Pioneers of a New Age

By WERNHER VON BRAUN

APOLLO 11 will always be remembered as a magnificent achievement in the history of applied science and technology in the United States, and we Americans are justifiably proud of it. In reality, however, the team that brought Apollo 11 to fruition cuts across national boundaries. The mission itself had its beginnings not on July 16, 1969, but several centuries ago.

The sense of history involved in this realization of man's ancient dream of voyaging to the moon is easily overlooked, and we tend to consider this particular feat as a product of Twentieth Century science and technology. It is not overlooked, though, by men such as Col. Frank Borman, who is a pioneer himself in the centuries-long journey to

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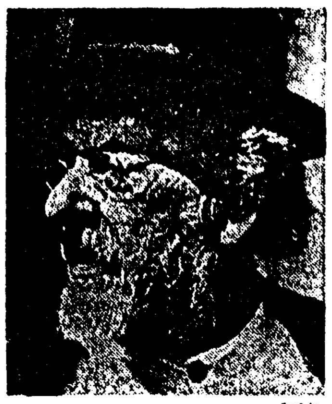
the moon. In addressing the House of Representatives on Jan. 9, following his return from orbiting the moon, the Apollo 8 commander said:

"Yet when we say that this was an American achievement, we really have to go back to Newton and paraphrase him. . . . How can anyone think of Apollo 8 without thinking of Galileo or Copernicus or Kepler or Jules Verne or Oberth or Tsiolkovsky or Goddard or Kennedy or Grissom or White or Chaffee or Komarov? We truly stood on the shoulders of giants."

Apollo 11 also owes as much to men such as those named by Colonel Borman as it does to the hundreds of thousands of engineers, scientists and technicians who labored for a decade to make possible man's first landing on the moon. For men such as Tsiolkovsky, Goddard, and Oberth worked out the basic principles of astronautics, drawing in turn on the earlier, fundamental work of Newton and Kepler in the Seventeenth Century. Without the knowledge of why a rocket works, we could not hope to place an artificial satellite around the earth or to escape earth's gravity and land men on the moon.

We sometimes, too, underestimate the influence of the arts on the sciences (and vice versa), particularly in astronautics. It is interesting to note that



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Konstantin E. Tsiolkovsky advocated the principle of rocket staging and was a pioneer in study of propellants.

the three modern pioneers in astronautics—Tsiolkovsky (1857-1935), Goddard (1882-1945) and Oberth (1894- —), all had something in common, in addition to their learning and passion for science. They had imaginations that were initially inspired by the fiction of Jules Verne, who made space travel sound exciting and—even more important—technically feasible to young boys with an aptitude for science. These two elements of his books were the spur needed to turn serious minds toward serious scientific problems in the latter years of the Nineteenth Century and the opening years of the Twentieth Century.

How many people for how many years idly watched the sky rocket streaking into the air and thought nothing of it except to marvel at the colorful pyrotechnics? The prose magic of Verne was the probable catalyst that began the process of scientific inquiry within Tsiolkovsky's mind. In his later years he wrote:

"For a long time I thought of the rocket as everybody else did — just as a means of diversion and of petty everyday uses. I do not remember exactly what prompted me to make calculations of its motions. Probably the first seeds of the idea were sown by that great author of fantasy, Jules Verne —he guided my thought along certain channels, then came a desire, and after that, the work of the mind."

Nearly two centuries elapsed between Newton's formulation of the laws of motion and Tsiolkovsky's mathematical proof that the rocket was the only means by which man would some day place himself into space (a date which Tsiolkovsky predicted as 2017, an underestimation of 53 years). His mathematics revealed the principle of mass ratio. Basically, this told him that the size and weight of the rocket was ultimately limited. However, it suggested two alternatives to overcoming the problem. He could find the best combinations of propellants to increase the velocity of his exhaust gases or he could reduce the weight of the rocket and all its parts in order to carry more propellants.

These alternatives opened up new vistas for theoretical research to Tsiolkovsky: using various combinations of fuels and oxidizers to produce the greatest exhaust velocities. His calculations, done painstakingly by hand, led him to state that the best propellants for practical use were kerosene and liquid oxygen or liquid oxygen and liquid hydrogen. He even pointed that the ozone as an oxidizer would be better than liquid oxygen. In this suggestion, he is still ahead of contemporary propellant chemists.

