Although the converging-diverging (De Laval) nozzles significantly improved the performance of gunpowder rockets, Goddard became convinced that reaching high altitudes and ultimately escaping the Earth's gravity would require more powerful liquid-propellant rockets.

Early Bazooka

During World War I, Goddard experimented with solid rockets for the U.S. Army Signal Corps. Together with C.N. Hickman and H.S. Parker, he demonstrated a small rocket that could be launched from a tube and traveled straight distances of 60–80 ft (18–24 m). The rocket tests were conducted in summer 1918 at Mount Wilson Observatory in California. The development of this early prototype of bazooka had come to an end with the Armistice signed in Europe.

"A Method of Reaching Extreme Altitudes"

Robert Goddard presented the results of his early rocket work in the *Smithsonian Miscellaneous Collections*, v. 71, N.2, 1919, a publication of the respectable Smithsonian Institution. This famous treatise of Goddard, entitled "A Method of Reaching Extreme Altitudes," outlined his ideas on rocketry and included detailed calculations of rocket dynamics and results of his various tests.

Goddard's paper included a section, "Calculation of Minimum Mass Required to Raise One Pound to an 'Infinite' Altitude." Goddard presented calculations of the initial, starting mass of a rocket capable of sending 1 lb on the "parabolic" velocity, or what we would commonly call today the "escape" velocity. He was also concerned with the experimental proof that the rocket would indeed escape. Goddard wrote,

> It is of interest to speculate upon the possibility of proving that such extreme altitudes had been reached even if they actually were attained. In general, the proving would be a difficult matter. Thus, even a mass of flash

All the Wisdom That's Fit to Bestow

TOPIC OF THE TIMES

... After the rocket quits our air and really starts on its longer journey [to the moon], its flight would be neither accelerated not maintained by the [proposed by Goddard solid rocket based on] explosion of the charges ... . To claim that it would be is to deny a fundamental law of dynamics, and only Dr. Einstein and his chosen dozen, so few and fit, are licensed to do that.

... That Professor Goddard with his "chair" in Clark College and the countenancing of the Smithsonian Institution, does not know the relation of action and reaction, and of the need to have something better than a vacuum against which to react — to say that would be absurd. Of course he only seems to lack the knowledge ladled out daily in high schools.

... As it happens, Jules Verne, who also knew a thing or two in assorted sciences ... deliberately seemed to make the same mistake that Professor Goddard seems to make. For the Frenchman, having get his travellers to or toward the moon into the desperate fix of riding a tiny satellite of the satellite, saved them from circling it forever by means of explosion, rocket fashion, where an explosion would not have had in the slightest degree the effect of releasing them from their dreadful slavery. That was one of Verne's few scientific slips, or else it was a deliberate step aside from scientific accuracy, pardonable enough in him as a romancer, but its like is not so easily explained when made by a savant who isn't writing a novel of adventure.

Editorial comments, *The New York Times*, 13 January 1920

M. Gruntman, *Blazing the Trail. The Early History of Spacecraft and Rocketry*, AIAA, Reston, Va., 2004. Page 117