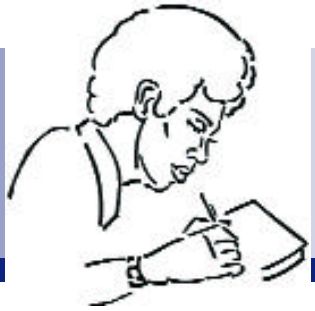

REDSTONE Written Phase

A BRIEF HISTORY OF ROCKETRY AND ITS GREAT PIONEERS

Perhaps the first true rockets were "accidents!" In the first century AD the Chinese were reported to have experimented with a simple explosive powder made from saltpeter, sulfur and charcoal. Although these powders were used to create small explosions in religious festivals, they eventually ended up in a weapon. The Chinese would fill bamboo tubes with this mixture and attach them to arrows. These "fire arrows," as they were called, were used at the battle of Kai-Keng where the Chinese repelled the Mongol invaders with a "rocket barrage." This occurred in the year 1232.

Much later, in 1405, a German engineer by the name of Konrad Kyeser von Eichstadt devised a rocket that was propelled by gunpowder. Another European country, France, used rockets to defend Orleans against the British in 1429 and again at the siege of Pont-Andemer in 1449.

During the Thirty Year War (1618-1648) rockets weighing as much as 100 pounds were fired. These exploded and sent small pieces of shrapnel in all directions. Rockets were extensively used in India when they were fired at the British in the battles of Seringapatam (1792 and 1799).

During the latter part of the 17th century the scientific foundations for modern rocketry were laid by Sir Isaac Newton, a great British scientist. Newton organized his understanding of physical motion into three scientific laws (covered in the Titan Stage of this text). Newton's laws soon began to have a practical impact upon the design of rockets in those days. During the 18th century, rockets experienced a brief revival as a weapon of war. India used rockets with great success against the British in 1792 and this caused Colonel William Congreve, a British artillery expert, to start using more of a scientific approach to the development of sophisticated rockets. He standardized the composition for gunpowder explosives and then added flight-stabilizing guide sticks. Congreve was able to increase the rocket's range from approximately 300 to over 3000 yards. Approximately 25,000 Congreve rockets were used in 1807 at the battle of Copenhagen.

In the War of 1812 between Britain and the United States, the British used rockets against the U.S. troops. During a typical siege the rockets would light up the night sky and in the battle at Fort McHenry, in 1812, Francis Scott Key witnessed the display. This inspired him to write a poem which later became part of America's National Anthem, the "Star Spangled Banner."

Even with William Congreve's technological developments the accuracy of rockets still left much to be desired. William Hale, an Englishman, developed a technique called spin stabilization. In this technology, the escaping exhaust gases struck small vanes at the bottom of the rocket, causing it to spin like a bullet in flight. This gave the rocket much greater stability and accuracy.

Even with improvements in stabilization the rocket was never used as a major military weapon until the 20th century. Standard artillery was much more widely used because of the superior accuracy of a cannon projectile for hitting a specific target.

By the end of the 19th century, men were beginning to dream of traveling into space and reaching other planets. To accomplish such a feat required a machine that had great power and speed. At first, the scientific community scoffed at the idea of space flight, but a few brave scientists continued to dream and even develop experiments using rocket power.

FOUR OF THE GREAT ROCKET PIONEERS

Konstatin Eduardovich Tsiolkovsky (1857-1935)

Tsiolkovsky was a Russian teacher who made some of the first mathematical computations for rocket flights into space. He was born in Izhevskoe, Russia, and was the 5th of 18 children. His father was a forester by trade.

Konstatin Eduardovich Tsiolkovsky

He was a visionary and is still considered by his countrymen to be the first scientist to lay the foundation for space exploration. At the age of ten, he came down with scarlet fever and was handicapped with near total deafness for the rest of his life. This disability forced him to turn inward and he developed a lifelong passion for books. The hearing impairment forced him to leave public education, and it was then young Konstatin decided to educate himself at home. In the early 1870's, his family recognized the boy's brilliance and sent him to Moscow to study. Here he met Nikolai Fedorov, an eccentric philosopher who shared his radical theories on "cosmism." This relationship had a profound effect on the future thinking of the young Tsiolkovsky. Historians agree that Nikolai Fedorov's theories inspired Tsiolkovsky's interest in space flight. In his quest to read everything about the subject, he discovered the novels of Jules Vern and was especially fascinated with the novel *Earth To The Moon* (1865).

