J Indian Inst Sci., Mar.–Apr. 1996, **76**, 323–336.

Book Reviews

History of rocketry and astronautics, AAS History Series, Vol. 10, edited by A. Ingemar Skoog, Series Editor: R. Cargill Hall. Published for the American Astronautical Society by Univelt, Inc., P. O. Box 28130, San Diego, California 92198, USA, 1990, pp. 318, $60.

The volume covers the proceedings of the 12th, 13th and 14th History Symposia of the International Academy of Astronautics held in 1978, '79 and '80, respectively. The papers presented in these symposia have been grouped into five topics: Early solid propellant rocketry; Rocketry and astronautics—concepts, theories and analyses; Development of liquid and solid propellant rocketry (1880–1945); Rocketry and astronautics after 1945 and Pioneers of rocketry and astronautics. A total of 25 papers have been included in the volume. Each of the papers covers a topic which is important by its own merit. Only a few of these will be cited in this review.

From the early history of solid propellants it is evident that the origin of rocketry is buried in antiquity. Both India and China could take the credit. Many authors believe that the first rockets were used in India around 2000 BC. The *agniastra* or 'weapon of fire' in the ancient Vedic rhymes is believed to be a rocket. Rama's *Indra baan* mentioned in *Ramayana* and *Shakti* in *Mahabharata* composed around 300 BC, are said to be true missiles by some authors. The renowned historian, Frank Winter, who has made an extensive study of the Indian as well Chinese claims, however, has given the verdict in favour of China. According to him, the Indian claim cannot be substantiated because "(a) mythological interpretations of rockets or other devices thousands of years ago or long before the development of requisite technologies are unacceptable, (b) certain Sanskrit words taken to be rockets are too often misinterpreted, (c) Indian sources or claims are generally undated or over exaggerated, and (d) the true rocket and other firearms do not appear to have been fully established on the subcontinents of Asia until the 15th century, long after the appearance of more substantial and datable Chinese evidence of firearms, including rockets". Winter's observation may be valid, and it could well be that the Indian claim is lost entirely on the nonavailability of written records. It is well known knowledge was passed on from one generation to another by the word of mouth in ancient India. However, historical accounts in the times of Alexander (325 BC) indicate that Indian people called 'oxydracae' used fire power or thunderbolts hurled from above to repulse the enemy's approach, which were believed to be rockets by some authors. Here again, the assumption is somewhat fictional. However, even science fiction is not utopia, after all. For that matter, despite the existence of war rockets for a long time the first use of rockets in space flights was conceived in science fiction only in the late 1920s, long after Tsiolkovsky (1903) worked out the basic concepts in the beginning of this century.

Johannes Kepler's work on planetary motion along with his unbalanced life history has been sketched in the concepts and theories of the rocketry section. His realization that an ellipse was the correct reproduction of distances paved the way in establishing the laws of planetary motion. As usually happens in science, the new ideas of Kepler were not appreciated by his contemporaries like Galileo Galilei, whose judgment he valued most. He had to wait till Issac Newton, who fully recognized the importance of the work, later on. The application of findings in celestial mechanics to problems in space flight mechanics has been outlined starting with Kepler, Newton, continuing with Euler, Lagrange, Laplace, Gauss, Hamilton, Jacobi and Le Verrier and finally touching Poincaré, Levi–Civita and Birkhoff, in a subsequent article. It is interesting to note that the origin of delta-V equation, the basic equation of rocket dynamics, has been traced to a Russian M.Sc. thesis written by I. V. Meshchersky (1859–1935).

The history of rockets prior to 1945 traces the development of methods of cooling liquid propellant rocket engines. The external regenerative (flow) cooling which was first described by Tsiolkovsky in 1903 was used by H. Oberth and R. H. Goddard subsequently in 1923. The first large-scale American rocket company, Reaction Motors, Inc., came into being in 1941. An account of the development of rocket motors in the initial stage by this company makes interesting reading. The company's most outstanding achievement was the development of the motor for the US Navy's Viking sounding rocket. Eventually, in 1956, the company which was started by four men became a major division of Thiokcol Corp.

Significant development in rocketry and astronautics occurred only after 1945. A description of the early experiments with liquid rockets at high pressures at Purdue University reveals the efforts made by Prof. M. J. Zukrow for improving the performance of the liquid rocket by increasing the combustion pressure. Typical results on the propellant system comprising white fuming nitric acid (WFNA) and kerosene are reported. The story of evolving technological steps for liquid hydrogen propulsion, similarly, is highly fascinating. Although the concept of using liquid hydrogen for manned space flight was proposed by Tsiolkovsky, over 50 years elapsed before it was adopted and became a reality with the Apollo moon landing. Liquefaction of hydrogen and its *ortho–para* conversion equilibrium presented major unseen technological problems. Glenn L. Martin Company (now the Martin Marietta Corporation) played a key role in the development of liquid rocket propulsion systems in the USA. The German V-2 rocket was the prototype space carrier vehicle in those days. Despite its adaptability, it was not suited to high altitude research and was eventually developed as a ballistic missile. Improvements on V-2 resulted in the Viking, Vanguard and Titan series of rockets and missiles. A memoir of the rocket research and test at the NASA Wallops Island flight test range during 1945–59 records a detailed program concerning the development of missiles and sounding rockets. The problems encountered at the transonic and hypersonic flight speeds by a missile were studied. In a radiation-measuring program, sounding rockets were used to carry small nuclear bombs to high altitudes and were then exploded. The emitted radiation intensity in space before, during and after the explosions was measured to determine if such radiations would become entrapped in the magnetic field of the Earth. An account of the design and development work on the antecedents of the Space Shuttle since Eugen Sanger's concept (1944) on winged orbital reentry illustrates a variety of new design concepts tried out. A chronology of the events leading to the founding of the International Astronautical Federation is also included in this section.