Brown Brothers

Robert H. Goddard, the father of U.S. rocketry, launched the world's first liquid-propellant rocket in 1926

Other studies led him to the principle of rocket staging to achieve the velocities required for escape from earth's gravity. He pointed out that the staging could be done in two ways: in series or in parallel. In other words, one rocket could be placed on top of another (as we do with Saturn 5) or several could be clustered into a bundle (as we do with the Titan 3C).

Tsiolkovsky's deep insight into the full scope of astronautics led him also to speculate on the life support system for the future astronaut. Indeed, he envisioned the spacecraft as "a metallic elongated chamber (the least resistant shape) supplied with light, oxygen, absorbers of carbon dioxide, miasmata, and other excretions . . ." While his studies in the biomedical field are not as extensive as his other contributions to astronautics, they do show that he had a total grasp of what is involved in manned spaceflight.

The implications of Tsiolkovsky's pioneering work are obvious today. It supplied us with the mathematical tools we need to design multistage space carrier vehicles such as Saturn 5. The studies in propellant chemistry and rocket propulsion gave us the starting point for the design of the F-1 and J-2 engines used by the Saturn 5. These engines are powered by liquid oxygen and kerosene and liquid oxygen and liquid hydrogen because Tsiolkovsky's findings over a half century ago are as valid today as they were then. Tsiolkovsky's theories have stood the tests of time and the empirical tests of our modern laboratories.

Contemporary rocketry and Apollo 11 also owe a debt to a native American pioneer in astronautics—Robert H. Goddard, the shy and brilliant professor of physics at Clark University in the early nineteen-hundreds at Worcester, Mass. Though some 25 years younger than Tsiolkovsky, Goddard was certainly his intellectual peer. Goddard was a theoretician, but he was also a builder. He was the perfect example of the practical New Englander who likes to prove things to himself. His work most relevant to today's problems began shortly after World War I, but his theoretical studies and experiments with gunpowder rockets antedate that conflict.

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Goddard's monograph, "A Method of Reaching Extreme Altitudes," published by the Smithsonian Institution in 1919, is a classic in the literature of astronautical science. It was a primer for the early research in rocketry in the United States and was well known in Europe. But Goddard was not content with mathematical models and theories. He designed and helped build his own flight hardware.

His contributions to the modern space booster are too numerous to recite. During the 42 years between 1914 and 1956, he received 214 patents in the field of rocketry alone. Many of these were for components that have become standard today. Goddard's greatest contribution was probably in the field of rocket engineering. He proved that liquid propellant rockets could be built and that they would perform as he and Tsiolkovsky before him had mathematically predicted they would. He launched the world's first one in 1926. He introduced, among other things, the gyroscope control, turbopump-fed liquid propellant engines, regeneratively cooled engines and the gimballed engine mounting. All these proved essential to the later rockets that boosted man into space, and without them the Saturn 5 would simply have not been possible. In summary, it can be said that Goddard did most of the basic research and development that made possible rockets such as the Saturn 5.

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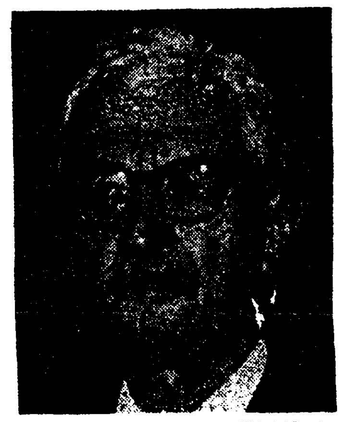
Apollo 11 also owes a debt to the work of Hermann Oberth, the German pioneer in astronautics. He was a contemporary of Goddard, and in one of those twists of circumstance that one often finds in the history of science, Oberth spent many long hours performing intricate mathematical proofs of what had taken Tsiolkovsky and Goddard an equally long time. Tsiolkovsky was an obscure Russian school teacher working by himself in a small rural village. His work was published in Russian, and he had little contact with fellow scientists in his own country and practically none outside. Thus, Oberth was completely unaware of the Russian's work until his own was practically done. The same was true with Goddard, who worked in secrecy for the most part, publishing little except for his masterpiece, "A Method of Reaching Extreme Altitudes," a copy of which he sent to Oberth upon request.

Oberth was more like Tsiolkovsky than Goddard. He was a theoretician rather than a designer and builder. And like Tsiolkovsky his scope of interest in astronautics encompassed more than just the rocket. He was interested in the problems of man in space, because of his early training in medical school.