He decided to try his own luck at writing science fiction and his work reflected technical expertise that was based on real science, not fantasy. This included such previously unknown concepts such as microgravity, space suits and control of a rocket outside the atmosphere.

Years of study paid off when Tsiolkovsky passed the examination to become a certified teacher. He moved to the town of Borovsk where he was assigned to teach mathematics. During this period, he met and married Varvara Sokolova in 1880. Over the next few years, the teacher-scientist wrote a piece titled *Svobodnoe Prostranstvo* or "Free Space." It was never published during his lifetime, but was later put into print in the mid-twentieth century. In this historic text he spoke of vacuum, weightlessness and many of the other dangers facing future space voyagers. He also talked about using gyroscopes to control the orientation of a spacecraft.

In 1903, Tsiolkovsky published an article titled *"The Exploration of the World Space with Jet Propulsion Instruments"* in *Nauchnoe Obozrenie* (Scientific Review) magazine. Experts now recognize this as being the first true, scientifically-based proposal for space exploration. In the article, he formulated relationships between the changing mass of a rocket as it burned fuel, the velocity of exhaust gases and the rocket's final velocity. His work also included, and illustrated, a rocket engine that was fueled by liquid hydrogen and oxygen, a fuel combination that is used to this day in the Space Shuttle. In later works, he spoke of multi-stage rockets, rocket-powered airplanes, an orbiting space station and eventually colonization of the galaxy.

Although he never built an actual rocket, he did lay much of the groundwork in theoretical aerospace engineering. He was a humble teacher who is, today, held in the highest regard by the people of Russia. He is recognized as the **Father of Space Travel.**

Hermann Oberth (1894-1989)

Hermann Julius Oberth was born on June 25, 1894 in the town of Hermannstadt, Transylvania. In some circles he too is given the title of "Father of Space Travel." His interest in rocketry started in 1905 when he was 11 years old. Once again the book *From the Earth To The Moon,* by Jules Verne, excited his imagination about the possibilities of manned space exploration. After careful study, Oberth realized that many of the "fantasies" found in the book, had sound scientific principles behind them. By age 14, Oberth theorized that a "recoil rocket"

Hermann Oberth

that could travel through space by the expulsion of exhaust gases.

As a student in college, he found that it was not much of a challenge. However, when he reached graduate school, and was working on his doctoral degree, he found many challenges and immersed himself in science. It was during this time that he wrote a thesis on the development of a rocket. This work, published in 1923, was titled *The Rocket into Planetary Space.* At first, it was rejected by the scientific community, In this book, Oberth covered concepts such as a rocket's fuel consumption, fuel handling hazards, the dangers of working with solid propellants and the possible hazards to humans. He also reasoned that as a rocket flies higher and higher, the mass of the propellant becomes less while the mass of the rocket remains unchanged. In relative terms, this means that the rocket becomes heavier in relation to the engine's ability to provide thrust. It was this thinking that gave Oberth the idea of multi-staging. When the first stage fuel is burned off, that stage should be discarded. Needless to say, that idea is still in use today.

In the thirties, Oberth developed a close working relationship with Werner von Braun. They worked together on the development of the infamous V2, or Vengence Weapon, for the German Army. Later, after World War II, the two, von Braun and Oberth, worked at the United States' Army Ballistic Missile Agency in Huntsville, Alabama.

Hermann Oberth, a great pioneer in the field of astronautics, died in West Germany on December 29th, 1989, at the age of 95. He made an enormous contribution to mankind's space exploration.

Robert H. Goddard (1882-1945)

Dr. Robert Goddard is considered to be the father of practical modern rocketry. Robert's father was a great believer in education and encouraged his son to experiment with things. Robert and his father spent many hours hiking through the woods studying nature. He had a telescope and while still in primary school, developed an interest in space.

Goddard eventually entered Clark University and majored in the sciences. This allowed him an opportunity to put his scientific knowledge to work with rocket experimentation. As a graduate student, Robert worked closely with a nationally-known physicist, Dr. Gordon A. Webster. This association gave him an extensive background in the sciences. He eventually earned his PhD. and was hired by Clark University as a faculty member.