In the Pioneers of rocketry and astronautics section, the volume lists the biographies and achievements of three famous men, Johannes Winkler (1897–1947), a rocket technologist, Walter Hohmann (1880–1945), an engineer from Germany and Maurice J. Zucrow (1899–1975), a professor at the Purdue University of USA. Needless to say, all the three were great space pioneers. Winkler launched his rocket in 1931 and thought that this was the first flight by a liquid propellant rocket; much later did he learn that Goddard had already made the first successful launch in 1926. Hohmann is recognized for his first rate work in space flight mechanics. He realized that choosing a half-ellipse as transfer trajectory between orbits presents the most economic transfer with regard to the consumption of mass. This form of transfer is known by the name of "Hohmann transfer". Prof. Zucrow not only contributed greatly by training outstanding young men (affectionately known as 'sons of Zucrow'), his achievements in solid and liquid propellant rocket research are highly significant. Development of sodium nitrate–asphalt solid propellants and self-igniting (hypergolic) propellant systems based on WFNA and aniline for JATO applications, basic studies in hypergolic ignition and heat-transfer problems at high pressures are cited as some of his major works.

The full development of rocketry from its infancy stage to the mighty Energia rocket, and to Space Shuttle within a span of 50 years is indeed a great leap. The history of events occurring at such high speed has to be interesting. The papers listed in this volume provide a good glimpse of how things happened in various areas of rocketry and astronautics. Not only is the information given of lasting value, the inside stories of the technological development makes very refreshing reading. The chronological narration also helps in understanding the issues involved more fully. The volume makes a good source of reference and is highly recommended to space science professionals, teachers and students. As is usual with the AAS publications the proceedings is bound in hard cover, and has a portrait of the giant of Russian rocketry, Sergei Pavlovitch Korolyev (1907–1966), on the front cover.

Department of Aerospace Engineering
Indian Institute of Science
Bangalore 560 012.

S. R. JAIN

History of rocketry and astronautics, AAS History Series, Vol. 11, edited by Roger D. Launius, Series Editor: R. Cargill Hall. Published for the American Astronautical Society by Univelt, Inc., P. O. Box 28130, San Diego, California 92198, USA, 1994, pp. 224, $60.

The volume covers 18 of the papers presented at the 15th and 16th History Symposia of the International Academy of Astronautics held in 1981 and 1982, respectively. The goal of this publication is to record in one place the historical observations about astronautical developments offered by individuals from broad and divergent backgrounds with differing perspectives on events, and from many nations. The papers presented have been grouped into five sections: Early solid propellant rocketry; Rocketry and astronautics—concepts, theories and analyses; Development of liquid and solid propellant rockets (1880–1945); Rocketry and astronautics after 1945 and Pioneers of rocketry and astronautics.

Under the first three sections, only five short papers are included covering a total of about 50 pages. Of these, the one entitled, Evolution of space fiction in film, by Frederick I. Ordway, III is a repetition of the one published in the AAS History series, Vol. 5, entitled, 'Science fiction and space futures–past and present' published in 1982, which incidentally was reviewed by the present reviewer for this Journal itself. The paper on training of rocketry personnel in the USSR (1924–36) cites the overall curriculum for a 2.5 year program amounting to 1000 h of teaching. The supersonic wind tunnel activities at Peenemunde listed in the next paper started with a staff of 60 in 1937. The wind tunnel which became operational in 1939 was moved to Kochel in 1943 following a succession of Allied air raids. A layout of the tunnel, wave patterns for nozzle at Mach 4.4 and the aerodynamic performance parameters of various rocket-powered vehicles obtained is reported.

The section on Rocketry and astronautics after 1945 has eight articles. James A. Van Allen, the discoverer of the Earth's 'radiation belt', popularly known as 'Van Allen's belt', gives a detailed account of its discovery in his article, the origin of magnetospheric physics. In 1958, the US exploded five atomic bombs in the Earth's atmosphere at varying altitudes to observe the effects of a planned series of tests. Electrons produced by these bursts were trapped in the geomagnetic field and produced a well-defined shell of artificially injected electrons as observed by 'Explorer IV'. Later on, however, a combination of these results with those obtained from 'Pioneer III' revealed the full geometric form of the two distinctly different radiation belts, an inner and an outer one.

The next two papers, by two noted historians, Winter and Ordway, pertain to a corporate history of Reaction Motors, Inc., America's first enterprise devoted to commercialization of rocket engines. An account of this enterprise by J. Shesta, one of the four founder members, appeared in Vol. 10 of the AAS History Series. The present account is more detailed. It records the earliest method devised for igniting vertically fired LOX rockets. The person volunteering for igniting a rocket, "would dash up with a gasoline rag on the end of a stick, light up and run like hell. Occasionally he would be wearing an asbestos suit"! The company perfected several liquid propellant systems, such as, the hypergolic (self-igniting) aniline–nitric acid, liquid ammonia–LOX, kerosene–nitric acid, MAF (hydrazine)–nitric acid and alcohol–water–LOX, and the 6000C4 engine known as 'Black Betsy'.