The influence of Oberth on modern astronautical engineering is probably more direct than that of Tsiolkovky, however, because of geographical and temporal factors. Oberth was working in Germany and publishing in German at a period when a group of young rocket enthusiasts were beginning to associate in the late 1920's and early 1930's. Oberth's work, including the layout of a two-stage, liquid propellant rocket using liquid oxygen and alcohol, was known to them and became the basis of the practical work that soon found the amateur spacemen building and firing liquid propellant rockets. From these groups came the cadre of engineers and scientists that were to build the first really large rockets such as the V-2 of World War II, which proved that the space booster was an engineering possibility.

Lesser known but equally important early members of the Apollo 11 team include men such as Robert Esnault-Pelterie (1881-1957) of France. He was an adventuresome French aviation pioneer who had made flights in the Wright brothers' airplane, and he was the author of L'Astronautique (1930),



Pictorial Parade

Hermann Oberth, whose theories on rocketry influenced the work of German engineers before World War II.

Bettmann Archive

Robert Esnault-Pelterie of France, who wrote one of the earliest and most comprehensive books on astronautics.

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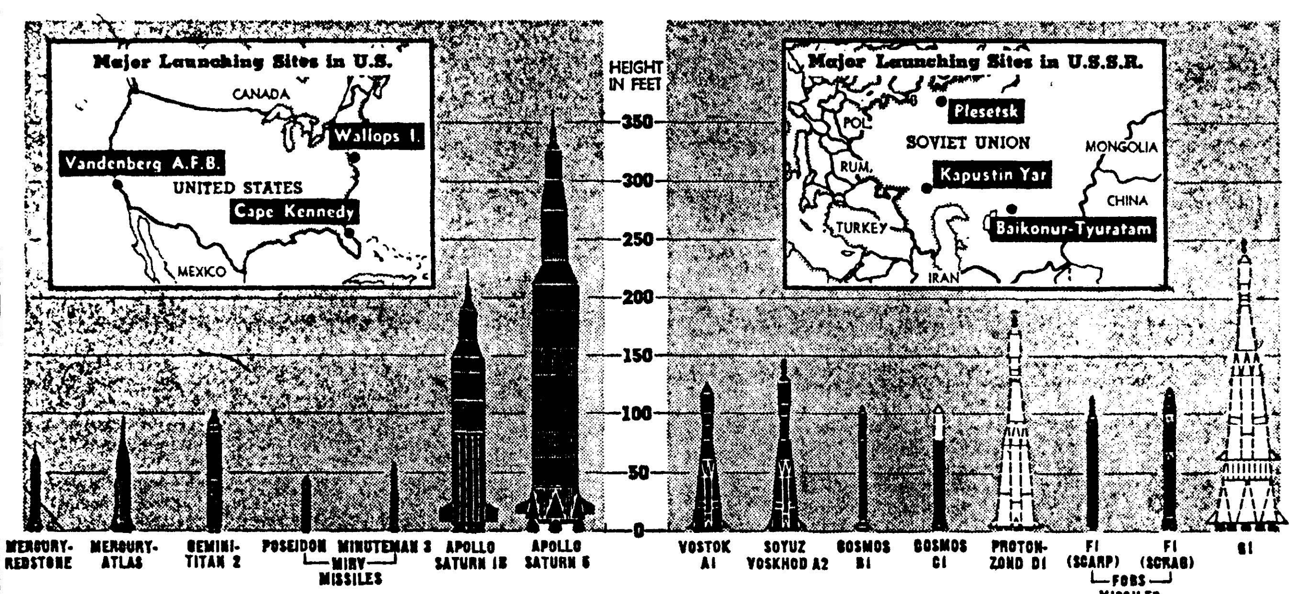
Dr. Walter Hohmann (1880-1944), city engineer of Essen, made theoretical studies of the energy required for the optimum trajectories to the moon and planets. His work, of course, is indisputably present in the mission planning that preceded Apollo 11's lunar trip and landing.

Other names that can be added to the role include Eugen Saenger (1905-1964) of Germany; Helmut von Zborowski (1905- —) of Germany; Guido von Pirquet (1880-1966) of Austria; Johannes Winkler (1897-1947) of Germany; and Friedrich A. Tsander (1887-1933) of Russia. All of them made significant scientific or technical contributions to rocketry, which, in turn, made missions such as Apollo 11 possible.

Today we see that manned exploration of space is a continuum. It began several centuries ago, and Apollo 11 is one of its more historic points. The essential timelessness of spaceflight was recognized well before our first satellites were even thought of by one of those giants upon whose shoulders men like Armstrong, Collins, and Aldrin stood. In 1932, Robert H. Goddard wrote:

"There can be no thought of finishing for aiming at the stars, both literally and figuratively, is the work of generations, but no matter how much progress one makes there is always the thrill of just beginning."



