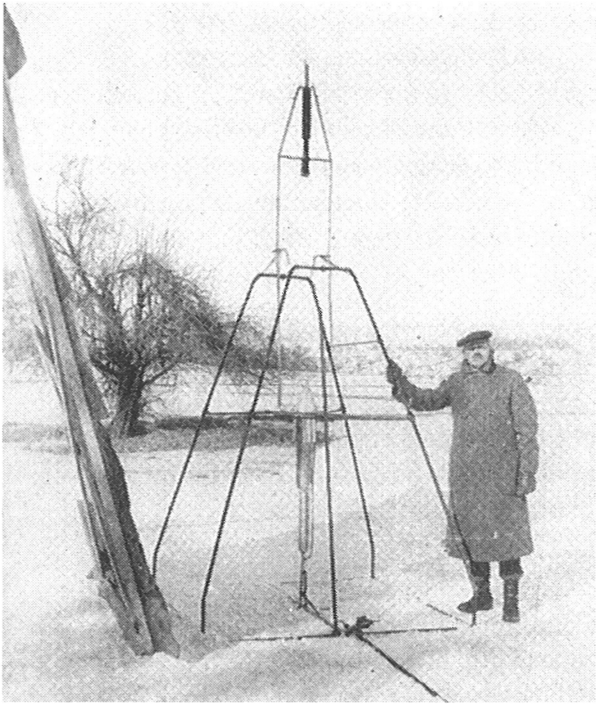
A first model was built, feeding pellets of dry fuel into the combustion chamber in a kind of machine gun action, designed to be fired from a gun like a shell. This was found to be too complicated for military use. A second was produced, eighteen inches long, this time a short range weapon propelled by a solid stick of dynamite type fuel, designed to be fired from a light launching tube. The idea worked and was the basis for the standard US infantry anti-tank weapon of WW2. WW1 ended. The Government decided not to pursue rocketry studies and Goddard returned to his civilian experimentation. In 1920 he produced a further report. This had several crucial features – proof that rockets operate at greater efficiency in a partial vacuum, a description of mechanisms for feeding dry charges into the combustion chamber, tables showing starting weights to achieve heights over 400 miles and momentously for the first time including calculations demonstrating that a step rocket could attain a velocity high enough to escape the earth's gravity and ' fall onto the moon '.

Goddard was still encountering problems with the mechanism for feeding dry charges and he turned to the possibility of liquid fuel. This would require a separate oxygen source. He settled on liquid oxygen with petrol as fuel. To force these into the combustion chamber would require pressure. After two false starts he devised a system in which an 'alcohol stove ' boiled the oxygen to produce pressure.

World's first liquid fuelled rocket ascent

On 16th March 1926 Goddard took his trial rocket to a field on the farm of Miss Effie Ward at Auburn, Massachusetts. It had a two foot motor and overall with fuel tanks was ten feet high. To ignite the motor involved turning on the oxygen and fuel taps and applying a blowlamp to the top of the rocket. Judiciously attaching the blowlamp to a pole, Goddard ignited the motor. The rocket surged upwards with a roar. Two and a half seconds later its fuel was exhausted and it fell to earth. It had covered a distance of 184 feet at 60 miles per hour. The world's first liquid fuelled rocket ascent had been achieved.

The goal remained the carrying of meteorological instruments and by 1929 he had advanced to the stage of a 60 foot launch tower from which he sent up a rocket carrying a barometer, a thermometer and a recording camera which would trip a parachute via its shutter release. The experiment was a complete success with the instruments landing unbroken. By this time Goddard's work was attracting considerable press publicity and the wealthy Daniel Guggenheim offered funding for further work via the Guggenheim Foundation. This enabled a move to a desert test ground near Roswell, New Mexico with a full scale research centre and workshop.