Martin Summerfeld in a short memoir lists the fundamental scientific questions in the early period (1940–42) of rocket propulsion development. The first and foremost question asked was, do the most energetic chemical rocket propellants possess enough energy to permit, say, escape from the Earth? It certainly looks unbelievable that all the major propulsive problems were overcome within a span of just about 20 years as is evident from the next article on the history of extravehicular activity (EVA) in human space flight which goes back to the early 1960s. EVA in the US started with Gemini missions. Adequate simulation of the EVA environment, proper foot restraints and sizing the life support system for greater heat dissipation, were the major lessons learned during Gemini. Later missions, especially Skylab and Space Shuttle, were routinely involved in EVA.

The section on Pioneers of rocketry and astronautics includes the works of five outstanding scientists, K. E. Tsiolkovsky (1837–1935) and N. A. Rynin (1877–1942) of Russia, Robert Esnault Pelterie of France, E. Carafoli of Romania and A. Szternfeld (1905–1980) of Poland. Of these, Tsiolkovsky's work is well known. He forecast the feasibility of space travel with the aid of liquid propellant rockets and propounded the theory of launch systems and multiple launchers, for the first time. However, many people may not know that Tsiolkovsky became deaf at the age of ten. He used to joke that deafness saved him from mean-spirited irritations generated by surroundings, but the sadness is bitterly reflected in his statement "life presented me much grief, and it was only my soul, which was boiling with joyful world of new ideas, that helped me overcome these misfortunes".

Articles collected in this volume reflect divergent topics and interests. Surely, people working in the field of space science and rocketry will appreciate at least a few of them, if not all. As a collection, the volume should serve as a good source of information although a few of the articles do not reach the standard expected for this series. As usual, the collection is bound in hard cover, and has an attractive portrait of the famous aerospace pioneer, Dr. Wernher von Braun (1912–1977) on the front cover. Unfortunately, this reviewer's copy is a binder's blunder, as a result, it has to be read from the back cover to the front all the way!

Department of Aerospace Engineering
Indian Institute of Science
Bangalore 560 012.

S. R. Jain

History of rocketry and astronautics, AAS History Series, Vol. 12, edited by John L. Sloop, Series Editor: R. Cargill Hall. Published for the American Astronautical Society by Univelt, Inc., P. O. Box 28130, San Diego, California 92198, USA, 1991, pp. 242, $60.

The volume covers the proceedings of the 17th History Symposium of the International Academy of Astronautics held in Budapest in 1983. The papers presented have been grouped into five categories: Early solid propellant rocketry; Rocketry and astronautics—concepts, theories and analyses; Development of liquid and solid propellant rockets (1880–1945); Rocketry and astronautics after 1945 and Pioneers of rocketry and astronautics. A total of 15 papers have been included in the volume, each of which covers a topic which is important by its own merit.

A study of early Korean rocketry shows that the first Korean rocket called 'ju-hwa' meaning 'running fire', was manufactured between 1377 and 1389 AD. It was a rocket propelled arrow, which seems to have been used until 1448, after which the magical-machine-arrows of different types appeared. A description of a scientifically designed fire-cart with the magical-machine-arrow launcher, capable of launching 100 arrows in groups of 15 at a time in quick succession, is found as early as 1451.

Importance of Leonhard Euler's work in aerospace sciences has been recalled on the occasion of the bicentenary of his death in 1983 in Concepts, theories and analyses section. Not only is he considered to be one of the greatest mathematicians of all time, almost all branches of mathematics—algebra, calculus, theory of numbers, differential equations, geometry, topology, fluid dynamics, ballistics, optics, celestial mechanics, etc.—owe basic findings to him. In flight mechanics and guidance and control, the three Eulerian angles are still used in order to describe the position of a body. In fluid mechanics, he formulated the equations of motion for frictionless fluids. Although Euler became totally blind, in the later years of his life, his creativity, however, remained unbroken.

Part III of the volume includes an account of the founding of the Jet Propulsion Research Institute and the main field of its activity, in the Soviet Union, on its 50th anniversary in 1983. The British Interplanetary Society (BIS) also completed its first 50 years in the same year. A summary of the events leading to the formation of the BIS and its activities and the key role it played in founding the International Astronautical Federation (IAF) in 1951, shows an immense amount of organisational effort by its founding members. A detailed account of the founding of the IAF is given in the AAS History Series, Vol. 10. The involvement of the US Navy in developing liquid propellant rockets during World War II is recalled by R. C. Traux, who himself was responsible for initiating its various activities. The replacement of nitric acid–gasoline system by the self-igniting nitric acid–aniline propellants resulted in the successful development of JATO seaplanes. Another interesting memoir of early rocketry is presented by Bernard Smith at the American Rocket Society. Besides attempting several innovative ideas, solid-fueled hybrid system comprising graphite and LOX was tried out, perhaps for the first time.

Arthur Clarke's prediction of commercial satellites was realized much sooner than anticipated. The experimental communication satellites became operational in the early '60s and the first commercial satellite 'Early Bird' entered service in 1965. An account of the developments during the 'experimental years' 1958–64 reveals the evolution of various communication satellites from Score to Syncom and finally INTELSAT in 1965. The next article included in Part IV of the volume, pertains to project Rover: the US nuclear rocket program, which was initiated in the mid-1950s but was terminated in 1972 after spending over $1.5 bn. Nuclear rockets have an edge over chemical rockets only in interplanetary space travel. Using hydrogen as the working fluid, the basic technology of nuclear rockets was worked out. However, the expense of developing such systems could not be justified in the absence of a manned mission to Mars or a lunar base program, where nearly 100 trips a year could be required. Another paper makes a comparative study of the evolution of manned and unmanned space flight operations. Apparently, both have their own merits, but of late, have become more interdependent and have to grow together to produce benefits in efficiency and service to the users in the next phase of space exploration.