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V-2 to Saturn 5

The V-2: Its successful launching at Peenemünde in October of 1942 opened modern rocket age.

ON Oct. 3, 1942, a 46-foot-long missile, fueled by ethyl alcohol and liquid oxygen and designated A-4 by its developers, roared into the sky from Peenemünde on Germany's Baltic shore.

It was the masterpiece of the triumphant German rocket scientists who had put together in hardware the ideas of Oberth, their countryman, Goddard, the American, and Tsiolkovsky, the Russian. With its rise into the Baltic sky, the age of modern rocketry opened.

In the fall of 1944 this rocket took the place of what the Third Reich called Vengeance-Weapon One, the famous jet-propelled "buzz bomb" that had been raining death and destruction on London. The new weapon was renamed Vengeance-Weapon Two, or, more simply, V-2.

Although the V-2 appeared too late to influence the course of World War II, it was nonetheless the first ballistic missile, the ancestor of the missiles that today carry nuclear warheads. It was the progenitor of the boosters that blast men into space as well.

For some years after the United States and the Soviet Union appropriated the V-2 and its builders for their own rocket development programs, both nations concentrated on military missiles.

For example, the American Redstone, Atlas and Titan 2 were all designed expressly to carry atomic warheads, as were the Russian A-1 and A-2.

These five rockets were adapted as spacecraft boosters when the days of manned flight came along—the Redstone and Atlas for Project Mercury, the Titan 2 for Project Gemini, the A-1 for the Vostok series, the A-2 for the Voskhod and Soyuz vehicles.

Soon, though, both nations were turning out families of rockets for specialized purposes.

In Russia, the B-1 and C-1 boosters were developed for launching unmanned earth satellites of the Cosmos series. (In the large chart above, dotted lines indicate informed estimates as to rockets' shapes.)

The Proton, which appeared in 1965 and has already sent two Zond spacecraft around the moon, is thought to be capable of sending men around it too.

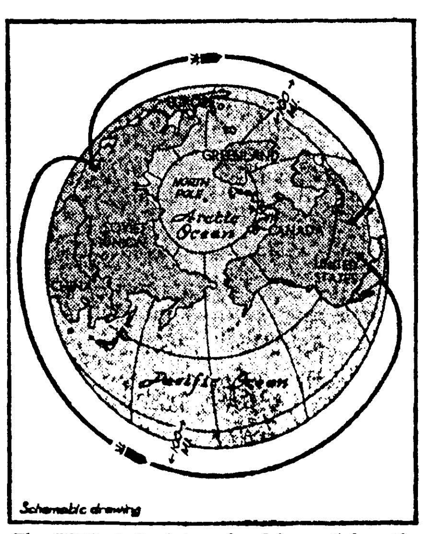
The G-1 is believed to be under development for future manned spaceflights, possibly to the moon.

Either the "Scarp" or "Scrag," both wholly military missiles, might be used for the Russians' fractional orbital bombardment system (FOBS), in which a nuclear warhead would be sent in either of two directions in a partial earth orbit (See diagram at right, above).

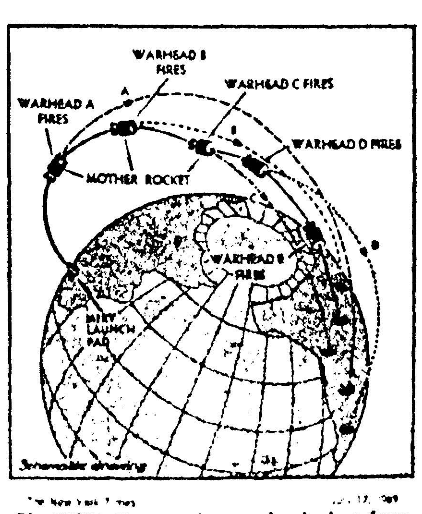
America's Poseidon and Minuteman 3 missiles, each of which can carry the multiple warheads of the Multiple Independently Targeted Re-entry Vehicle, or MIRV (diagram at right), represent the latest in specialized military rockets.

The Saturn family was created especially for Project Apollo.

It was a Saturn 5, so far the biggest and most powerful of the V-2's descendants, that blasted the Apollo 11 astronauts yesterday toward a planned lunar landing.



The FOBS: A Soviet warhead in partial earth orbit could evade detection by United States' northern radar defenses, or even approach the U. S. over its unguarded southern borders.



The MIRV: Many nuclear warheads drop from a single mother rocket that can change course.