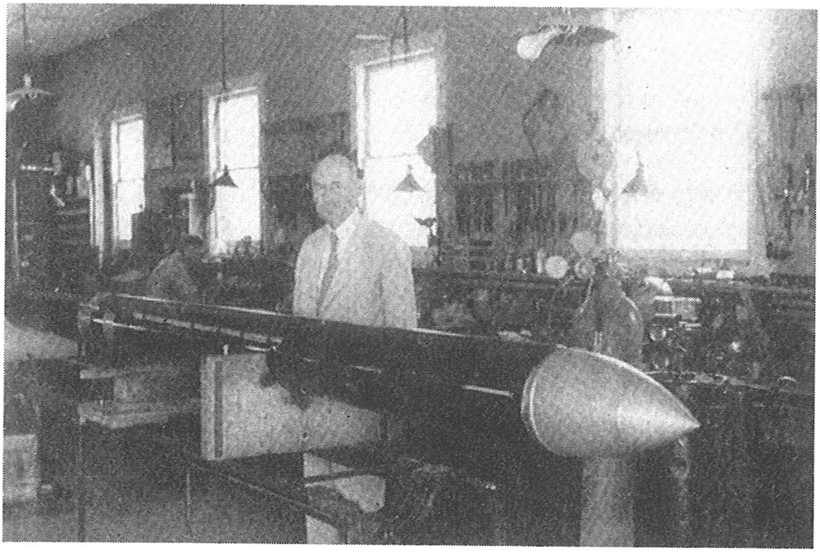


R.H.Goddard with the the world's first liquid fuelled rocket to achieve an ascent, on 16 March 1926

The next few years were devoted to cracking the problem of satisfactorily steering the rocket. Large fins attached to the rear of the rocket were unsuccessful. Goddard then correctly deduced that the steering medium would have to involve placing small moveable vanes directly in the exhaust blast deflecting it to one side or the other. But how to control the vanes; a gyroscope appeared to be the answer, but first attempts failed. Pendulum control was then tried, again without success. After many trials he finally succeeded in perfecting gyroscope control.

Problem number two was the question of forcing the fuel into the combustion chamber. An inert gas such as nitrogen under high pressure had been used, but this had the disadvantage that the whole system is under that high pressure and therefore the tanks containing it had to be very strong and heavy, imposing a weight penalty. The answer was to design pumps made as light as possible, which meant in its turn that the oxidant and fuel, no longer under high pressure could be contained in lighter tanks.

The next problem was how to prevent the chamber and nozzle being destroyed by the heat of the motor. Lining the combustion chamber with heat-resistant clays, the refractory material used to protect blast furnaces, was unsuccessful. Water cooling would add too much weight, air cooling would be insufficient. Finally Goddard concluded that the only way to cool a rocket motor would be to use its own fuel. The method he devised was to allow an excess of oxidant or fuel to be introduced along the walls of the of the combustion chamber creating a thin film protecting the metal from the heat of the blast. Prophetically this was the system used in the V2.



R.H.Goddard with one of the rockets which he built at Roswell, New Mexico ca.1939

He was now achieving his dream of a high altitude meteorological instrument carrying rocket, but by now war was threatening. In 1941 Pearl Harbour brought the US into the War and the Government revived its interest in rocketry, which had completely lapsed after WW1. From a standing start by 1945 the US Army was spending 150million dollars a year on rockets and the Navy eight times as much.

At this point events took a completely unforeseen turn, in which Goddard unwittingly influenced the entire US rocket programme. As far as direct work was concerned he spent the War working with the Navy on a variety of rocket matters, such as further improving pumps, rocket assisted take-off etc. However entirely separate from this his 1917 graduate assistant C.N. Hickman had been working for the Bell Telephone Laboratories. His superior Dr. F.B. Jewett was appointed to a senior post in the new National Defense Research Committee and Hickman remembering his days with Goddard wrote to Jewett with a report on his work. This resulted in Hickman being appointed to head a section in the NDRC – called Section H after Hickman, which became the starting point for the ultimately massive US rocket development programme.

Goddard had never enjoyed good health, but had driven himself relentlessly and he died in 1945, following a throat operation.

Whilst the German effort in military rocketry led them to a commanding position, the fact remains that almost all of the solutions which they had arrived at were also achieved by Robert Goddard and he richly deserves the title of one of the fathers of rocketry, in the last year of his life still dedicated to solving 'the most fascinating problem in applied physics'.

However this was by no means the whole early American rocketry story. From initial obscurity another group was forging a path to great things.

To be continued.

Les Tucker