Continuing with the history of Reaction Motors, Inc., of which Part I was published in the AAS History Series, Vol. 11, Frederic Ordway and Frank Winter present Parts II and III, respectively, after it became a division of Thiokol, and was called the Reaction Motors Division (RMD). While Thiokol is famous for solid rockets, RMD concentrated on liquid propellant rockets. The two pictorial presentations describe RMD's work on an X-15 research plane, packaged liquid rocket engines for small missiles, and missiles such as Sparrow III, Bullpup, Condor, etc. A project history of the various systems emphasises the development of a variety of storable self-igniting (hypergolic) propellant systems. Packaged vernier rockets giving small thrusts for mid-course flight correction were also developed by RMD.

The biographical section describes the work of the Polish scientist Olgierd Wolczek (1922–1982) who was one of the founders of the Polish Astronautical Society. His contributions in the areas relating to nuclear energy in rocketry, planetology and evolution of life in the universe, are recalled.

As is usual with the AAS History series, this volume has several excellent articles. People working in space sciences, rocketry and related areas will find them full of interesting information. Bound in hard cover, it has a portrait of one of the great men of science, engineering and education, Dr. Theodore von Karman (1881–1963) of USA on its front cover.

Department of Aerospace Engineering S. R. Jain
Indian Institute of Science
Bangalore 560 012.

History of rocketry and astronautics, AAS History Series, Vol. 14, edited by Tom D. Crouch and Alex M. Spencer, Series Editor: R. Cargill Hall. Published for the American Astronautical Society by Univelt, Inc., P. O. Box 28130, San Diego, California 92198, USA, 1993, pp. 209, $60.

The volume covers 18 of the papers presented at the 18th and 19th History Symposia of the International Academy of Astronautics held in 1984 and 1985, respectively. The goal of this publication is to record in one place the historical observations about developments in rocketry and astronautics offered by individuals with differing perspectives on events. The papers presented have been grouped, as usual, into five sections: Early solid propellant rocketry; Rocketry and astronautics—concepts, theories and analyses; Liquid and solid propellant rockets (1880–1945); Rocketry and astronautics since 1945 and Pioneers of rocketry and astronautics.

An account of the rockets and rocket propulsion devices in ancient China was reported in the AAS History Series, Vol. 10, by Fang-Toh Sun. The same author has given another record of early rocket weapons in China to dispel the doubt expressed by some writers whether the early

Chinese rockets (13th century AD) indeed could be regarded as reaction-propelled devices like the modern rockets, in this volume. The development of rocketry in France, on the other hand, did not assume much importance even during the 19th century. Only after they knew about the British work around 1810, their activities in rocketry commenced. From the diagrams given in the paper, 19th century rocketry in France, it is clear that several rocket-propelled devices existed during the Crimean war (1853–56) but the war rockets went into oblivion soon after the Indo-China (Vietnam) War in 1864. The work on the rescue rockets, however, continued as is evident from another article on life-saving rockets in the 19th and early 20th centuries. These rockets were widely employed in those times to rescue crews and cargo of shipwrecks not far from the shore. It is interesting to note that while Europeans abandoned the use of combat rockets by 1875, the use of life-saving rockets expanded. With advances in navigation and development of other life-saving devices, however, the importance of life-saving rockets declined eventually. Another article in this section gives an account of the first British liquid-propellant rocket motor, affectionately called 'Lizy' built in 1941, which used petrol and liquid oxygen as propellants.

The next section includes an article on space station design concepts developed by NASA since 1959. Several configurations evolved are apparently determined by the changing functions of space stations and available technologies. Basic details of some of the configurations conceived by the NASA's Langley and Marshall space centers and McDonnell-Douglas, during the period 1959–85, are given. New technological developments called for discarding the rotating configurations as it was realized that for limited periods of about 3 months human crews would not require artificial gravity. Also, the costly Saturn vehicle was abandoned in favour of the reusable space transport system, which provided a relatively cost-effective means of rotating crews and expandable supplies. Reaching for the planet Mars forms the topic of another paper. Evolving views of Mars since the early period of history makes interesting reading. Martian canals as seen by the famous astronomers Schiaparelli (1879) and Lowell (1907) were proved to be optical illusions by Viking 1 and 2 spacecraft in 1976. Mariner 9 discovered huge volcanoes; it is now confirmed that Mars is a very cold, dry, almost airless world and probably lifeless.

The section on liquid and solid propellant rockets (1880–1945) includes an account of the British rocketry during World War II. Although the gunpowder war rockets were successfully developed in England by men like Congreve in the early 19th century, the British interest in rocketry disappeared by the end of the 19th century until the mid-1930s. It actually restarted with the development of anti-aircraft rockets using cordite as the propellant in 1935, to act as a deterrent to Germany's combat rockets. The work on four radio-guided missiles started only around 1944, just before the end of World War II. The next article is a memoir of the first US jet-assisted take-off (JATO) flight test carried out in 1941 at CalTech. The end-burning solid propellant rocket motors developed by von Karman and his group reduced considerably the take-off distances and times of the airplanes. A comparative analysis of developments in the active and reactive methods of projection forms the topic of another article. It essentially analyses the process of imparting velocity to a body in guns and rockets.