After a long period of experimentation, Goddard built a successful liquid-fuel rocket that was launched on March 16, 1926, from a field near the city of Worcester,

Robert H. Goddard

Massachusetts. Although the rocket flew for just 2.5 seconds and rose to a height of only 41 feet, it proved that liquid-fuel rockets worked. One of the great advantages of liquid-fuel is that it can be controlled, whereas, solid-fuel burns to completion once ignited.

During World War I, Goddard received a grant from the U.S. Army to work on solid fuel rocket projects. One invention, developed during this time, was a three-inch rocket fired through a steel tube. This later evolved into the well-known anti-tank bazooka that was so widely used in World War II.

In the 20s, Goddard's rocket experiments caught the attention of the media. In one of his papers, published by the Smithsonian Institution, he speculated on the eventual travel to the moon using high-powered rockets. Unfortunately, he was ridiculed by the press and this caused him to continue most of this later experiments in secret.

Goddard and his wife, Ester, eventually moved to Roswell, New Mexico, where he conducted experiments without the humiliation of the news media. Much of his work was funded by the Guggenheim Foundation and was even witnessed by Charles A. Lindbergh, world famous aviator. Although not recognized as being a scientist of any significance in the United States, his work was seen as very important by scientists in Germany who were preparing for war in Europe.

His experiments included fuel feeding devices, propellant pumps, gyroscopic stabilizers, and instruments for monitoring the flight of rockets. Just before WWII, Dr. Goddard was hired to help develop rocket-powered, quick-takeoff propulsion units for U.S. Navy aircraft. In Germany, rocketry went forward with the development of higher-powered engines. These experiments eventually evolved into the infamous V-2 which was used as

intercontinental ballistic missiles against Great Britain.

After World War II, both the U.S. and Russia acquired German rocket scientists. These men formed the nucleus of a program that developed into the powerful launch vehicles used today.

DR. WERNER von BRAUN (1912-1977)

Werner von Braun was one of the most important figures in the advancement of space exploration in aerospace history. As a youth, he was inspired, like many others, by the fictional works of Jules Verne and H.G. Wells. During his teen years, von Braun became involved in a German rocket society and used this connection to further his desire to build large rockets. He

Werner von Braun

was also a great follower of Hermann Oberth and worked with him in the thirties and during the development of German rocketry during World War II. He continued his college work and eventually received a PhD. in physics.

Werner von Braun was the team leader of a group that developed the V-2 ballistic missile for the Nazis during WWII. Today, there is still controversy over his role in the use of slave labor to build the highly successful rockets. The V-2 was incredible for its time and was eventually used in the rocket development program of the United States. The V-2 was 46 feet long, weighed 27,000 pounds and had a sophisticated, but reliable liquid fuel propellant system. The rocket could fly at speeds in excess of 3,000 miles per hour and would deliver a 2,200-pound warhead to a distance of 500 miles from its launch site. Before the end of WWII, von Braun managed to get many of his top rocket scientists to surrender to the Americans. This enabled the U.S. to get most of the science and test vehicles from the Germans before the Russians.

For 15 years after the war, von Braun worked with the U.S. Army in the development of ballistic missiles. As part of the military operation, known as "Project Paperclip," von Braun and his team were sent to Fort Bliss, Texas, and did the experimental launch work at White Sands Proving Ground in New Mexico. Eventually, the team moved to the Redstone Arsenal near Huntsville, Alabama.

In 1960, the rocket center transferred from the Army to a newly established organization called NASA, or National Aeronautics and Space Administration. It was during this time that von Braun was given the task of developing the giant Saturn rockets. He was to become the chief architect of the Saturn V launch vehicle that propelled American astronauts to the moon.

He became one of the most prominent spokesmen of space exploration for the United States during the latter part of his career. In 1970, NASA asked him to move to Washington, D.C., to head up the strategic planning efforts of the Administration. He left Huntsville, Alabama, but in less than two years, retired from NASA and went to work for Fairchild Industries. He died in Alexandria, Virginia, on June 16, 1977.

Rocket posters make great cadet bulletin board learning tools. This poster features many of the rockets that were the result of pioneering work of the scientists featured in this unit. It can be purchased from the Pitsco company for under $10 and is titled as "Space Rockets." Pitsco's toll-free number is 1-800-835-0686 and item number is AA52715. Cadets left to right are Nathan Cuellar, Kyle Drumm and Alec Atwood, of the Valkyrie Squadron, Denver, Colorado.