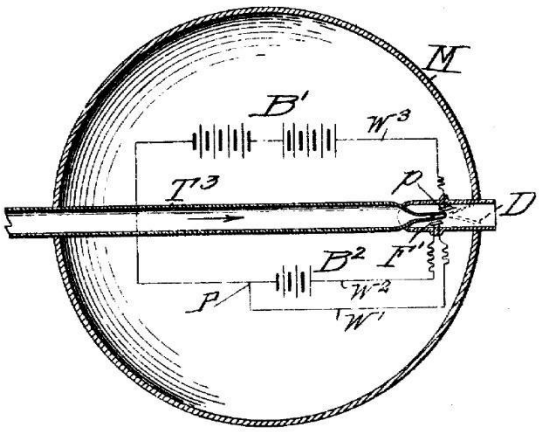
Alternative Sources of Propulsion

Although Dr. Goddard is known primarily for his work on liquid-fuel rockets, he considered other types of propulsion that were not technically feasible during the early twentieth century.

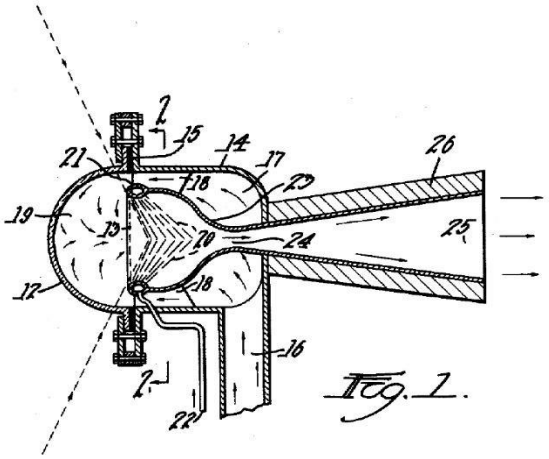
As early as 1906, Goddard wrote in his research notebooks about the possibility of using **atomic energy** to propel rockets. On November 1 of that year, he wrote, "… as far as means of propulsion go, the reaching of the moon will only be possible through atomic disintegration—which may or may not be performed, and what is just as important, may or may not be controllable." Even as he worked on the more practical solution of liquid propellants, he continued to believe that atomic energy offered great potential for rocket propulsion. In a *Scientific American* article dated August 1928, he commented, "If atomic energy were available, it would be a very convenient means of propelling an interplanetary rocket."

It wasn't until December 1938 that "atomic disintegration," or nuclear fission, was first accomplished.

Goddard was also an early proponent of **ion propulsion**. He included the design of an ion accelerator in a patent application he filed in 1917 (the patent was granted in 1920). He envisioned a small electrode plate (marked p in Figure 1) and a platinum filament electrode (F') that would generate charged particles (ions) that would be drawn into a stream of gas flowing through the tube T^3. The surrounding sphere (M) repels the ions because it carries the same charge as the ions produced by F'. In this way, the ions are accelerated away from the rocket in its exhaust stream.



The first spacecraft to use ion propulsion was the Space Electric Rocket Test (SERT-1), which NASA launched in 1964.



Solar power was also considered by Goddard. In a 1907 notebook entry, he described a possible multi-stage rocket launch scheme in which the rocket was first carried to a high altitude by a balloon. Then a mirror-like surface would collect heat from the sun and focus it into a device that would convert it to mechanical or electrical energy for propelling the spacecraft. Twenty years later, Goddard applied for the patent for a "vaporizer for use with solar energy" that could use solar

heat to vaporize a liquid and accelerate it to a high speed. In his design, shown here, a parabolic mirror would focus the sun's rays onto a flat plate after passing through the circular glass surface marked 11 in Figure 2. The concentrated heat would vaporize a liquid entering through the pipe marked 16. As the liquid vaporized, it would greatly increase in volume, and nozzle through which it would escape would increase its speed. That rapid vapor flow could then be used, for example, to operate a turbine to generate electrical power for propulsion. It was a complicated design, but it was innovative for its time.

The photovoltaic cell, a more efficient method of converting solar energy into electricity, was developed in 1954, nine years after Goddard's death. Vanguard I, an Earth satellite launched in 1958, was the first spacecraft to use solar power, although it was not used for propulsion.