The section on Rocketry and astronautics since 1945 includes an article on engines and propulsion units for space vehicles constructed by Alexey M. Isaev. Isaev's bureau in the Soviet Union was responsible for building the first multiple ignition liquid-propellant rocket engine with long flight life. Another article surveys the world meteorological and environmental satellites during 1960–1985. A highly illustrative summary of US civilian meteorological satellites starting from TIROS-I in 1960 to NOAA-9 in 1984, a total of 48 satellites, is given. This account also includes the satellite programs of ESA, Japan, USSR, India and China during this period. An interesting account of the history of heat shields for manned space flight is the next entry in this section. Early advances in this area involved the use of ablative materials as a heat-protecting measure. It was soon realized that material advances alone could not solve the problem of manned re-entry since the kinetic energy involved would vaporize any known material. The idea that a streamlined configuration was best was proven to be wrong for re-entry. The concept of blunt-shaped configuration helped immensely in distributing the heat evenly. The requirement for Space Shuttle orbiter heat shield to be reusable led to the development of ceramic reradiation tiles for the lower surface and carbon–carbon for the leading edges and nose.

The part dealing with Pioneers of rocketry and astronautics includes the contributions of the eminent Soviet scientist and science activity organizer, Anatole Arkadievich Blagonravov.

Overall, the volume has several well searched-out chronologies on different topics. Researchers and people interested in the area of rocketry will certainly enjoy browsing through them. Bound in elegant hard cover, the volume has a portrait of the German space engineer Hermann Noordung (1892–1929) on its front cover.

Department of Aerospace Engineering S. R. JAIN
Indian Institute of Science
Bangalore 560 012.

History of rocketry and astronautics, AAS History Series, Vol. 15, edited by Lloyd H. Cornett, Jr, Series Editor: R. Cargill Hall. Published for the American Astronautical Society by Univelt, Inc., P. O. Box 28130, San Diego, California 92198, USA, 1993, pp. 438, $60.

The volume covers the proceedings of the 20th and 21st History Symposia of the International Academy of Astronautics held in 1986 and 1987, respectively. The papers presented have been grouped into five categories: Early solid propellant rocketry; Rocketry and astronautics—concepts, theories and analyses; Development of liquid and solid propellant rockets (1880–1945); Rocketry and astronautics since 1945 and Pioneers of rocketry and astronautics. A total of 31 papers have been included in this volume.

An account of the genesis of rockets in China and its spread to the east and west appeared earlier in the AAS History Series, Vol. 10. The same author examines the origin of 'Baun Bang Fai' rockets of Thailand and Laos, as a possible key to determine the spread of rocketry in the orient. The allegedly millennia-old Baun Bang Fai, which literally means 'rocket festival' is celebrated every year with great fanfare, where a remarkable range of solid rockets is displayed. The author examines whether the knowledge of gunpowder rockets first reached these regions from China, India or whether it was indigenously developed. The second article in the Early solid propellant rocketry section examines the Congreve's (1772–1828) rockets. The English inventor had an influence on the story of rocketry far in excess of the actual results achieved by his rockets, which, in fact, could not be thrown with any precision of shells and invariably missed the targets.

The Concepts, theory and analysis section (Part II) records the legacy of the famous astronomers G. Schiaparelli and P. Lowell. Both of them are well known for their postulation of the existence of artificial canals on the planet Mars. Lowell by his photographs and vehement assertion in his lectures almost convinced the public not only of the existence of canals but eventual possibility of life on Mars. The media praised his work sky-high during his life time. All this was proven wrong, however, by space probes, Mariners and Vikings, later on. These probes found neither canals nor a trace of life, but confirmed that Mars is a very cold, dry and almost airless world. The article is detailed in comparison to the one published on similar lines in the AAS History Series, Vol. 14.

Project Horizon: an early study of a lunar outpost, prepared by the US Army in 1959, is a detailed document wherein the feasibility of establishing a lunar post by late 1966 was examined. However, soon after the report was published, the army was phased out of the space business and the project which was a virtual blueprint for landing men on the moon, disappeared into oblivion. Another work listed under this section, entitled, Speculative spacecraft, 1610–1957, chronicles the concept of a spacecraft in science fiction. Here, human imagination indeed ran wild from wishful thinking to utopian ideas, in conceptualizing a spacecraft to reach the moon. Spaceships propelled by an imaginary antigravity substance 'Lunarium', light as a mechanical agent, antigravity repulsive force devices called 'apergy' derived from 'interatomic energy', space guns and what not, were proposed. A clear-cut account of the rockets and their use in space flights started appearing only after Herman Oberths's book published in 1923. The article, however, makes very interesting reading.

The paper concerning the development of space flight theory by Soviet scientists is actually a summary of the pioneering contributions made by Tsiolkovsky, Tsander and Kondratyuk. Tsiolkovsky (1903) compared various types of propellants emphasizing that the contributions of hydrogen and oxygen and of fluid hydrocarbon and oxygen had great future. The three scientists contributed immensely to modern rocketry and their individual contributions are far too many to be recounted here. It is interesting to note that none of them could foresee the broad utilization of radio and electronics, without which every modern spaceflight is absolutely unbelievable. Another article in this section traces the development, in the USSR, of the theory of correction maneuvers for the first transfer trajectories to Mars and Venus.

Liquid and solid propellant rockets, 1880–1945, in Part III of the volume, opens up with an article on camera rockets and space photography concepts before World War II. Mark Madden, an obscure electrical engineer in New York was perhaps the first to suggest broadcasting photos of Earth from a space rocket using a phototransmitter in 1924. Mostly rockets carrying movie cameras were used till the early thirties to take pictures of the Earth and its atmosphere, which were subsequently recovered after having been dropped by a parachute. A description of the reconstruction of a full-sized replica of Goddard's first liquid propellant rocket as launched in 1926, for the Science Museum in England, and the problems encountered are given in the next article. The replica, constructed in 1985, is supposed to be as faithful to the original as can be, but whether it would reach a height of 41 ft and travel a distance of 184 ft in 2.5 s, as Goddard's rocket, no one knows! .

Among the several interesting articles listed in Part IV of the volume dealing with rocketry and astronautics since 1945, is included a memoir of the propellant chemist's contribution to modern rocket flight. Development of composite solid propellants owes much to the chemist's ingenuity. Ever since black powder as a rocket propellant was replaced by compositions containing perchlorates as oxidizers, which incidentally was not long ago (in 1946), it is amazing to note the rapid strides made by the chemists. The theoretical specific impulse increased from about 80s for black powder to 186 s for asphalt-type propellants and finally today's high-energy polybutadiene–ammonium perchlorate compositions exceed 270 s, at standard conditions. Many new and energetic products were produced exclusively for rocketry. As a result, monolithic massive rocket grains with 260 in dia having 770 tons of propellant have been produced. The story of these achievements is indeed fascinating.

Another memoir included in this section relates to the beginning of the US space program, which actually started only after the end of World War II with the V-2 rockets brought from Germany. Smaller rockets used for high-altitude scientific experiments around that time included the JPL's Wac Corporal, NRL's Viking and Aerojet's Aerobee. In 1955, there were three possibilities for a satellite launch: NRL's Viking, Air Force's Atlas and Army's Redstone. Finally, the modified Redstone, built by Von Braun's team, was successful in putting the first American satellite, Explorer 1 into orbit on January 31, 1958. This highly absorbing memoir written by W. H. Pickering, a former director of JPL, also reflects the sudden spurt in rocketry which occurred in the US soon after the launch of Sputnik.

The decision to make manned lunar landing by the US in 1961 was essentially to restore its international prestige which had seriously declined as a result of the USSR's early successes in space flights; it owed nothing to any scientific interest in the moon. As per an account of the Apollo scientific exploration of the moon, the importance to lunar science was duly given only in the subsequent flights which followed Apollo 11. Another article entitled 'Lunar surface photography: A study of Apollo 11' gives a highly detailed account of the photographs taken and photographic equipment used during the first lunar landing. Apparently, Buzz Aldrin did not take any photographs of Neil Armstrong during the lunar surface operation, although he had a better camera!

In the 1950s, Project 'Manhigh', which became one of the most ambitious aerospace medical efforts, used balloons to place humans at very high altitudes. The idea was to investigate man's ability to live for an extended period of time in a spacecraft-like cabin and also to gather data on the effects of cosmic radiation on living organisms. The article gives an interesting description of the test flights. The scientific data collected were used in planning for project Mercury. This section also includes a historical review of the developments of communication in the space age. The detailed article recalls the phenomenal explosion of the operating frequency into the upper frequencies of the radio spectrum—from 30 MHz in 1957 (Sputnik 1) to 2300 MHz in 1969 (Apollo 11) just in 12 short years. During this period, the NASA space program forced the communication industry to develop new techniques for RF transmission, new modulation methods, etc., which were subsequently incorporated into the manned space flight network and deep space network systems.

White Sands Proving Ground, New Mexico, was the prime center for V-2 operations during 1946–52. Its main activity involved refurbishing and testing of the captured V-2 components and using V-2 as a scientific instrument carrier. Components sufficient to assemble nearly 100 V-2s were shipped to the center. A detailed account of the facilities set-up, static and flight-testing of V-2 and other development projects, such as Hermes II, Wac Corporal designed by JPL, Blossom project, which involved flying of biological payloads, etc., carried out at this range, gives a clear picture of how things were done. Another article included in this section recalls 30 years of astronautics with McDonnell and Douglas which is one of the largest US suppliers of space products and services today. Back in 1957, McDonnell and Douglas were two separate aircraft companies which merged in 1967. Both companies are well known for their contributions—Douglas built launch vehicles such as Thor and Delta, McDonnell built manned spacecraft, notably, Mercury, Gemini and Skylab. Today McDonnell–Douglas is working to build the NASA's space station and is involved in many other space programs.

The article entitled 'Peenemunde and Los Alamos: Two studies' gives a moving account of the two great scientific and technological teams during World War II, the German Peenemunde rocket team under the direction of Von Braun and the American Los Alamos atomic bomb team under the direction of J. R. Oppenheimer. The teams working in different countries under radically different political systems encountered severe political difficulties during and after the war. Yet taken together, the two teams made the age of intercontinental nuclear warfare possible. The article also addresses the question as to what led scientists to create weapons of such awesome power? The answer is given in terms of the dictum 'the context of times'. George Kistiakowsky, the chemist who designed the trigger for the first nuclear weapon when asked in a 1982 interview, "would you do it again?" responded, "certainly the way I feel now I would answer no, I would not do it. But I was intensely influenced by my hatred of authoritarianism in politics...." The events at Los Alamos and Peenemunde amply demonstrate that the finest minds and the most noble dreams are likely to be caught up in a maelstorm of events that are remembered with regret The last article included in this section describes the French SE-1990 and SE-1910 rocket sleds which were built in the fifties. The rockets used H_2O_2 as a liquid monopropellant and were designed to run on rails. The project was abandoned in 1953 presumably because of vanishing need.

The Pioneers of rocketry and astronautics section describes the contributions made by G. N. Babakin, the Russian designer, Yuri Gagarin, the Russian cosmonaut, and Theodore von Karman, the American research engineer and scientist. While Babakin is known for his work on automatic space station, Gagarin, being the first spaceman, is a household name throughout the world. van Karman is regarded as one of the greatest research engineers and scientists of the 20th century who left the world a legacy of theories and principles that will guide the aeronautical and space sciences for years to come. His laboratory, the Gauggenheim Aeronautical Laboratory at CalTech (GALCIT), became a Mecca of the world of aeronautical sciences. Described as 'father of supersonic age' with nothing of the 'great man' complex about him; he was simple and friendly.

Overall, the volume has covered a large number of articles; most of them are absolutely absorbing and informative. Browsing through them is indeed a treat. The volume is recommended not only to people working in rocketry and astronautics but to all those interested in general reading, with an inclination to know more. As usual, the volume is bound in hard, blue cover and has a portrait of V. P. Glushko (1908–), the soviet aerospace engineer, on its front cover.

Department of Aerospace Engineering
Indian Institute of Science
Bangalore 560 012.

S. R. JAIN

History of rocketry and astronautics, AAS History Series, Vol. 17, edited by John Becklake; Series Editor: R. Cargill Hall. published for the American Astronautical Society by Univelt, Inc., P. O. Box 28130, San Diego, California 92198, USA, 1995, pp. 466, $60.

The volume covers 25 of the papers presented at the 22nd and 23rd History Symposia of the International Academy of Astronautics held in Bangalore (1988), India, and Malaga (1989), Spain, respectively. The goal of this publication is to record in one place, the historical observations on developments in rocketry and astronautics offered by individuals with differing perspectives on events. The papers presented have been grouped into four parts: Early solid propellant rocketry; Rocketry and astronautics—concepts, theories and analyses; Rocketry and astronautics after 1945; and Pioneers of rocketry and astronautics.

The section on early solid propellant rocketry opens with a paper on the Indo-Aryan traditions and the history of astronautics (in India). Citing from Ramayana and Mahabharata, the article claims that the descriptions of Vimana, Indra's dart and Brahma weapon give a clear impression of space travel, air raids and total destruction caused by incredible weapons, in those times. The identical characteristics of Vimana and modern UFOs, in fact, caused several authors to make the sensational claim that in Hindu texts we have proof that extraterrestrial spaceships visited Earth in the ancient times. A discussion on the Vymanika Shastra written in the present Sanskrit form around 1918–23 reveals that the principles expressed therein would not have been too different from today's aeronautical concepts. The second article describes how the Indian rockets developed during 1778–1803, entered the British royal arsenal, and how William Congreve improved upon them. Congreve used the rockets against France in the Toulouse battle (1814).

Section II lists only two articles, both of which call for preserving aerospace chapters/sites for posterity sake. The first article calls for preserving video-taped interviews of the leaders of this area. Chapters in aerospace history, a project of the Aerospace Historical Committee, California, has already collected several interviews of eminent persons as regards to their perceptions of various space explorations in the next 40 years. Surprisingly, there is hardly a match in the view of any two individuals. Preserving sites and major space components as relics is a rather expensive proposal. For example, the Apollo Saturn V launch vehicle with launcher–umbilical tower is a gigantic 134 m tall structure; its dismantling and transportation to move the segments to a suitable storage site and subsequent reassembling will cost huge amounts of money. However, the article makes a good case for their preservation keeping in view that the world's historic space sites serve as a guide port for future generations seeking to trace the roots of our civilization's progression into the universe.

Rocketry and astronautics after 1945 section lists several interesting articles. The work on liquid rocket propulsion in France, which started in 1945, is reviewed. The initial development of motors involving hypergolic (self-igniting) propellant combinations like HNO_3–TX (triethylamine and xylidine) and HNO_3–furaline resulted in their use as take-off boost liquid rocket engines in the aircraft Mirage III. Engines employing nonhypergolic propellant combinations (HNO_3–kerosene), developed later on, were replaced by HNO_3–UDMH, another hypergolic combination, which was used subsequently in Ariane propulsion. By 1968, France developed motors based on LOX and LH, and became the second country in the world after US to have cryogenic engines. The SE4100 family of rockets based on liquid/solid propellants remained in secrecy till recently. This antiaircraft missile system, which was meant for testing different guidance systems, was used in no less than 14 different configurations for a total of 80 shots until 1956. By the detailed descriptions of these systems, it is apparent that French people knew much about rocketry in little more than six years after World War II, which explains how France became the third nation to orbit a satellite and how Ariane established Europe as the third space power. Another article sketches the story of hypersonic ramjets developed in the 1950s in France. The so-called SE4400/4401 missiles were the probable firsts of ramjet supersonic flight and speed records up to Mach 3.5. A detailed description of the components, log-schedule and major findings in each of the 92 launches is listed.

The next two articles contributed by the volume editor himself pertains to British rocketry in the 1950s and 1960s. Three fairly large size rockets, Blue Streak, Black Knight and Skylark were developed. Of these, Blue Streak was developed as a medium range ballistic missile, Skylark was a solid-propellant high-altitude sounding rocket and Black Knight was based on liquid propellants, burning kerosene and hydrogen peroxide, meant for carrying scientific experiment payloads. An account of the world's first cooperative scientific satellite between US and UK, Ariel I, is detailed in the next article. It was launched using a Thor-Delta rocket from Cape Canaveral, and collected data on the ionosphere and solar X-rays. The section also includes brief memoirs of the American Rocket Society (1953–1963) and German Rocket Society.

A detailed article on Black Betsy, the 6000C-4 rocket engine, gives a highly interesting account of its development and manufacture by Reaction Motors, Inc., USA. Its turbopump engine used LOX and aqueous alcohol as propellants; the turbine was driven by superheated steam from 90% hydrogen peroxide passed over a catalyst. The next paper tells a detailed story of the X–20 space plane, known as Dyna–Soar. This aerospace project, initiated by the US Air Force in 1957 was termed as the most innovative, but it never reached operational status—it was cancelled in 1963 before the first prototype was built. In concept, this manned spacecraft was more like the Space Shuttle of today; it was to be launched by Titan III, after an orbital mission the glider would reenter the atmosphere under its pilot's control and land on a runway like an ordinary jet fighter. However, due to lack of adequately justified space missions at that point of time, the project became superfluous and could not get enough financial support.

Charlie Bossart was the man responsible for designing the pressure-stabilized, thin steel, monocoque structure with a common intertank bulkhead—a 'steel balloon', propellant tanks for the Atlas and Centaur rockets. Conceived in 1946 and first produced in 1955, the tank design still appears to be the most weight efficient ever built. These tanks have been used in over 567 flights (till 1989), with virtually no change in structural design. The details of its design, structural characteristics and development, told in a rather lengthy article, make enjoyable reading. Another interesting article entitled 'Mercury primates' is a story of the primates, mainly monkeys and chimpanzees used in space flights. Each of these primates was given a name, and housed in a special container, which was recovered after the flight. The primate tests provided proof of the proper working of an environmental control system under actual space conditions; the psychomotor tests proved that higher primates could function in space, and that the noise, acceleration of launch, the weightlessness of orbital flight, and stress of entry would not incapacitate a human pilot.

A pictorial description of the first American man-rated space launch vehicle, Mercury–Redstone, details the concept, design, launch and recovery aspects of the project. Redstone vehicle was a highly modified version of the Redstone missile. The Mercury spacecraft, in view of the human life involved, was exceptionally detailed, so as to track down any conceivable malfunction during the flight. The preceding unmanned mission, was conducted with a chimpanzee named Ham, while the subsequent checking out of various systems was carried out by astronauts, L. Gordon Cooper, Sohn Glenn, A. B. Shepard and V. I. Grissom, before the spacecraft was man-rated for committing man to orbital flight. The next article gives a lucid account of the Aeromedical Field Laboratory of Space Medicine at New Mexico, which was responsible for many advances in space medicine throughout 1950s. Project Manhigh, described in the AAS History Series, Vol. 15, was an off-shoot of this laboratory. Research performed on high-speed test track was even more spectacular. Sleds powered with rockets when stopped by water, break suddenly subjecting the rider up to 43 g's causing a number of peculiar physiological effects.

The paper entitled, 'Apollo scientific exploration of the moon' is a repetition. It appeared in Vol. 15 of the AAS History Series, which was covered by the present reviewer earlier. During 1962–1968, several future missions for space flight were identified. An account of the American manned planetary mission studies, reveals the details of the project, 'Early Manned Planetary Interplanetary Roundtrip Expedition' (EMPIRE), which focussed on different aspects of possible missions of Venus and Mars. Several interesting pictures of the artists' concept of the Empire spacecraft, PERT charts of mission schedules and cost estimates to land man on Mars, and other mission information listed, makes these missions almost achievable. Although these studies never fructified into any real project, they surely make exciting reading.

The Pioneers of rocketry and astronautics section lists the activities of two Russian rocket scientists, Mikhail Klavdiyevich Tikhonravov, and Vladimir Petrovich Vetchinkin (1888–1950). While Tikhonravov is known for suggesting the clustered configuration of rockets, Vetchinkin was a pioneer of rocketry, who distinguished himself in aerodynamics, theory of propellers and jet propulsion.

As is the case with other volumes of the AAS History Series, this collection of articles on various topics of rocketry and astronautics, gives an insight into how things actually happened. People interested in real science stories will find them full of information and entertainment. Bound as usual in blue hard cover, it has an attractive illustration of three space scientists, William H. Pickering, James A. Van Allen and Wernher von Braun, hoisting a model of Explorer I, on its front cover.

Department of Aerospace Engineering
Indian Institute of Science
Bangalore 560 012.

S. R. JAIN

Published by N. M. Malwad, Executive Editor, Journal of the Indian Institute of Science, Bangalore 560 012; Typeset by Creative Literati Pvt. Ltd., Bangalore, Tel.-cum-Fax: 546 2698; Printed at Lotus Printers, Bangalore, Tel.: 338 0167; Fax: 335 7378